Stormwater Manual

Vol. 2
Construction Stormwater Control Technical Requirements Manual

Director's Rules for Seattle Municipal Code Chapters 22.800 - 22.808

Directors' Rules:
2009-004 SPU
16-2009 DPD

City of Seattle
Seattle Public Utilities
Department of Planning & Development
November 2009

Note:
Some pages in this document have been purposefully skipped or blank pages inserted so that this document will copy correctly when duplexed.

DPD	Director’s Rule 16-2009
SPU	Director’s Rule 2009-004

Applicant:	**Page:**	**Supersedes:**
Department of Planning & Development Seattle Public Utilities	ii	16-2000
	Publication: 11/5/2009	**Effective:** 12/1/2009

Subject:	**Code and Section Reference:**
Stormwater Manual Vol. 2 of 4: Construction Stormwater Control Technical Requirements Manual	SMC 22.800-22.808
	Type of Rule: Code interpretation
	Ordinance Authority: 3.06.040 SMC
Index:	**Approved:** **Date:**
Title 22.800 Stormwater Code	**_(signature on file)__________11/25/09__** **Diane M. Sugimura, Director, DPD**
	Approved: **Date:**
	_(signature on file)__________11/30/09__ **Ray Hoffman, Acting Director, SPU**

Table of Contents

Appendices

Tables

Figures

Preface

Background

This Directors' Rule, the *Construction Stormwater Technical Requirements Manual*, presents approved methods, criteria, details, and general guidance for preventing contaminants from leaving a site during construction pursuant to the Seattle Municipal Code, Chapters 22.800 – 22.808, the *Stormwater Code.*

Purpose of the Stormwater Code

In addition to meeting the specific stormwater needs of the City of Seattle, the Stormwater Code also meets certain requirements of the City's Phase I National Pollutant Discharge Elimination System (NPDES) and State Waste Discharge General Permit for Discharges from Municipal Separate Storm Sewer Systems. Issued to the City under the federal Clean Water Act by the Washington State Department of Ecology, one of the conditions of this permit requires Seattle to regulate activities that impact the quality and quantity of stormwater runoff. This is accomplished, in large measure, through the Stormwater Code and its associated Directors' Rules, which Ecology has determined to be equivalent to the minimum requirements contained in the City's Phase I NPDES Municipal Stormwater Permit and the Department of Ecology's 2005 *Stormwater Management Manual for Western Washington*.

The City of Seattle's Stormwater Code is contained in the Seattle Municipal Code (SMC) Chapters 22.800 – 22.808. The Stormwater Code contains regulatory requirements that provide for and promote the health, safety, and welfare of the general public. The provisions of the Stormwater Code are designed to accomplish the following purposes:

1. Protect, to the greatest extent practicable, life, property and the environment from loss, injury, and damage by pollution, erosion, flooding, landslides, strong ground motion, soil liquefaction, accelerated soil creep, settlement and subsidence, and other potential hazards, whether from natural causes or from human activity;

2. Protect the public interest in drainage and related functions of drainage basins, watercourses, and shoreline areas;

3. Protect receiving waters from pollution, mechanical damage, excessive flows, and other conditions in their drainage basins which will increase the rate of downcutting, stream bank erosion, and/or the degree of turbidity, siltation, and other forms of pollution, or which will reduce their low flows or low levels to levels which degrade the environment, reduce recharging of groundwater, or endanger aquatic and benthic life within these receiving waters and receiving waters of the state;

4. Meet the requirements of state and federal law and the City's Phase I NPDES Municipal Stormwater Permit ;
5. Protect the functions and values of environmentally critical areas as required under the state's Growth Management Act and Shoreline Management Act;
6. Protect the public drainage system from loss, injury, and damage by pollution, erosion, flooding, landslides, strong ground motion, soil liquefaction, accelerated soil creep, settlement and subsidence, and other potential hazards, whether from natural causes or from human activity; and
7. Fulfill the responsibilities of the City as trustee of the environment for future generations.

To support implementation of the Stormwater Code, the Director of Seattle Public Utilities (SPU) and the Director of the Department of Planning and Development (DPD) promulgate rules that provide specific technical requirements, criteria, guidelines, and additional information. There are currently four joint Directors' Rules:

- **Volume 1: Source Control Technical Requirements Manual** (Directors' Rule 2009-003 [SPU], 15-2009 [DPD]) provides information designed to help individuals, businesses, and public agencies in Seattle implement best management practices (BMPs) for controlling pollutants at their source and preventing contamination of stormwater runoff.
- **Volume 2: Construction Stormwater Control Technical Requirements Manual** (Directors' Rule 2009-004 [SPU], 16-2009 [DPD]) contains temporary erosion and sediment control technical requirements, which are required to prevent contaminants from leaving projects during construction. It also provides submittal requirements for drainage control review to help ensure stormwater controls are appropriately implemented during construction projects.
- **Volume 3: Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual** (Directors' Rule 2009-005 [SPU], 17-2009 [DPD]) presents approved methods, criteria, and details for analysis and design of stormwater flow control and water quality treatment BMPs. It also provides information regarding hydrologic modeling for stormwater designs
- **Volume 4: Stormwater Code Enforcement Manual** (Directors' Rule 2009-006 [SPU], 18-2009 [DPD]) provides standards, guidelines, and requirements for enforcing the Stormwater Code.

Chapter 1 - Introduction

1.1 What is the Purpose of this Manual?

This manual is designed to help businesses, individuals, responsible parties, and public agencies in Seattle implement best management practices (BMPs) at construction sites to:

- Prevent impacts to the public drainage system and downstream resources
- Stop pollutants from contaminating stormwater.

Uncontrolled stormwater can threaten downstream resources, such as public storm drains, real property, and natural habitat. It can also pollute our public drainage system and receiving waters (e.g., creeks, streams, rivers, lakes, and the Puget Sound). The resulting impacts can pose serious risks to the health, safety, and welfare of humans and the environment.

The City of Seattle Department of Planning and Development (DPD) and Seattle Public Utilities (SPU) produced this manual as a joint Directors' Rule to meet the requirements of the Stormwater Code, SMC Chapters 22.800 – 22.808.

The manual and Stormwater Code have been revised in part to fulfill the City's state and federal stormwater permit obligations and to be equivalent to the requirements contained in the City's Phase I NPDES Municipal Stormwater Permit as well as the Washington State Department of Ecology's 2005 *Stormwater Management Manual for Western Washington*.

A comprehensive list of definitions is provided in Appendix A.

1.2 How Does this Manual Apply to Construction?

This manual applies to all construction projects in Seattle, defined in SMC 22.801.170 as the addition or replacement of impervious surface or the undertaking of land disturbing activity.

The construction stormwater BMPs and requirements in this manual have been integrated from many programs and regulations, including the provisions of the:

- Federal Clean Water Act
- Federal Coastal Zone Management Act
- City of Seattle Phase I NPDES Municipal Stormwater Permit coverage
- Puget Sound Water Quality Action Team's Puget Sound Water Quality Management Plan
- Ecology's Construction Stormwater General Permit
- Seattle's Stormwater Code.

1.2.1 City of Seattle Requirements

Under current City of Seattle law, if construction occurs, the owner and others associated with the work are responsible parties for Stormwater Code violations, water quality problems, and impacts to downstream resources caused by the work. Although most construction projects require a permit from DPD, construction stormwater must be controlled to the extent required by the Stormwater Code to prevent negative impacts regardless of whether or not a permit is required.

If you are planning a construction project and need information concerning the applicable requirements, the first step is reviewing this manual (see Section 1.6 Getting Started) and the applicable elements of the Stormwater Code. Code sections to refer to include but are not limited to SMC 22.805.020 (particularly subsection D), SMC 22.807.020 (for requirements related to drainage control review) as well as the definitions in SMC 22.801. The second step is to review two other City of Seattle Directors' Rules for additional stormwater controls that may be applicable to the project:

- Volume 1, the Source Control Technical Requirements Manual
- Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.

The City also has resources available at the DPD Applicant Services Center, including DPD staff available to answer questions and relevant Client Assistance Memos (CAMs) with detailed information for construction projects. Visit the PD Applicant Services Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or the website (http://www.seattle.gov/dpd/). Copies of all available CAMs are also available at the DPD Public Resources Center (same location as above) or visit DPD's CAM website (http://web1.seattle.gov/DPD/CAMs/CamList.aspx).

Figure 1. "Dump No Waste" Storm Drain Stencil.

1.2.2 Other Regulatory Requirements

Depending on the location and nature of a particular construction project, many other regulatory requirements may apply.

1.3 What is Considered "Compliance"?

The City expects that the selection and implementation of appropriate BMPs outlined in this manual, and other applicable manuals, will result in compliance with the Stormwater Code's minimum requirements for construction site stormwater pollution prevention control. However, if compliance is not achieved, additional measures must be implemented. Proper implementation and maintenance of appropriate BMPs is critical to adequately control any adverse water quality or downstream resource impacts from construction activity.

1.3.1 Surface Water Quality

Pollutants that might be expected in the discharge from construction sites include but are not limited to sedimentation (as measured by turbidity), pH, and petroleum products. The public drainage system and/or receiving waters can be contaminated by direct discharges of these pollutants, or from stormwater discharges that have become contaminated by direct contact with the pollutants or pollutants absorbed into sediment.

Soil erosion by rain drops, sheet erosion, or downstream channel erosion can cause turbid (muddy) stormwater when the sediment contacts rainwater; this is the most common and visible form of construction stormwater pollution. The resulting high turbidity (Figure 2) can adversely impact receiving waters if not properly controlled using the BMPs contained in this manual.

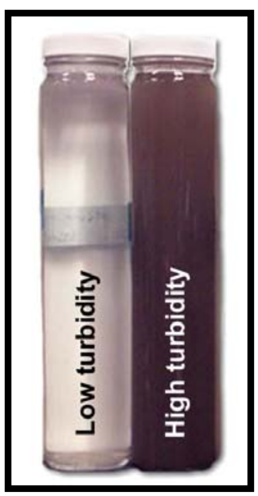


Figure 2. Turbidity is a Measure of Water Clarity.

The sources of other commonly encountered pollutants include materials and chemicals used during day-to-day construction activities, such as concrete pouring, paving, truck and heavy equipment operation, and maintenance activities. Low and high acidity and petroleum products can adversely impact the public drainage system and/or receiving waters in more than one way. One direct impact is reducing water quality by introducing pollutants; another impact is decreasing the function of the public drainage system by fouling and spreading pollutants in the pipe network.

Ecology's Water Quality Standards for Surface Waters of the State of Washington are provided in WAC Chapter 173-201A. Contractors and other responsible parties must be familiar with the current water quality standards, particularly those targeting typical construction-related pollutants. For more information on surface water quality standards and specific criteria, contact Ecology at (425) 649-7000 or visit Ecology's website (http://www.ecy.wa.gov/programs/wq/swqs/new-rule.html).

1.3.2 Ground Water Quality

The Ecology ground water quality standards are created for protection of ground water from contamination. The primary water quality consideration for stormwater discharges to ground water from construction sites is the control of contaminants other than sedimentation.

For more information on ground water quality standards, contact Ecology at (425) 649-7000 or visit Ecology's website (http://www.ecy.wa.gov/programs/wq/grndwtr/index.html).

1.3.3 Downstream Resources

Impacts to downstream resources can result if construction sites have uncontrolled discharges of stormwater. The public drainage system, real property, and natural habitat can be adversely impacted when an uncontrolled discharge leaves a construction site. Common negative impacts can include soil erosion, flooding, habitat degradation, and/or subsequent destructive after-effects due to increases in the stormwater volume, velocity, and peak flow rate.

The Stormwater Code and this manual may require construction of temporary stormwater retention, detention, or infiltration facilities to protect downstream resources. It is important to note that these facilities must be functioning prior to implementation of other land disturbing activity. If a permanent facility is used to control flows during construction, see Volume 3 for design guidelines and criteria. Volume 3 also provides design criteria to protect permanent infiltration facilities from siltation during the construction phase of the project.

1.4 What is Considered "Out of Compliance"?

The Stormwater Code outlines compliance requirements for construction stormwater pollution prevention. If the required BMPs being implemented are not effectively addressing erosion issues or the discharge of pollutants, additional BMPs may be required.

Violations of the Stormwater Code are enforceable under the City of Seattle's Stormwater Code (SMC Chapters 22.800 – 22.808). The Volume 4 Stormwater Code Enforcement Manual is a separate Directors' Rule available to help interpret the stormwater enforcement provisions of SMC Chapters 22.800 – 22.808.

Circumstances when a project would be considered out of compliance with the Stormwater Code include, for example:

- A discharge leaves the project site that causes or contributes a prohibited discharge or a known or likely violation of water quality standards in the receiving water, or a known or likely violation of the City's Phase I NPDES Municipal Stormwater Permit (SMC 22.805.010).
- A project that has not received all required permits from DPD, and discharges to the public drainage system.
- A discharge of oil or other hazardous substances leaves the project site and enters the public drainage system or directly into a receiving water.
- Sediment is tracked off the project site.
- The site does not have a Construction Stormwater Control Plan.

This is not a comprehensive list of out of compliance events. If there is a question about compliance, visit the DPD Applicant Services Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or the website (http://www.seattle.gov/dpd/).

1.5 Purpose of Construction Stormwater Best Management Practices (BMPs)

Construction stormwater BMPs are measures implemented to protect the public drainage system, sewer system, and receiving waters from pollution and impacts to downstream resources during land-disturbing and other construction activities (see also SMC 22.801.030). For example:

- Construction activities such as clearing, grading, excavation, and stockpiling disturb established vegetation and stable soils
- Concrete, asphalt, treated timber, and other construction materials involve chemicals and contaminants that must be retained on the project site
- Construction activities introduce the risk of increased volume of stormwater leaving the site, with sediment, eroding and polluting downstream waters
- Construction equipment introduces the potential for spills involving oil, gasoline, or other petroleum products.

The general criteria for construction BMPs include preventing pollution from leaving the project site, preventing ponding and/or flooding in the public right-of-way, and minimizing impact to the public drainage system. These measures fall into two general categories – erosion and sedimentation control, and control of pollutants other than sediment.

Erosion and sediment control BMPs can be grouped according to three methods of controlling erosion and sediment:

- Cover practices – temporary or permanent cover designed to stabilize disturbed areas.
- Erosion control practices – physical measures designed and constructed to prevent erosion of project site soils (Figure 3).
- Sediment control practices – prevent eroded soils from leaving the project site by trapping them in a depression, filter, or other barrier.

Pollutants other than sediment are primarily controlled using good "housekeeping" practices and other methods outlined in this manual to reduce the risk of pollutant contact with stormwater, or direct discharge to receiving waters.

Figure 3. Properly Installed Filter Fence Adjacent to a Roadway.

Refer to the City of Seattle Directors' Rules manual entitled "Source Control Technical Requirements Manual." This manual should be reviewed to ensure that all Directors' Rules requirements are being met for each construction project.

1.6 Getting Started

The first step is reviewing this manual and the Stormwater Code to determine the project requirements. **Chapter 1** of this manual serves as an introduction to stormwater controls at construction sites, the regulatory requirements that mandate implementing this manual, and an introduction to construction site stormwater BMPs.

Continue with **Chapter 2** to determine the category of your project, the required submittal process, and the documentation that must be produced for your project. **Chapter 3** provides an explanation for BMP selection based on project category and a checklist that must be reviewed to select the required and appropriate BMPs for your project. **Chapters 4 and 5** provide the standards and specifications for the BMPs contained in this manual.

The second step is to review two City of Seattle Directors' Rules for other stormwater controls that may be applicable to the project:

- Volume 1, the Source Control Technical Requirements Manual
- Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.

Questions can be answered by visiting the DPD Applicant Services Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or our website (http://www.seattle.gov/dpd/).

Chapter 2 - The Submittal Process

Most construction projects in Seattle require a permit from DPD. Timely submittal of appropriate permit application materials is critical to obtaining any permits needed prior to the start of construction.

This chapter, along with the Stormwater Code, is used to determine:

1. Drainage review requirements
2. Project category
3. Documentation requirements.

Once the submittal process is completed, the Stormwater Code and the Chapter 3 checklist are used to select the appropriate minimum BMPs for a project site based on category requirements.

Specific project site requirements should be determined using the Stormwater Code, this manual, and by visiting the DPD Applicant Services Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or the DPD website (http://www.seattle.gov/dpd/).

2.1 Drainage Review Requirements

Project drainage review and approval is required for most construction projects that occur in the City of Seattle. Although this section presents resources for obtaining drainage review and approval, DPD reserves the right to require review and approval for additional activities on a case-by-case basis.

To determine if a project requires drainage review, see SMC 22.807.020. In addition, DPD has project screening and submittal checklists available for use at the DPD Applicant Services Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or the DPD website (http://www.seattle.gov/dpd/site_development/).

Other resources, including information for the pre-application site visit (PASV) and site inspection, if applicable, are also available at the DPD Applicant Services Center.

2.2 Project Category

The next step after determining drainage review requirements is determining whether the project falls into the Small or Large Project category under the Stormwater Code, which ultimately directs the construction stormwater control documentation requirements. All projects must submit a Construction Stormwater Control Plan (Section 2.3); however, the project category determines what level of detail is required for the plan documentation.

Project categories are based on the amount of new and/or replaced impervious surface and the amount of total land disturbance. The following thresholds determine which plan is applicable to a specific project. If a project involves:

- 5,000 square feet or more of new plus replaced impervious area

OR

- 1 acre or more of land disturbing activity

it falls under the **Large Project** category. Otherwise, the project falls under the **Small Project** category.

Projects that exceed 1 or more acres of land disturbing activity will also be responsible for obtaining coverage under Ecology's Construction Stormwater General Permit. Although the City's Large Project Construction Stormwater Control Plan requirements will meet some of Ecology's requirements, the two are substantially different and should not be considered equivalent.

For more information on Ecology's permit submittal process, contact Ecology at (425) 649-7000 or visit Ecology's website (http://www.ecy.wa.gov/programs/wq/stormwater/construction/).

2.3 Construction Stormwater Control Plan

The Construction Stormwater Control Plan applies BMPs that fall within the 18 elements of water quality and downstream resource protection and are required by the Stormwater Code (SMC 22.805.020.D). These elements cover an aspect of the general water quality protection strategies of limiting project site impacts, protecting the public drainage system and receiving waters, preventing erosion and sedimentation, and managing activities and sources.

The 18 elements are:

1. Mark Clearing Limits and Sensitive Areas
2. Retain Top Layer
3. Establish Construction Access
4. Protect Downstream Properties and Receiving Waters
5. Prevent Erosion and Sediment Transport from the Site
6. Prevent Erosion and Sediment Transport from the Site by Vehicles
7. Stabilize Soils
8. Protect Slopes
9. Protect Storm Drains
10. Stabilize Channels and Outlets

11. Control Pollutants
12. Control Dewatering
13. Maintain BMPs
14. Inspect BMPs
15. Execute Construction Stormwater Control Plan
16. Minimize Open Trenches
17. Phase the Project
18. Install Permanent Flow Control and Water Quality Facilities.

Project designers must review the applicable elements of SMC 22.805.020.D and ensure the specific requirements under each of the 18 elements in the code are fully addressed by the project's construction site stormwater pollution prevention controls.

2.3.1 Small Projects

For Small Projects (i.e., 5,000 square feet or less of new plus replaced impervious surface, and 1 acre or less of land disturbing activity), the applicant must submit a Small Project Construction Stormwater Control Plan that demonstrates how the project will cover the 18 elements listed above by using BMPs contained in this manual.

The first step after reviewing the Stormwater Code requirements is to refer to Chapter 3 for the Small Construction Stormwater Control Plan BMP selection checklist. Small Projects are required to implement BMPs from all 18 elements except 1, 3, 8, and 10. If a required element is not applicable, the reason must be justified briefly on the checklist and in detail in the plan narrative, described below. The BMPs listed in elements 1, 3, 8, and 10 are recommended only and intended to provide further guidance for minimizing potential stormwater pollution resulting from activities. Using these additional BMPs is encouraged.

The next step is to prepare the Small Project Construction Stormwater Control Plan narrative section that describes the project and selected BMPs.

The plan narrative must include descriptions of:

- The name, address, and phone number of the owner or contact person.
- A north arrow, lot number and plat, address, date, and street name fronting structure.
- All existing and proposed structures on the project site.
- The location and size all stream, swales, and drainage channels on or within 25 feet of the project site that may involve or affect the drainage of the project site to be developed.

- Indicate all existing stormwater pipes and their diameters and approximate lengths.
- The direction and location of surface water runoff entering and exiting the project site from all adjacent properties. This may be done with topographic contour lines.
- Include the label 'point of discharge' to all discharges of stormwater, wastewater, etc. that leave the site.
- The types of systems that will be used to convey runoff away from the proposed structures, if applicable.
- The types of wastewater that may be generated during the work and the types of collection or conveyance systems used to manage the waste, including disposal options.
- Clearly identify the location(s) where stormwater discharges or is collected from the project site, including individual (point) flow, sheet flow (i.e., overland flow).
- How construction will be phased so that only those areas actively being worked are uncovered.
- The construction entrance(s) and egress, as applicable.
- Stockpile and excavation locations.

Once the narrative has been completed, the plan sheet (i.e., engineering drawing) should be completed. The plan sheet is not required to be prepared by a civil engineer; however, it is required to graphically show the information provided in the narrative, including how BMPs will be implemented.

To assist in meeting the plan sheet requirement, DPD offers a prescriptive plan sheet, which contains illustrations of some of the most effective BMPs required for Small Projects. It is called "The Temporary Erosion and Sediment Control Standard Plan" (TESC Plan) and provides a quick way for the applicant to document erosion control methods, integrate stormwater controls with building plans, and provides a clear field guide for both the applicant and the City. Refer to Chapters 4 and 5 for details on how to implement the BMPs during construction.

The Temporary Erosion and Sediment Control Standard Plan can be obtained from the DPD Public Resources Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124, or the website which has both pdf and CAD formats (http://www.seattle.gov/DCLU/news/20021112a.asp).

Once the Small Project Construction Stormwater Control Plan (narrative and TESC Plan sheet) has been completed, approved by DPD, and the necessary permits obtained, a Site Inspection by the City is required before ground disturbance begins (see Section 2.1). Finally, the applicant is responsible for modifying the Small Project Construction Stormwater Control Plan whenever there is a change in design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on code compliance or the discharge of pollutants.

2.3.2 Large Projects

For Large Projects (i.e., over 5,000 square feet of new plus replaced impervious surface, or more than 1 acre of land disturbing activity), the applicant must submit a Large Project Construction Stormwater Control Plan, including narrative and plan sheet(s), that demonstrate how the project will cover the 18 elements by using BMPs contained in this manual.

The first step is to refer to Chapter 3 for the Large Construction Stormwater Control Plan BMP selection checklist. Large Projects are required to implement BMPs from all 18 elements. If a required element is not applicable, the reason must be justified briefly on the checklist and in detail in the plan narrative, described in Section 2.3.1. The recommended BMPs are intended to provide further guidance for minimizing potential stormwater pollution resulting from activities. Using these additional BMPs is encouraged.

The next step is to prepare the Large Project Construction Stormwater Control Plan narrative section and plan sheets that describe the project and selected BMPs. The Large Project Construction Stormwater Control Plan includes the same narrative and plan details required for the Small Project Construction Stormwater Control Plans (Section 2.3.1) plus additional narrative and plan sheet(s), as applicable.

The Large Project Construction Stormwater Control Plan must be prepared by a qualified professional. When the plan includes engineering calculations, it must be stamped and signed by an engineer licensed in the State of Washington.

Once the Large Project Construction Stormwater Control Plan (narrative and plan sheets) has been completed, approved by DPD, and the necessary permits obtained, a Site Inspection by the City is required before ground disturbance begins (see Section 2.1). Finally, the applicant is responsible for modifying the Large Project Construction Stormwater Control Plan whenever there is a change in design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on code compliance or the discharge of pollutants.

Chapter 3 - Selection Process for Construction Stormwater Controls

This chapter introduces checklists for the Small Project Construction Stormwater Control Plan (Table 1a) and the Large Project Construction Stormwater Control Plan (Table 1b).

Small and Large Projects must implement BMPs covered by the 18 elements listed in Section 2.3, which cover the general water quality and downstream resource protection strategies of limiting project site impacts, protecting the public drainage system and receiving waters, preventing erosion and sedimentation, and managing activities and sources. Refer to Section 2.3 for a discussion of Small and Large Project Construction Stormwater Control Plans, including the level of detail required for submittals.

Tables 1a and 1b present each of the 18 elements and required or recommended BMPs for Small and Large Project plans, respectively. Required BMPs must be implemented during construction. If a required element is not applicable, the reason must be justified briefly on the checklist and in detail in the plan narrative (Section 2.3). The recommended BMPs are intended to provide further guidance for minimizing potential stormwater pollution resulting from activities. Using these additional BMPs is encouraged.

During the pre-application site visit, refer to Table 1a or 1b with the City to identify the appropriate required and recommended BMPs for your project. The Small Project Construction Stormwater Control Plan and the Large Project Construction Stormwater Control plan should document each selected BMP and its implementation, maintenance requirements, and inspection. Note: the City may require additional measures beyond what are shown on the approved plan depending on Stormwater Code requirements, and on construction sequencing and actual site conditions.

Table 1a. Checklist to Select Small Project Construction BMPs.

Element	Element	Project Name: ___	
		Small Project [a] (check selection)	**If not applicable, describe why in the space below.**
1	Mark Clearing Limits and Sensitive Areas	Recommended [b] BMPs: ☐ E1.30 Preserving Natural Vegetation ☐ E1.35 Buffer Zones	
2	Retain Top Layer	Required BMP: Within the boundaries of the project site, the duff layer, top soil, and native vegetation, if there is any, shall be retained in an undisturbed state to the maximum extent feasible. If it is not feasible to retain the top layer in place, it should be stockpiled on-site, covered to prevent erosion, and replaced immediately upon completion of the ground disturbing activities to the maximum extent feasible.	
3	Establish Construction Access	Required BMP: ☐ E2.10 Stabilization Construction Entrance Recommended BMPs: ☐ E2.15 Tire Wash ☐ E2.20 Construction Road Stabilization	
4	Protect Downstream Properties and Receiving Waters	Recommended BMP: ☐ E3.45 Temporary Sediment Pond (or Basin)	
5	Prevent Erosion and Sediment Transport from the Site	Required BMPs – one or more of the following: ☐ E2.95 Turbidity Curtain ☐ E3.10 Filter Fence ☐ E3.15 Brush Barrier ☐ E3.20 Gravel Filter Berm ☐ E3.30 Vegetated Strip ☐ E3.35 Straw Wattles, Compost Socks, and Compost Berms ☐ E3.40 Sediment Trap ☐ E3.45 Temporary Sediment Pond (or Basin) ☐ E3.50 Portable Sediment Tank ☐ E3.55 Construction Stormwater Chemical Treatment ☐ E3.60 Construction Stormwater Filtration	

Table 1a (continued). Checklist to Select Small Project Construction BMPs.

Element	Element	Project Name: ______ Small Project [a] (check selection)	If not applicable, describe why in the space below.
6	Prevent Erosion and Sediment Transport From the Site by Vehicles	Required BMPs – one or more of the following: ☐ E3.65 Cleaning Inlets and Catch Basins ☐ E3.70 Street Sweeping and Vacuuming	
7	Stabilize Soils	Required BMPs for all exposed soils and stockpiles – one or more of the following: ☐ E1.10 Temporary Seeding ☐ E1.15 Mulching, Matting, and Compost Blankets ☐ E1.20 Clear Plastic Covering ☐ E1.25 Polyacrylamide for Soil Erosion Protection ☐ E1.40 Permanent Seeding and Planting ☐ E1.45 Sodding ☐ E1.50 Topsoiling ☐ E2.45 Dust Control ☐ E2.50 Gradient Terracing ☐ E2.75 Surface Roughening	
8	Protect Slopes (refer to the Environmentally Critical Areas ordinance [SMC 25.09.180] for additional requirements and development standards for steep slopes)	Required BMPs – one or more of the following: ☐ E2.30 Level Spreader ☐ E2.35 Check Dams ☐ E2.40 Triangular Silt Dike (Geotextile-Encased Check Dam) ☐ E2.50 Gradient Terraces ☐ E2.55 Bioengineered Protection of Very Steep Slopes ☐ E2.65 Pipe Slope Drains ☐ E2.70 Subsurface Drains ☐ E2.75 Surface Roughening ☐ E2.80 Earth Dike and Drainage Swale ☐ E2.90 Grass-Lined Channels	
9	Protect Storm Drains	Required BMPs: ☐ E3.25 Storm Drain Inlet Protection ☐ E3.65 Cleaning Inlets and Catch Basins ☐ E3.25 Street Sweeping and Vacuuming	

Table 1a (continued). Checklist to Select Small Project Construction BMPs.

Element	Element	Project Name: ______ Small Project [a] (check selection)	If not applicable, describe why in the space below.
10	Stabilize Channels and Outlets	Recommended BMPs: ☐ E2.25 Water Bars ☐ E2.30 Level Spreader ☐ E2.35 Check Dams ☐ E2.60 Channel Lining ☐ E2.80 Earth Dike and Swale ☐ E2.85 Outlet Protection ☐ E2.90 Grass-Lined Channels	
11	Control Pollutants (also refer to Volume 1, the Source Control Technical Requirements Manual)	Required BMPs: ☐ C1.15 Material Delivery, Storage and Containment ☐ C1.20 Use of Chemicals During Construction ☐ C1.25 Demolition of Buildings ☐ C1.30 Building Repair, Remodeling, and Construction ☐ C1.35 Sawcutting and Surfacing Pollution Prevention ☐ C1.45 Solid Waste Handling and Disposal ☐ C1.50 Disposal of Asbestos and Polychlorinatedbiphenols (PCBs) ☐ C1.55 Airborne Debris Curtain	
12	Control Dewatering	Recommended BMP: ☐ C1.40 Temporary Dewatering	
13	Maintain BMPs	Required BMP: ☐ All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function.	
14	Inspect BMPs	Required BMP: ☐ All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function.	

Table 1a (continued). Checklist to Select Small Project Construction BMPs.

Element	Element	Project Name: ____ Small Project [a] (check selection)	If not applicable, describe why in the space below.
15	Execute Construction Stormwater Control Plan	Required BMPs: Implement and Maintain an Updated Construction Stormwater Control Plan ☐ The Small Project Construction Stormwater Control Plan shall be retained on-site or within reasonable access to the site, and shall be modified as needed. Coordination with Utilities and Other Contractors ☐ The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Small Project Construction Stormwater Control Plan. Project Close-out ☐ All temporary erosion and sediment control BMPs must be removed within 5 business days after final site stabilization is achieved, or after they are no longer needed, whichever is later.	
16	Minimize Open Trenches	Required BMP: In the construction of underground utility lines, where feasible, no more than one hundred fifty (150) feet of trench shall be opened at one time, unless soil is replaced within the same working day, and where consistent with safety and space considerations, excavated material shall be placed on the uphill side of trenches. Trench dewatering devices shall discharge into a sediment trap or sediment pond.	
17	Phase the Project	Required BMPs: Construction Phasing ☐ Phase development projects where feasible in order to prevent soil erosion and, to the maximum extent practicable, the transport of sediment from the site during construction. Seasonal Work Limitations ☐ From October 1 through April 30, clearing, grading, and other soil disturbing activities will be subject to additional limitations.	
18	Install permanent flow control and water quality facilities	See Volume 3 for applicable minimum requirements and BMPs.	

[a] A small project is defined as one with less than 5,000 square feet of new plus replaced impervious surface, and less than 1 acre of land-disturbing activity.

[b] Recommended BMPs provide further guidance for minimizing potential stormwater pollution resulting from activities.

Table 1b. Checklist to Select Large Project Construction BMPs.

Element	Element	Project Name: ______	
		Large Project [a] (check selection)	**If not applicable, describe why in the space below.**
1	Mark Clearing Limits and Sensitive Areas	Required BMPs: ☐ E1.30 Preserving Natural Vegetation ☐ E1.35 Buffer Zones	
2	Retain Top Layer	Required BMP: Within the boundaries of the project site, the duff layer, top soil, and native vegetation, if there is any, shall be retained in an undisturbed state to the maximum extent feasible. If it is not feasible to retain the top layer in place, it should be stockpiled on-site, covered to prevent erosion, and replaced immediately upon completion of the ground disturbing activities to the maximum extent feasible.	
3	Establish Construction Access	Required BMPs: ☐ E2.10 Stabilization Construction Entrance ☐ E2.15 Tire Wash ☐ E2.20 Construction Road Stabilization	
4	Protect Downstream Properties and Receiving Waters	Required BMP: ☐ E3.45 Temporary Sediment Pond (or Basin)	
5	Prevent Erosion and Sediment Transport from the Site	Required BMPs: ☐ E3.10 Filter Fence ☐ E3.15 Brush Barrier ☐ E3.20 Gravel Filter Berm AND ☐ E3.40 Sediment Trap OR ☐ E3.45 Temporary Sediment Pond (or Basin) OR ☐ E3.50 Portable Sediment Tank Additional recommended BMPs: ☐ E2.95 Turbidity Curtain ☐ E3.30 Vegetated Strip ☐ E3.35 Straw Wattles, Compost Socks, and Compost Berms ☐ E3.55 Construction Stormwater Chemical Treatment ☐ E3.60 Construction Stormwater Filtration	

Table 1b (continued). Checklist to Select Large Project Construction BMPs.

Element	Element	Project Name: ______ Large Project [a] (check selection)	If not applicable, describe why in the space below.
6	Prevent Erosion and Sediment Transport From the Site by Vehicles	Required BMPs: ☐ E3.65 Cleaning Inlets and Catch Basins ☐ E3.70 Street Sweeping and Vacuuming	
7	Stabilize Soils	Required BMPs for all exposed soils and stockpiles – one or more of the following: ☐ E1.10 Temporary Seeding ☐ E1.15 Mulching, Matting, and Compost Blankets ☐ E1.20 Clear Plastic Covering ☐ E1.25 Polyacrylamide for Soil Erosion Protection ☐ E1.40 Permanent Seeding and Planting ☐ E1.45 Sodding ☐ E1.50 Topsoiling ☐ E2.45 Dust Control ☐ E2.50 Gradient Terracing ☐ E2.75 Surface Roughening	
8	Protect Slopes (refer to the Environmentally Critical Areas ordinance [SMC 25.09.180] for additional requirements and development standards for steep slopes)	Required BMPs – one or more of the following: ☐ E2.30 Level Spreader ☐ E2.35 Check Dams ☐ E2.40 Triangular Silt Dike (Geotextile-Encased Check Dam) ☐ E2.50 Gradient Terraces ☐ E2.55 Bioengineered Protection of Very Steep Slopes ☐ E2.65 Pipe Slope Drains ☐ E2.70 Subsurface Drains ☐ E2.75 Surface Roughening ☐ E2.80 Earth Dike and Drainage Swale ☐ E2.90 Grass-Lined Channels	
9	Protect Storm Drains	Required BMPs: ☐ E3.25 Storm Drain Inlet Protection ☐ E3.65 Cleaning Inlets and Catch Basins ☐ E3.25 Street Sweeping and Vacuuming	

Table 1b (continued). Checklist to Select Large Project Construction BMPs.

Element	Element	Project Name: ______ Large Project [a] (check selection)	If not applicable, describe why in the space below.
10	Stabilize Channels and Outlets	Required BMPs – one or more of the following: ☐ E2.25 Water Bars ☐ E2.30 Level Spreader ☐ E2.35 Check Dams ☐ E2.60 Channel Lining ☐ E2.80 Earth Dike and Swale ☐ E2.85 Outlet Protection ☐ E2.90 Grass-Lined Channels	
11	Control Pollutants (also refer to Volume 1, the Source Control Technical Requirements Manual)	Required BMPs: ☐ C1.15 Material Delivery, Storage and Containment ☐ C1.20 Use of Chemicals During Construction ☐ C1.25 Demolition of Buildings ☐ C1.30 Building Repair, Remodeling, and Construction ☐ C1.35 Sawcutting and Surfacing Pollution Prevention ☐ C1.45 Solid Waste Handling and Disposal ☐ C1.50 Disposal of Asbestos and Polychlorinatedbiphenols (PCBs) ☐ C1.55 Airborne Debris Curtain	
12	Control Dewatering	Required BMP: ☐ C1.40 Temporary Dewatering	
13	Maintain BMPs	Required BMP: ☐ All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function.	
14	Inspect BMPs	Required BMP: ☐ All BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. For projects over one (1) acre, inspections shall be conducted by the Certified Erosion and Sediment Control Lead identified in the Large Project Construction Stormwater Control Plan.	

Table 1b (continued). Checklist to Select Large Project Construction BMPs.

Element	Element	Project Name: ______ Large Project [a] (check selection)	If not applicable, describe why in the space below.
15	Execute Construction Stormwater Control Plan	Required BMPs: Implement and Maintain an Updated Construction Stormwater Control Plan ☐ The Large Project Construction Stormwater Control Plan shall be retained on-site or within reasonable access to the site, and shall be modified as needed. Coordination with Utilities and Other Contractors ☐ The primary project proponent shall evaluate, with input from utilities and other contractors, the stormwater management requirements for the entire project, including the utilities, when preparing the Small Project Construction Stormwater Control Plan. Project Close-out ☐ All temporary erosion and sediment control BMPs must be removed within 5 business days after final site stabilization is achieved, or after they are no longer needed, whichever is later.	
16	Minimize Open Trenches	Required BMP: In the construction of underground utility lines, where feasible, no more than one hundred and fifty (150) feet of trench shall be opened at one time, unless soil is replaced within the same working day, and where consistent with safety and space considerations, excavated material shall be placed on the uphill side of trenches. Trench dewatering devices shall discharge into a sediment trap or sediment pond.	
17	Phase the Project	Required BMPs: Construction Phasing ☐ Phase development projects where feasible in order to prevent soil erosion and, to the maximum extent practicable, the transport of sediment from the site during construction. Seasonal Work Limitations ☐ From October 1 through April 30, clearing, grading, and other soil disturbing activities will be subject to additional limitations.	
18	Install Permanent Flow Control and Water Quality Facilities	See Volume 3 for applicable minimum requirements and BMPs.	

[a] A large project is one with greater than or equal to 5,000 square feet of new plus replaced impervious surface, or greater than or equal to 1 acre of land-disturbing activity.

[b] Recommended BMPs provide further guidance for minimizing potential stormwater pollution resulting from activities.

Chapter 4 - Standards and Specifications for Construction Erosion and Sedimentation Control

This chapter contains the standards and specifications for erosion and sediment control practices that form the backbone of erosion and sediment control planning in the City of Seattle. These BMPs are grouped according to their method of controlling erosion and sedimentation at construction sites:

- Cover Practices (Section 4.1)
- Erosion Control Practices (Section 4.2)
- Sediment Retention Practices (Section 4.3).

Refer to the sections for a list of BMPs in each category.

All temporary erosion and sediment control BMPs **must be removed within 5 business days** after final site stabilization is achieved, or after they are no longer needed, whichever is later. In either case, trapped sediment must be removed or stabilized on site and the disturbed areas permanently stabilized.

The standards and specifications for each BMP have been divided into six sections to facilitate the selection process and implementation:

1. Definition
2. Purpose
3. Conditions Where Practice Applies
4. Planning Considerations
5. Design Criteria
6. Maintenance.

Note that “Conditions Where Practice Applies” always refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance with the Stormwater Code.

4.1 Cover Practices

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

The cover BMPs for erosion and sedimentation control can be divided into two categories:

1. Temporary cover practices, such as temporary seeding and clear plastic covering (beginning at Section 4.1.1)
2. Permanent cover practices, such as sodding and planting (beginning at Section 4.1.6).

The requirements for maintaining permanent BMPs are included with each description; however, all temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

4.1.1 Temporary Cover Practices

Temporary cover BMPs are implemented to provide a cover to soils exposed during the life of the project. Soil stockpiles must be stabilized from erosion; protected with sediment trapping measures; and where possible located away from storm drain inlets, waterways, and drainage channels. From October 1 to April 30, no soils shall remain exposed and unworked for more than 2 days. From May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.

Clear plastic covering should be applied in most cases. However, additional protection by temporary seeding, mulching, and/or matting may be needed due to steeper slopes.

The standards and specifications for temporary cover BMPs are described in the sections below and include:

- BMP E1.10: Temporary Seeding (Section 4.1.2)
- BMP E1.15: Mulching, Matting, and Compost Blankets (Section 4.1.3)
- BMP E1.20: Clear Plastic Covering (Section 4.1.4)
- BMP E1.25: Polyacrylamide for Soil Erosion Protection (Section 4.1.5).

4.1.2 BMP E1.10: Temporary Seeding

4.1.2.1 Definition

The establishment of temporary vegetative cover on disturbed areas by seeding with appropriate rapidly growing annual plants.

4.1.2.2 Purpose

To provide temporary soil stabilization by planting grasses and legumes to areas that would remain bare for more than 7 days where permanent cover is not necessary or appropriate (Figure 4).

Figure 4. Hydroseeding Method.

4.1.2.3 Conditions Where Practice Applies

- Permanent structures are to be installed or extensive re-grading of the area will occur prior to the establishment of permanent vegetation
- Areas which will not be subjected to heavy wear by construction traffic
- Areas sloping up to 15 percent for 100 feet or less (where temporary seeding is the only BMP used).

4.1.2.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Sheet erosion, caused by the impact of rain on bare soil, is the source of most fine particles in sediment. To reduce this sediment load in runoff, the soil surface itself should be protected. The most efficient and economical means of controlling sheet and rill erosion is to establish vegetative cover. Annual plants that sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover. Temporary seeding is effective when combined with construction phasing so that bare areas of the site are minimized at all times.

Temporary seeding may prevent costly maintenance operations on other erosion control systems. For example, sediment basin clean-outs will be reduced if the drainage area of a basin is seeded where grading and construction are not taking place. Perimeter dikes will be more effective if not choked with sediment.

Temporary seeding is essential to preserve the integrity of earthen structures used to control sediment, such as dikes, diversions, and the banks and dams of sediment basins.

Proper seedbed preparation and the use of quality seed are important in this practice just as in permanent seeding. Failure to carefully follow sound agronomic recommendations will often result in an inadequate stand of vegetation that provides little or no erosion control.

4.1.2.5 Design Criteria

- **Time of Seeding** – Seeding should preferably be done between April 1 and June 30, and September 1 through October 31. If seeding is done in the months of July and August, irrigation will be required until 75 percent grass cover is established. If seeding is done between October 1 and March 31, mulching shall be required immediately after seeding. If seeding is done during the summer months, irrigation of some sort will probably be necessary.
- **Site Preparation** – Before seeding, install needed surface runoff control measures such as gradient terraces, earth dike/drainage swales, level spreaders, and sediment basins.
- **Seedbed Preparation** – The seedbed should be firm with a fairly fine surface. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Perform all cultural operations across or at right angles to the slope. See BMP E1.50, Topsoiling, and BMP E2.75, Surface Roughening for more information on seedbed preparation. A minimum of 2 to 4 inches of tilled topsoil is required.
- **Fertilization** – as per suppliers and/or Soil Conservation Service recommendations or apply a 10-4-6 ratio of nitrogen-phosphorus-potassium (N-P-K) fertilizer at a rate of 90 pounds per acre.

Developments adjacent to receiving waters must use non-phosphorus fertilizer.

- **Seeding –** seeding mixtures will vary depending on the exact location, soil type, slope, etc. Information on mixes may be obtained from local suppliers, the Washington State Department of Transportation, or the Soil Conservation Service. The seed mix in Table 2 is supplied as guidance. Hydroseed applications should include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier.

Table 2. Seeding Mixture. [a]

Name	Proportion by Weight
Turf-type perennial rye (blend of 3 approved varieties) [b]	50 percent
Creeping Red Fescue [b]	20 percent
Chewings Fescue [b]	20 percent
Hard Fescue	10 percent

[a] Hydro-seeding applications with approved seed-mulch-fertilizer mixtures may also be used. Mixture must be no less than 98 percent pure and have a minimum germination rate of 90 percent.

[b] See City of Seattle Standard Specification 9-14.2(1) for approved varieties.

- **Mulching –** mulch is required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding. Refer to BMP 1.15 Mulching, Matting, and Compost Blankets for more information on mulching.
- **Tackifier** – apply a tackifier and a tracer to indicate where the seeding has been applied.

4.1.2.6 Maintenance

- Seeding should be supplied with adequate moisture. Supply water as needed, especially in abnormally hot or dry weather or on adverse sites. Water application rates should be controlled to prevent runoff.
- Re-seeding – Areas which fail to establish at least 80 percent cover vegetative cover shall be re-seeded as soon as such areas are identified. If reseeding is ineffective, an alternate method, such as sodding, mulching, or nets/mats, shall be used.

4.1.3 BMP E1.15: Mulching, Matting, and Compost Blankets

4.1.3.1 Definition

Application of plant residues or other suitable materials to the soil surface.

4.1.3.2 Purpose

To provide immediate protection to exposed soils during the period of short construction delays, or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas.

Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seed, and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface.

4.1.3.3 Conditions Where Practice Applies

- Areas that cannot be seeded because of the season, or are otherwise unfavorable for plant growth.
- Areas that have been seeded as specified in Temporary Seeding (BMP E1.10).
- In an area of greater than 25 percent slope, mulching should immediately follow seeding.

4.1.3.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Mulches are applied to the soil surface to conserve a desirable soil property or to promote plant growth. Surface mulch is one of the most effective means of controlling runoff and erosion on disturbed land (see Table 3 for a comparison of pollutant loading reductions for various mulches).

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent crusting and sealing of the soil surface, modify soil temperatures, and provide a suitable microclimate for seed germination.

Organic mulch materials, such as compost, straw, wood chips, bark, and wood fiber, have been found to be the most effective. Compost has the advantage of being reusable by tilling it in to meet the City's soil amendment requirement at the end of the project. A variety of nets and mats have been developed for erosion control in recent years, and these are also used as mulches, particularly in critical areas such as waterways. They may be used to hold other mulches to the soil surface.

Table 3. Guide to Mulch Materials, Rates and Uses.

Mulch Material	Quality Standards	Application Depth	Remarks [a]
Gravel, slag or crushed stone	Washed, 0.75 to 1.5 inch size	3 inches	Excellent mulch for short slopes and around woody plants and ornamentals. Use where subject to foot traffic. Approximately 2,000 lbs/yd^3.
Straw	Air dried Free from unwanted seeds and coarse material	Minimum 2 inches	Use for immediate protection, hand application generally requires greater thickness than blown straw. Thickness of straw may be reduced by half when used in conjunction with seeding. Most common and widely used mulching material. Can be used in critical erosion areas.
Wood fiber Cellulose (partially digested wood fibers)	Dyed green. Should not contain growth-inhibiting factors		If used on critical areas, double normal application rate. Apply with a hydromulcher with seed and tackifier. No tie-down required. Fibers should be less than 3/4 inch; packaged in 100-lb. bags.
Compost blanket, mulch, and compost	No visible water or dust during handling.	Minimum 2 inches	Excellent mulch for protecting final grades until landscaping. Can be directly seeded or tilled into soil as an amendment. A 3-inch layer provides superior protection.
Chipped site vegetation	Average size shall be several inches. Gradations from fines to 6 inches.	Minimum 2 inches thick	Cost-effective way to dispose clear and grubbing debris. Should not be used on slopes above 10 percent. Not recommended within 200 feet of surface waters.
Wood-based mulch	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit (unless exempt).	Minimum 2 inches thick	Often called hog or hogged fuel and is useful organic matter. Typically does not provide any weed seed control. Prevent introduction of weed plants or seeds with application.

[a] All mulches will provide some degree of (1) erosion control, (2) moisture conservation, (3) weed control, and (4) reduction of soil crusting.

ft^2 feet squared.

lbs/yd^3 pounds per cubic yard.

The choice of materials for mulching will be based on the type of soil to be protected, site conditions, season, and economics. It is especially important to mulch liberally in mid-summer and prior to winter, and on cut slopes and southern slope exposures.

Compost Blankets

Compost for use as a mulch layer (i.e., a compost blanket) should meet the definition of "composted materials," including contaminant limits, in WAC 173-350-220. Coarsely screened compost (1-inch-minus screen) provides superior protection in higher rainfall and on steeper slopes, and is may be tilled in later for tree and shrub planting areas. A finer compost (1/2- or 5/8-minus screen) may be preferred where it will be tilled in later before planting lawn areas. A 2-inch thick compost blanket is usually sufficient, but 3 inches provides superior protection.

Compost blankets are a preferred cover practice because they provide superior ground contact compared to rolled mats, are more effective at filtering both sediment and pollutants such as oil, may be seeded when placed and promote superior seed germination, and the compost can be reused at the end of the project by tilling it in to meet the City's Post Construction Soil Quality and Depth requirement.

Chemical Mulches and Soil Binders

The use of synthetic, spray-on materials (except tacking agents used with hydro-seeding) is not recommended because they can create impervious surfaces and, possibly, adverse effects on water quality. Research shows that they can cause more erosion when used than bare exposed soil.

Nets and Mats

Used alone, netting does not retain soil moisture or modify soil temperature. It stabilizes the soil surface while grasses are being established, and is useful in grassed waterways and on slopes. Light netting may also be used to hold other mulches in place. Its relatively high cost makes it most suitable for small sites.

The most critical part of installing nets and mats is obtaining firm, continuous contact between material and soil. Without such contact, the material is useless and erosion occurs. It is important to use an adequate number of staples and to roll the material after laying it to ensure soil is protected.

4.1.3.5 Design Criteria

- Site Preparation – Same as Temporary Seeding (BMP E1.10).
- Mulch Materials, Application Rates, and Specifications – see Table 3.
- Erosion nets and mats may be used on level areas, on slopes (Figure 5a) up to 25 percent, and in channels (Figure 5b). Where soil is highly erodible, nets shall only be used in connection with organic mulch such

as straw and wood fiber. Jute nets shall be heavy, uniform cloth woven of single jute yarn, which if 36 to 48 inches wide shall weigh an average of 1.2 pounds per linear yard. It must be so applied that it is in complete contact with the soil. Netting shall be securely anchored to the soil with No. 11 gauge wire staples at least 6 inches long, overlap 2 inches across and 6 inches down.

- To install mats on slopes:
    - First complete the final grade and track walk up and down the slope. Install hydromulch with seed and fertilizer.
    - Dig a small trench, approximately 6 inches wide by 6 inches deep, along the top of the slope.
    - Install the leading edge of the mat into the small trench and staple approximately every 12 inches (metal, U-shaped, and a minimum of 6 inches long). Longer staples shall be used in sandy soils. Biodegradable stakes are also available.
    - Roll the mat slowing down the slope as the installer walks backwards, with the mat resting against the installer’s legs.
    - Install staples as the mat is unrolled. Do not allow the mat to roll down the slope unattended. No one is allowed to walk on the mat after it is in place. If the mat is not long enough to cover the entire slope length, the trailing edge of the upper mat should overlap the leading edge of the lower mat and be stapled.
    - On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.
- Excelsior blankets are considered protective mulches and may be used alone on erodible soils and during all times of year.

4.1.3.6 Maintenance

- Mulched areas should be checked periodically, especially following severe storms, when damaged areas of mulch or tie-down material should be repaired.

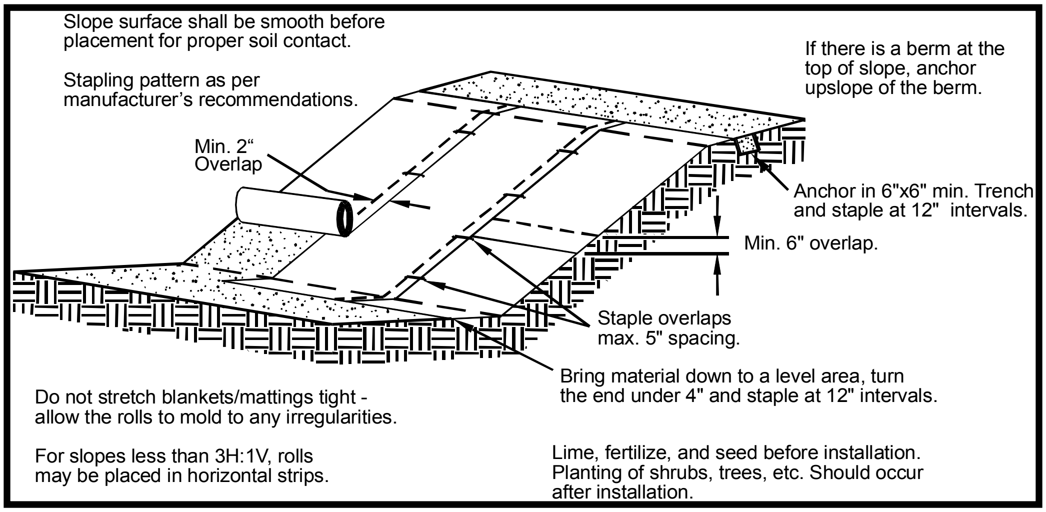


Figure 5a. Mat Installation on Slope.

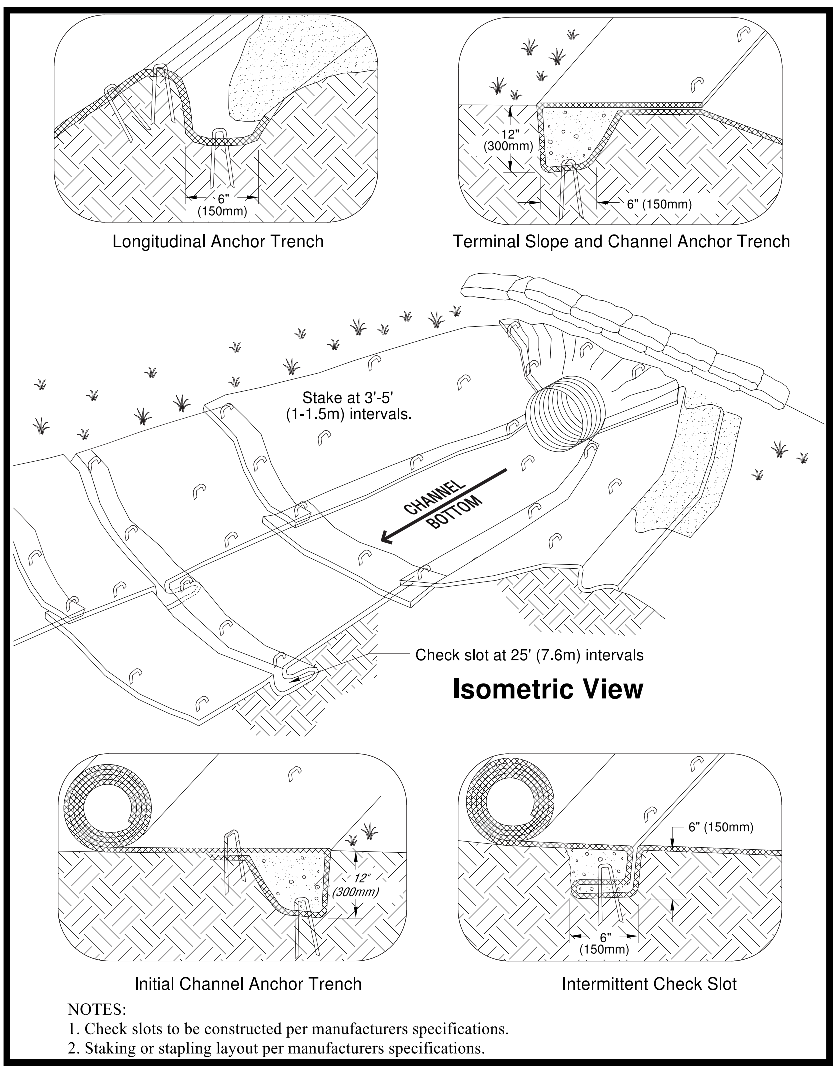


Figure 5b. Mat Installation on a Channel.

4.1.4 BMP E1.20: Clear Plastic Covering

4.1.4.1 Definition

The covering with clear plastic sheeting of bare areas that need immediate protection from erosion.

4.1.4.2 Purpose

To provide immediate temporary erosion protection to slopes and disturbed areas that cannot be covered by mulching, to provide protection to plantings during winter, or to cover stockpiles. Clear plastic also is used to protect disturbed areas that must be covered during short periods of inactivity to meet November 1 through March 31 cover requirements. Because of many disadvantages, clear plastic covering is the least preferred covering BMP (Figure 6).

Figure 6. Stockpile Covered with Plastic Sheeting.

4.1.4.3 Conditions Where Practice Applies

- Disturbed areas that require immediate erosion protection for less than 30 days
- Areas seeded during the time period from November 1 to March 1.

4.1.4.4 Planning Considerations

Plantings at this time require clear plastic covering for germination and protection from heavy rains.

4.1.4.5 Design Criteria

- Clear plastic sheeting shall have a minimum thickness of 6 mil and shall meet the requirements of the City of Seattle Standard Specifications Section 9-14.5.
- Place plastic into a small (12-inch wide by 6-inch deep) slot trench at the top of the slope and backfill with soil to keep water from flowing underneath.
- Covering shall be installed and maintained tightly in place by using sandbags or tires on ropes with a maximum 10 foot grid spacing in all directions. All seams shall be taped or weighted down full length and there shall be at least a 1- to 2-foot overlap of all seams. Seams should then be rolled and staked or tied.
- Covering shall be installed immediately on areas seeded between November 1 to March 1, and remain until vegetation is firmly established.
- When the covering is used on unseeded slopes, it shall be left in place until the next seeding period.
- Sheeting should be toed in at the top of the slope to prevent surface flow beneath the plastic. If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.
- Sheeting should be removed as soon as is possible once vegetation is well grown to prevent burning the vegetation through the plastic sheeting, which acts as a greenhouse.

4.1.4.6 Maintenance

- Check regularly for rips and places where the plastic may be dislodged. Contact between the plastic and the ground should always be maintained. Any air bubbles found should be removed immediately or the plastic may rip during the next windy period. Re-anchor or replace the plastic as necessary.

4.1.5 BMP E1.25: Polyacrylamide for Soil Erosion Protection

4.1.5.1 Definition

The application of polyacrylamide (PAM) to prevent soil erosion.

4.1.5.2 Purpose

Applying PAM to bare soil in advance of a rain event significantly reduces erosion and controls sediment in two ways. First, PAM increases the soil's available pore volume, thus increasing infiltration through flocculation and reducing the quantity of stormwater runoff. Second, it increases flocculation of suspended particles and aids in their deposition, thus reducing stormwater runoff turbidity and improving water quality.

4.1.5.3 Conditions Where Practice Applies

- PAM can only be applied to areas that drain to a sediment pond that will not discharge to a receiving water.
- In areas that drain to a sediment pond, PAM can be applied to bare soil under the following conditions:
  - During rough grading operations
  - Staging areas
  - Balanced cut and fill earthwork
  - Haul roads prior to placement of crushed rock surfacing
  - Compacted soil road base
  - Stockpiles
  - After final grade and before paving or final seeding and planting
  - Pit sites.

4.1.5.4 Planning Considerations

In the case of winter shut down, or where soil will remain unworked for several months, PAM should be used together with mulch.

All PAM are polymers, but not all polymers are PAM, and not all PAM products comply with ANSI/NSF Standard 60. PAM use shall be reviewed and approved by the Department of Planning and Development. Refer to Appendix B for information on chemical treatment.

4.1.5.5 Design Criteria

- PAM may be applied in dissolved form with water, or it may be applied in dry, granular, or powdered form. The preferred application method is the dissolved form.

- PAM is to be applied at a maximum rate of 2/3 pounds PAM per 1,000 gallons water (or 80 milligrams per liter [mg/L]) per 1 acre of bare soil. Table 4 can be used to determine the PAM and water application rate for a disturbed soil area. Higher concentrations of PAM do not provide any additional effectiveness.

Table 4. PAM and Water Application Rates.

Disturbed Area (acres)	PAM (pounds)	Water (gallons)
0.50	0.33	500
1.00	0.66	1,000
1.50	1.00	1,500
2.00	1.33	2,000
2.50	1.66	2,500
3.00	2.00	3,000
3.50	2.33	3,500
4.00	2.66	4,000
4.50	3.00	4,500
5.00	3.33	5,000

The Preferred Method:

- Pre-measure the area where PAM is to be applied and calculate the amount of product and water necessary to provide coverage at the specified application rate (2/3 pound PAM/1,000 gallons/acre).
- PAM has infinite solubility in water, but dissolves very slowly. Dissolve pre-measured dry granular PAM with a known quantity of clean water in a bucket several hours or overnight. Mechanical mixing will help dissolve the PAM. Always add PAM to water – not water to PAM.
- Pre-fill the water truck about 1/8 full with water. The water does not have to be potable, but it must have relatively low turbidity – in the range of 20 Nephelometric Turbidity Units (NTU) or less.
- Add PAM/Water mixture to the truck.
- Completely fill the water truck to specified volume.
- Spray PAM/Water mixture onto dry soil until the soil surface is uniformly and completely wetted.

An Alternate Method:

PAM may also be applied as a powder at the rate of 5 pounds per acre. This must be applied on a day that is dry. For areas less than 5 acres, a hand-held “organ grinder” fertilizer spreader set to the smallest setting will work. Tractor-mounted spreaders will work for larger areas.

The following shall be used for application of PAM:

- PAM shall be used in conjunction with other BMPs and not in place of other BMPs.
- Do not use PAM on a slope that flows directly into a stream or wetland. The stormwater runoff shall pass through a sediment control BMP prior to discharging to surface waters.
- Do not add PAM to water discharging from site.
- All areas not being actively worked shall be covered and protected from rainfall. PAM shall not be the only cover BMP used.
- PAM can be applied to wet soil, but dry soil is preferred due to less sediment loss.
- PAM will work when applied to saturated soil but is not as effective as applications to dry or damp soil.
- Keep the granular PAM supply out of the sun. Granular PAM loses its effectiveness in 3 months after exposure to sunlight and air.
- Proper application and re-application plans are necessary to ensure total effectiveness of PAM usage.
- PAM, combined with water, is very slippery and can be a safety hazard. Care must be taken to prevent spills of PAM powder onto paved surfaces. During an application of PAM, prevent over-spray from reaching pavement as pavement will become slippery. If PAM powder gets on skin or clothing, wipe it off with a rough towel rather than washing with water – this only makes cleanup messier and take longer.
- The specific PAM copolymer formulation must be anionic. Cationic PAM shall not be used in any application because of known aquatic toxicity problems. Only the highest drinking water grade PAM, certified for compliance with ANSI/NSF Standard 60 for drinking water treatment, will be used for soil applications. Recent media attention and high interest in PAM has resulted in some entrepreneurial exploitation of the term "polymer."
- PAM tackifiers are available and being used in place of guar and alpha plantago. Typically, PAM tackifiers should be used at a rate of no more than 0.5 to 1 pound per 1,000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 to 5 pounds per acre, which can be too much. In addition, pump problems can occur at higher rates due to increased viscosity.

4.1.5.6 Maintenance

- PAM may be reapplied on actively worked areas after a 48-hour period.
- Reapplication is not required unless PAM treated soil is disturbed or unless turbidity levels show the need for an additional application. If PAM

treated soil is left undisturbed a reapplication may be necessary after 2 months. More PAM applications may be required for steep slopes, silty and clayey soils (USDA Classification Type "C" and "D" soils), long grades, and high precipitation areas. When PAM is applied first to bare soil and then covered with straw, a reapplication may not be necessary for several months.

- Loss of sediment and PAM may be a basis for penalties per RCW 90.48.080.

4.1.6 Permanent Cover Practices

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Permanent cover BMPs are implemented both during and on completion of construction activities.

Permanent cover reduces erosion wherever practicable and can be achieved primarily by limiting site disturbance during construction. For example, by preserving existing conifers approximately 50 percent of all rain that falls onto the trees will be retained during a storm. Up to 20 to 30 percent of this rain may never reach the ground but is taken up by the tree or lost to evaporation. Another benefit of permanent cover is that rain held in permanent vegetation (plantings, grass, trees) can be released slowly to the ground after a rain event.

Note: equipment access and soil compaction is not allowed in areas where permanent cover is established.

The standards and specifications for permanent cover BMPs are described below and include:

- BMP E1.30: Preserving Natural Vegetation (Section 4.1.7)
- BMP E1.35: Buffer Zones (Section 4.1.8)
- BMP E1.40: Permanent Seeding and Planting (Section 4.1.9)
- BMP E1.45: Sodding (Section 4.1.10)
- BMP E1.50: Topsoiling (Section 4.1.11).

4.1.7 BMP E1.30: Preserving Natural Vegetation

4.1.7.1 Definition

Minimizing exposed soils and consequent erosion by clearing only where construction will occur.

4.1.7.2 Purpose

To reduce erosion by preserving natural vegetation wherever practicable (Figure 7).

Figure 7. Preserving Vegetation.

4.1.7.3 Condition Where Practice Applies

Natural vegetation should be preserved everywhere, but especially on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.

4.1.7.4 Planning Considerations

Refer to the Seattle Municipal Code 29.09 Trees and Vegetation and 25.11 Tree Protection for additional requirements for Environmentally Critical Areas.

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

New development often takes place on tracts of forested land. In fact, building sites are often selected because of the presence of mature trees. However, unless sufficient care is taken and planning done, in the interval between buying the property and completing construction much of this resource is likely to be destroyed. The property owner is ultimately responsible for protecting as many trees as possible, with their understory and groundcover. It takes 20 to 30 years for newly planted trees to provide the benefits for which we value trees so highly.

4.1.7.5 Design Criteria

It can be worthwhile to preserve natural vegetation both in the form of vegetated communities of trees and related understory plants, and in the form of individual trees retained along with the soil that supports them. The preservation of individual trees can be particularly challenging given the typical use of heavy construction equipment on site, and the need for clear field marking to guard against incidental impacts to the soil and or to the trunk, branches, and roots of the tree itself.

Design considerations include:

- Establish a monetary value for the tree or vegetated area and post this in some visible manner on protective fencing to help ensure care on the part of the site contractors. Monetary value is typically established by a professional in the tree care, landscape, and/or nursery industry with value assessment experience according to the “Guide for Establishing the Values of Trees and other Plants” prepared by the Council of Tree and Landscape Appraisers. An aspect of appraisal includes application of local standards to help ensure the protection of plants that are desirable native or non-native species.
- Prior to beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers. Clearly flag and provide a rigid (chain link or similar) fence to protect areas around trees and vegetated areas to be retained. Where protection of all surfaces within the drip line of the tree or vegetated area is not possible, consult a tree care professional with credentials in urban forestry, landscape architecture, or a related field to develop an appropriate plan. The plan should apply the requirements defined in City of Seattle Standard Plans 132, 133, and 134.
- The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum degree practicable.

- Trees and other plants need protection from three types of impacts:
  - **Construction Equipment** – Impacts can occur above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Roping or fencing a buffer zone around plants to be saved can prevent such injuries.
  - **Grade Change** – Any grade change impacting areas within the drip line of an existing tree should be reviewed and approved by a tree care professional with local construction experience to ensure familiarity with the tree species and local conditions associated with soil, drainage, and pests or disease that may be factors. Where appropriate, systems may be designed utilizing structural or engineered soil mixes and/or "rootways" to ensure the circulation of air to roots impacted by fill.
  - **Excavation** – Excavation within the drip line of trees commonly requires exploratory work utilizing hand equipment including the use of an air spade to fracture soil and reveal root locations without damage. Identifying the location of existing roots allows construction within areas where roots are expected to exist to occur with minimal damage to critical root systems.
- For specific information about preserving mature trees and/or large plants, see references listed on the DPD Tree and Landscaping Guidance and Requirements website at (http://www.seattle.gov/dpd/codes/Tree_Landscaping_Regulations/Overview/default.asp).
- In all situations involving vegetation preservation, it is fundamentally important to involve a qualified tree and/or vegetation care professional to assess the specific site issues. The above guidelines are designed to capture the major common issues associated with vegetation preservation; however each site will be unique and would benefit from the input of a dedicated professional.

4.1.7.6 Maintenance

Inspect flagged areas regularly to make sure flagging has not been removed. If the flagging has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored. If tree roots have been exposed or injured, "prune" cleanly with an appropriate pruning saw or loppers directly above the damaged roots and recover with native soils. Treatment of sap flowing trees (fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

4.1.8 BMP E1.35: Buffer Zones

4.1.8.1 Definition

An undisturbed area or strip of natural vegetation or an established suitable planting that will provide a living filter to reduce soil erosion and runoff velocities.

4.1.8.2 Purpose

Natural buffer zones are used along streams and other receiving waters that need protection from erosion and sedimentation (Figure 8).

Figure 8. Vegetated Buffer Zone.

4.1.8.3 Conditions Where Practice Applies

Vegetative buffer zones can be used to protect natural swales and incorporated into natural landscaping of an area. Critical-areas buffer zones should not be used as sediment treatment areas; these areas shall remain completely undisturbed.

4.1.8.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Seattle's Environmentally Critical Areas (ECA) regulations require undisturbed vegetative buffer zones from wetlands (SMC 25.09.160), steep slope areas (SMC 25.09.180), and fish and wildlife habitat conservation areas (SMC 25.09.200). Refer to the appropriate code section(s) for site-specific requirements.

4.1.8.5 Design Criteria

- Preserving natural vegetation or plantings in clumps, blocks, or strips is generally the easiest and most successful method.
- Leave all unstable steep slopes in natural vegetation.
- Fence or flag clearing limits and keep all equipment and construction debris out of the natural areas.
- Keep all excavations outside the drip line of trees and shrubs.
- Do not push debris or extra soil into the buffer zone area because it will cause damage from burying and smothering.

4.1.8.6 Maintenance

Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed.

4.1.9 BMP E1.40: Permanent Seeding and Planting

4.1.9.1 Definition

The establishment of perennial vegetative cover on disturbed areas.

4.1.9.2 Purpose

- To establish permanent vegetation (such as grasses, legumes and trees and shrubs) as rapidly as possible to prevent soil erosion by wind or water, and to improve wildlife habitat and site aesthetics.
- To provide pollutant filtration (biofiltration) in vegetation-lined channels and to establish constructed wetlands as required.

4.1.9.3 Conditions Where Practice Applies

- Graded, final graded or cleared areas where permanent vegetative cover is needed to stabilize the soil.
- Areas that will not be brought to final grade for a year or more.
- Vegetation-lined channels.
- Retention or detention ponds as required.

4.1.9.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Vegetation controls erosion by reducing the velocity and the volume of overland flow and protecting the bare soil surface from raindrop impact.

Land that has been disturbed requires vegetative cover. The most common and economical means of establishing this cover is by seeding grasses and legumes.

Advantages of seeding over other means of establishing plants include the small initial establishment cost, the wide variety of grasses and legumes available, low labor requirement, and ease of establishment in difficult areas.

Disadvantages that must be dealt with are the potential for erosion during the establishment stage, a need to reseed areas that fail to establish, limited periods during the year suitable for seeding, and a need for water and appropriate climatic conditions during germination.

Consider the microclimate(s) within the development area. Low areas may be frost pockets and require hardier vegetation since cold air tends to sink and flow towards low spots. South-facing slopes may be more difficult to re-vegetate because they tend to be sunnier and drier.

There are so many variables in plant growth that an end product cannot be guaranteed. Much can be done in the planning stages to increase the chances for successful seeding. Selection of the right plant materials for the site, good seedbed preparation, timing, and conscientious maintenance are important. Whenever possible, native species of plants should be used for landscaping. These plants are already adapted to the locale and survivability should be higher than with exotic species.

Native species are also less likely to require irrigation; which can require extensive maintenance, is not cost-effective, nor an ecologically sound practice.

4.1.9.5 Design Criteria

- Vegetation cannot be expected to supply an erosion control cover and prevent slippage on a soil that is not stable due to its texture, structure, water movement, or excessive slope.
- Seeding should be done immediately after final shaping, except during the period of November 1 through March 1, when the site should be protected by mulching or plastic covering until the next seeding period. Seeding completed between July 1 and August 30 will require irrigation until 75 percent grass cover is established.
- Permanent vegetation may be in the form of grass-type growth by seeding or sodding, or it may be trees or shrubs, or a combination of these. Establishing this cover may require the use of supplemental materials, such as mulch or jute netting (see BMP E1.15).
- **Site Preparation:** Install temporary surface runoff control measures prior to seeding or planting to protect the surface from erosion until the vegetation is established. The temporary measures include gradient terraces, berms, dikes, level spreaders, waterways, and sediment basins.
- **Seeding Grasses and Legumes:** Seedbed Preparation – If infertile or coarse textured subsoil will be exposed during land shaping, it is best to stockpile topsoil and re-spread it over the finished slope at a minimum 2- to 6-inch depth and roll it to provide a firm seedbed. If construction fills have left soil exposed with a loose, rough, or irregular surface, smooth with blade and roll. If cuts or construction equipment have left a tightly compacted surface, break with chisel plow or other suitable implement. Perform all cultural operations across or at right angles to the slope (contoured), such as with cat tracks on the final pass. The seedbed should be firm with a fairly fine surface. All soil should be roughened before seeding. If compaction is required for engineering purposes, slopes must be track walked before seeding.

- **Soil Amendments:** Soil amendments shall be used to achieve organic matter and permeability performance defined in engineered soil/landscape systems. Rates will depend on site characteristics and soil, but as a guide, apply a 10-4-6 nitrogen-phosphorus-potassium (N-P-K) fertilizer ratio at a rate of 90 pounds per acre. Work in the amendment to a depth of a minimum of 6 inches with suitable equipment. Scatter amendments uniformly and work into the soil during seedbed preparation.
- **Seeding:** Apply an appropriate mixture to the prepared seedbed at a rate of 120 pounds/acre. The erosion seeding mixture for application is presented in Table 5.

Table 5. Erosion Seeding Mixture.

Name	Percent by Weight
Turf-type Perennial Rye [1]	50 percent
Creeping Red Fescue	20 percent
Chewings Fescue	20 percent
Hard Fescue	10 percent

Notes:

[1] Three approved types; refer to City of Seattle Standard Specification 9-14.2.

Cover the seed with topsoil or mulch no deeper than 1/2 inch. It is better to work topsoil into the upper soil layer rather than spread a layer of it directly onto the top of the native soil.

"Hydro-seeding" applications with approved seed-mulch-fertilizer mixtures may also be used. Hydroseed applications should include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier.

Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.

Wetlands Seed Mixtures: For newly created wetlands, a wetlands specialist should design plantings to provide the best chance of success. See Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for more information on constructed wetlands.

Do not under any circumstances use introduced, invasive plants like reed canary grass (*Phalaris arundinacea*) or purple loosestrife (*Lythrum salicaria*). Using plants such as these will cause many more problems than they will ever solve.

Tree and Shrub Planting: Besides their erosion and sediment control values, trees and shrubs also provide natural beauty and wildlife benefits. When used for the latter, they are usually more effective when planted in clumps or blocks. These procedures should be followed:

- Trees and shrubs will do best in topsoil. If no topsoil is available, they can be established in subsoil with proper amendment. If trees and shrubs are to be planted in subsoil, particular attention should be paid to amending the soil with generous amounts of organic matter. Mulches should also be used.
- Good quality planting stock should be used. Normally 1- or 2-year old deciduous seedlings, and 3- or 4-year old coniferous transplants, when properly produced and handled are adequate. Stock should be kept cool and moist from time of receipt and planted as soon as possible.
- Competing vegetation, if significant, should be pulled out of the area where the plant or plants are to be placed.

4.1.9.6 Maintenance

Inspect seeded areas for failure and make necessary repairs and reseed areas with less than 80 percent cover immediately. Conduct or follow-up survey after one year and replace failed plants where necessary.

- If vegetative cover is inadequate to prevent rill erosion, apply other BMPs assuming vegetation was successful.
- If a stand has less than 40 percent cover, reevaluate choice of plant materials and quantities of lime and fertilizer. Re-establish the stand following seedbed preparation and seeding recommendations, omitting lime and fertilizer in the absence of soil test results. If the season prevents re-sowing, mulch or jute netting is an effective temporary cover.

4.1.10 BMP E1.45: Sodding

4.1.10.1 Definition

Stabilizing fine-graded disturbed areas by establishing permanent grass stands with sod.

4.1.10.2 Purpose

To establish permanent turf for immediate erosion protection or to stabilize drainage ways where concentrated overland flow will occur.

4.1.10.3 Conditions Where Practice Applies

- Disturbed areas which require immediate vegetative cover.
- Waterways carrying intermittent flow, where immediate stabilization or aesthetics are factors and other locations particularly suited to stabilization with sod.

4.1.10.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Sod can initially be more costly than seeding, but the advantages often justify the increased initial costs. Sod provides immediate erosion control and a green surface that must be protected from disturbance while it takes root. Sod is preferable to seed:

- Reduced failure as compared to seed and the lack of weeds
- Can be established nearly year round
- Preferable to seed in waterways and swales because of the immediate protection of the channel after application.

4.1.10.5 Design Criteria

- Shape and smooth the surface to final grade in accordance with the approved grading plan. Over excavate the swale 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.
- Use of topsoil shall be in accordance with the requirements of Topsoiling (BMP E1.50).
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than 10 percent or the permeability

is less than 0.6 inches per hour. Compost used should meet City of Seattle Standard Specifications 9-14.4(5) or 9-14.4(9) for Grade A quality compost.

- Add lime to reach a soil pH value of 6.5 (based on soil tests).
- Fertilize according to a soil test or in the absence of a test use available nitrogen, phosphorus and potash as prescribed for permanent seeding. Use fertilizers that are not highly soluble.
- Work lime and fertilizer into the soil 1 to 2 inches deep and smooth the surface.
- Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely in place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple the upstream edge of each sod strip if on slopes steeper than 18 percent.
- Roll the sodded area and irrigate.
- When sodding is carried out in alternating strips, or other patterns, seed the areas between the sod immediately after sodding.
- Sod should be free of weeds and be of uniform thickness (approximately 1 inch) and should have a dense root mat for mechanical strength.

4.1.10.6 Maintenance

- Inspect sodded areas regularly, especially after large storm events. Re-tack, re-sod, or re-seed and protect with a net or mat as necessary.

4.1.11 BMP E1.50: Topsoiling

While not a permanent cover practice in itself, topsoiling has been included in this section because it is an integral component of preparing permanent cover to those areas where there is an unsuitable soil surface for plant growth. Use of in-situ or imported topsoil is always preferable to planting in subsoil.

4.1.11.1 Definition

Preserving and using topsoil to enhance final site stabilization with vegetation.

4.1.11.2 Purpose

To provide a suitable growth medium for final site stabilization with vegetation.

4.1.11.3 Conditions Where Practice Applies

- Preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium, and the slopes are less than 26 percent.
- Applicable to those areas with highly dense or impermeable soils or areas where planting is to be done in subsoil, where mulch and fertilizer alone would not provide a suitable growth medium.

4.1.11.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

Native soils disturbed during clearing and grading should be restored, to the maximum extent practicable, to a condition where moisture-holding capacity is equal to or better than the original site conditions.

Topsoiling is strongly recommended where ornamental plants or high-maintenance turf will be grown. Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.

If topsoiling is to be done, the following items should be considered:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium.

Topsoil depth shall be at least 8 inches with a minimum organic content of 10 percent dry weight and pH between 6.0 and 8.0 or matching the pH of the undisturbed soil. This can be accomplished either by returning native topsoil to the site and/or incorporating organic amendments. Organic amendments should be incorporated to a minimum 8-inch depth except where tree roots or other natural features limit the depth of incorporation. Subsoils below the 12-inch depth should be scarified at least 2 inches to avoid stratified layers, where feasible. The decision to either layer topsoil over a subgrade or incorporate topsoil into the underlying layer may vary depending on the planting specified.

- If blended topsoil is imported, then fines should be limited to 25 percent passing through a 200 sieve.
- Location of the topsoil stockpile so that it meets specifications and does not interfere with work on the site.
- Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding, or planting.
- Care must be taken not to apply to subsoil if the two soils have contrasting textures. Sandy topsoil over clayey subsoil is a particularly poor combination, as water creeps along the junction between the soil layers and causes the topsoil to slough.
- If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. The best method to prevent a lack of bonding is to actually work the topsoil into the layer below for a depth of at least 6 inches.
- Ripping or restructuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.

4.1.11.5 Design Criteria

- Field exploration of the site shall be made to determine if there is surface soil of sufficient quantity and quality to justify stripping. Topsoil shall be friable and loamy (loam, sandy loam, silt loam, sandy clay loam, clay loam). Areas of natural ground water recharge should be avoided.
- Stripping shall be confined to the immediate construction area. A 4 to 6 inch stripping depth is common, but depth may vary depending on the particular soil. All surface runoff control structures shall be in place prior to stripping.
- Stockpiling of topsoil shall occur in the following manner:
  - Side slopes of the stockpile shall not exceed 26 percent.
  - An earth dike with gravel outlet and silt fence shall surround all topsoil stockpiles.

- Erosion control seeding or covering mulching materials (see BMPs E1.10 and E1.15) of stockpiles shall be completed within 7 days of the formation of the stockpile. Use of plastic cover is not recommended.

- Topsoil shall not be placed while in a frozen or muddy condition, when the subgrade is excessively wet, or when conditions exist that may otherwise be detrimental to proper grading or proposed sodding or seeding.
- Previously established grades on the areas to be topsoiled shall be maintained according to the approved plan.
- When native topsoil is to be stockpiled and reused the following should apply to ensure that the mycorrhizal bacteria, earthworms, and other beneficial organisms will not be destroyed:
  - Topsoil is to be re-installed within 4 to 6 weeks.
  - Topsoil is not to become saturated with water.
  - Plastic cover is not allowed.

4.1.11.6 Maintenance

- Cover piles until needed. Use of plastic cover is not recommended.
- Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.

4.2 Erosion Control Practices

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Naturally occurring (undisturbed) soil and vegetation provide important stormwater management functions including: water infiltration; nutrient, sediment, and pollutant adsorption; sediment and pollutant biofiltration; water interflow storage and transmission; and pollutant decomposition. These functions are largely lost when construction practices erode away native soil and vegetation.

This section presents BMPs that temporarily and permanently address erosion, including measures for construction site stabilization, slope protection, and drainage way protection. The BMPs in this section have been divided into three basic groups based on these characteristics:

1. Temporary erosion control practices, such as road stabilization, check dams, and dust control (beginning at Section 4.2.1)
2. Permanent erosion control practices, such as gradient terraces and channel lining (beginning at Section 4.2.10)
3. Temporary or permanent erosion control practices, such as subsurface drains, earth dike and drainage swales, and outlet protection (beginning at Section 4.2.14).

The requirements for maintaining permanent BMPs are included with each description; however, all temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

4.2.1 Temporary Erosion Control BMPs

Although temporary erosion control BMPs are emphasized in this section, they may be combined with permanent control facilities to provide protection of downstream properties during construction. Temporary facilities provide siltation control, but downstream erosion protection must also be provided. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for flow control requirements.

Temporary cover BMPs are described in the sections below and include:

- BMP E2.10: Stabilized Construction Entrance (Section 4.2.2)
- BMP E2.15: Tire Wash (Section 4.2.3)
- BMP E2.20: Construction Road Stabilization (Section 4.2.4)

- BMP E2.25: Water Bars (Section 4.2.5)
- BMP E2.30: Level Spreader (Section 4.2.6)
- BMP E2.35: Check Dams (Section 4.2.7)
- BMP E2.40: Triangular Silt Dike (Geotextile-Encased Check Dam) (Section 4.2.8)
- BMP E2.45: Dust Control (Section 4.2.9).

4.2.2 BMP E2.10: Stabilized Construction Entrance

4.2.2.1 Definition

A temporary stone-stabilized pad located at points of vehicular ingress and egress on a construction site.

4.2.2.2 Purpose

To reduce the amount of mud, dirt, rocks, etc. transported onto public roads by motor vehicles or runoff by constructing a stabilized pad of rock spalls at entrances to construction sites and washing of tires during egress (Figure 9).

Figure 9. Stabilized Construction Entrance.

4.2.2.3 Conditions Where Practice Applies

Whenever traffic will be leaving a construction site and moving onto a public road or other paved areas. Also refer to BMP E3.70 Street Sweeping and Vacuuming.

4.2.2.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Construction entrances provide an area where mud can be removed from vehicle tires before they enter a public road. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles. Construction vehicle access and exit shall be limited to one route, if possible.

It is important to note that this BMP will only be effective if sediment control is used throughout the rest of the construction site.

4.2.2.5 Design Criteria

- A separation geotextile shall be placed under the spalls to prevent the surface fines pumping up into the rock pad. The geotextile shall meet the standards presented in Table 6.

Table 6. Geotextile Standards.

Standard	Criteria
Grab Tensile Strength (ASTM D4751)	200 psi minimum
Grab Tensile Elongation (ASTM D4632)	30 percent maximum
Mullen Burst Strength (ASTM D3786-80a)	400 psi minimum
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

Notes:
AOS Apparent Opening Size.
ASTM American Society for Testing and Materials.
psi pounds per square inch.

- Material should be quarry spalls (where feasible), 2 inches to 6 inches size.
- The rock pad shall be at least 12 inches thick and 100 feet in length for sites more than 1 acre; and may be reduced to the maximum practicable size when the size or configuration of the site does not allow the full 100 foot length.
- The access width shall be the full width of the vehicle ingress and egress area.
- Additional rock should be added periodically to maintain proper function of the pad.
- Fencing shall be installed as necessary to restrict traffic to the construction entrance.
- Whenever possible, the entrance shall be constructed on level ground with a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.
- See Figure 10 for details.

Example 1: Manufactured metal plates to knock dirt off vehicle tires before exiting a site.

Example 2: Crushed stone entrance.

Figure 10. Stabilized Construction Entrance Details.

4.2.2.6 Maintenance

- If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include street sweeping, an increase in the dimensions of the entrance, or the installation of a tire wash (BMP E2.15).
- The entrance shall be maintained in a condition that will prevent tracking or flow of mud onto public rights-of-way. This may require periodic top dressing with 2-inch stone, as conditions demand, and repair and/or cleanout of any structures used to trap sediment. All materials spilled, dropped, washed, or tracked from vehicles onto roadways shall be cleaned thoroughly at the end of each day, or more frequently during wet weather.
- Any sediment that is tracked onto pavement shall be removed by shoveling or street sweeping. The sediment collected by sweeping shall be removed or stabilized on site.
- Street washing is allowed only after sediment is removed in accordance with the above bullet. Street washwater shall not enter the storm drain system or systems tributary to waters of the state. All street washwater must be collected and discharged either back onto the site or into the sanitary sewer system (if permitted).
- Any quarry spalls loosened from the pad that end up on the roadway shall be removed immediately.

4.2.3 BMP E2.15: Tire Wash

4.2.3.1 Definition

A system that uses water to wash motor vehicle tires located at points of egress from a construction site.

4.2.3.2 Purpose

A tire wash is used to remove mud, dirt, rocks, etc. from tires and under carriages, and to prevent sediment from being transported onto public roads.

4.2.3.3 Conditions Where Practice Applies

When a stabilized construction entrance (see BMP E2.10) is not preventing sediment from being tracked onto pavement.

4.2.3.4 Planning Considerations

If approval by King County for wastewater discharge to the sanitary sewer system isn't obtained, wastewater can be collected and taken off-site to an approved location. Indicate the ultimate discharge point or collection point on the Construction Stormwater Control Plan sheet that clearly identifies the location(s) of stormwater discharges.

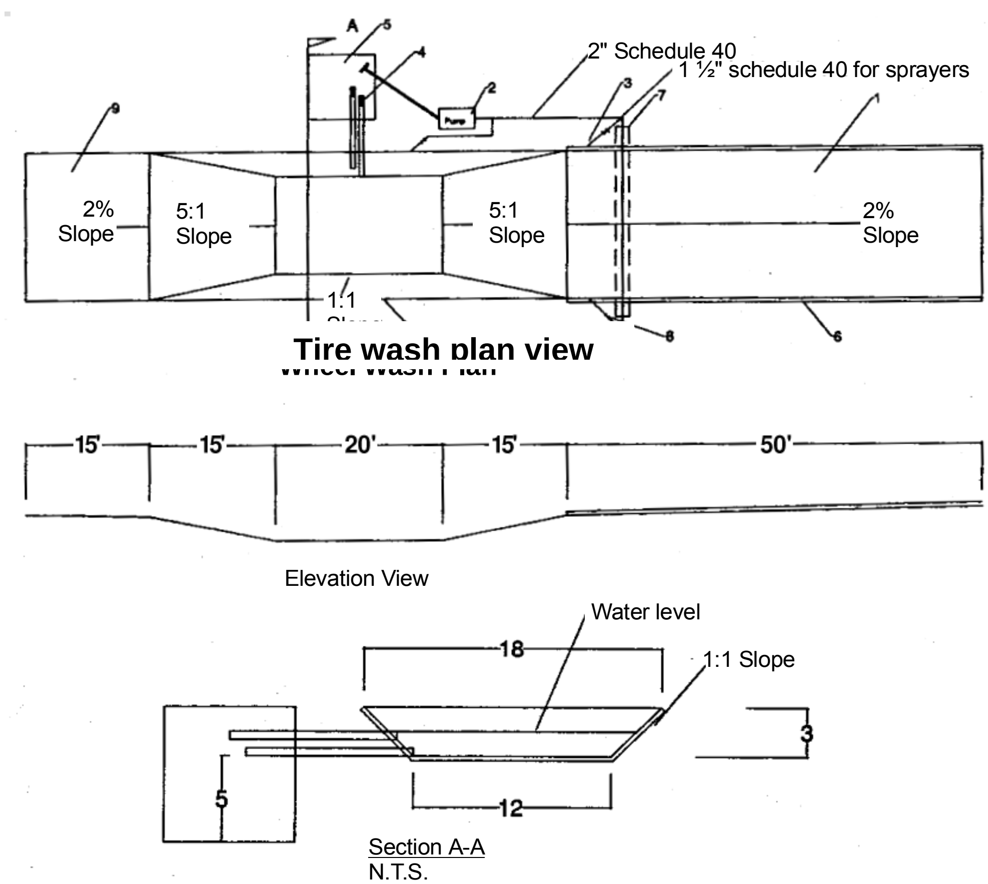
Tire washes provide an area where mud can be removed from vehicle tires before they enter a public road. Tire washes and construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles.

It is important to note that this BMP will only be effective if sediment control is used throughout the rest of the construction site.

4.2.3.5 Design Criteria

- Suggested details are shown in Figure 11. A minimum of 6 inches of asphalt treated base (ATB) over crushed base material or 8 inches over a good subgrade is recommended to pave the tire wash.
- Use a low clearance truck to test the tire wash before paving. Either a belly dump or lowboy will work well to test clearance.
- Keep the water level from 12 to 14 inches deep to avoid damage to truck hubs and filling the truck tongues with water.
- Midpoint spray nozzles are only needed in extremely muddy conditions.
- Tire wash systems should be designed with a small change in grade, 6 to 12 inches for a 10-foot wide pond, to allow sediment to flow to the low side of the pond to help prevent re-suspension of sediment. A drainpipe

with a 2- to 3-foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling. Polymers may be used to promote coagulation and flocculation in a closed-loop system. PAM added to the wheel wash water at a rate of 0.25 to 0.5 pound per 1,000 gallons of water increases effectiveness and reduces cleanup time. If PAM is already being used for dust or erosion control and is being applied by a water truck, the same truck can be used to change the wash water. Refer to BMP E1.25 for additional information on PAM.



Notes:
1. Asphalt construction entrance 6 inches asphalt treated base (ATB).
2. 3-inch trash pump with floats on the suction hose.
3. Midpoint spray nozzles, if needed.
4. 6-inch sewer pipe with butterfly valves. Bottom one is a drain. Locate top pipe's invert 1 foot above bottom of wheel wash.
5. 8 foot by 8 foot sump with 5 feet of catch. Build so can be cleaned with trackhoe.
6. Asphalt curb on the low road side to direct water back to pond.
7. 6-inch sleeve under road.
8. Ball valves.
9. 15 foot. ATB apron to protect ground from splashing water.

Figure 11. Tire Wash Details.

4.2.3.6 Maintenance

- The tire wash should start out the day with fresh water.

- The wash water should be changed a minimum of once per day. On large earthwork jobs where more than 10 to 20 trucks per hour are expected, the wash water will need to be changed more often.
- Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system, such as closed-loop recirculation or land application, or to the sanitary sewer with prior approval by King County.

4.2.4 BMP E2.20: Construction Road Stabilization

4.2.4.1 Definition

The temporary stabilization with stone of access roads, subdivision roads, parking areas, and other on-site vehicle transportation routes immediately after grading.

4.2.4.2 Purpose

- To reduce erosion of temporary road beds by construction traffic during wet weather.
- To reduce the erosion and therefore regrading of permanent road beds between the time of initial grading and final stabilization.
- To minimize the amount of dirt tracked offsite by vehicular traffic.

4.2.4.3 Conditions Where Practice Applies

- Wherever rock-base roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.
- Fencing may need to be installed to limit the access of vehicles to only those roads and parking areas that are stabilized.

4.2.4.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Areas graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. Such areas also tend to collect and transport runoff waters along their surfaces. During wet weather, they often become muddy quagmires that generate significant quantities of sediment that may pollute nearby streams or be transported off-site on the wheels of construction vehicles. Dirt roads can become so unstable during wet weather that they are virtually unusable.

Immediate stabilization of such areas with stone may cost money at the outset, but it may actually save money in the long run by increasing the usefulness of the road during wet weather.

Permanent roads and parking areas should be paved as soon as possible after grading. As an alternative, the early application of stone may solve potential erosion and stability problems and eliminate later regrading costs. Some of the stone will also probably remain in place for use as part of the final base course of the road.

4.2.4.5 Design Criteria

- A 6-inch course of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or the completion of utility installation within the right-of-way. A 4-inch course of asphalt treated base (ATB) may be used in lieu of the crushed rock.
- Temporary roads should not exceed 15 percent, minimize cuts in existing slopes, and be carefully graded to drain transversely. Drainage swales shall be provided to carry flow to a sediment control BMP (Section 4.3).
- Installed inlets shall be protected to prevent sediment-laden water entering the drain sewer system (see Storm Drain Inlet Protection BMP E3.25).

Undisturbed buffer areas should be maintained at all stream crossings.

- Areas adjacent to culvert crossings and steep slopes should be seeded and mulched and/or covered.
- Dust control should be used when necessary (see BMP E2.45).
- If the stabilized construction entrance does not adequately reduce the amount of tracked material, install one or more tire wash BMPs (BMP E2.15).

4.2.4.6 Maintenance

- Inspect stabilized areas regularly, especially after large storm events. Add crushed rock if necessary and re-stabilize any areas found to be eroding.

4.2.5 BMP E2.25: Water Bars

4.2.5.1 Definition

A small ditch or ridge of material is constructed diagonal to the slope of a road or right-of-way.

4.2.5.2 Purpose

To divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch (Figure 12).

Figure 12. Water Bar.

4.2.5.3 Conditions Where Practice Applies

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long narrow right-of-ways over sloping terrain. Disturbance and compaction promotes gully formation in these cleared strips by increasing the volume and velocity of runoff. Gully formation may be especially severe in tire tracks and ruts. To prevent gullying, runoff can often be diverted across the width of the right-of-way to undisturbed areas by using small predesigned diversions.

4.2.5.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Give special consideration to each individual outlet area, and to the cumulative effect of added diversions. Use gravel to stabilize the diversion where significant vehicular traffic is anticipated.

4.2.5.5 Design Criteria

- Height: as needed.
- Side slope of channel: 26 percent maximum; 18 percent or flatter when vehicles will cross.
- Base width of ridge: 6-inch minimum.
- Locate them to follow the site's natural drainage and to discharge into well-vegetated, stable areas.
- Guidelines for water bar spacing are shown in Table 7.

Table 7. Guidelines for Water Bar Spacing.

Slope %	Spacing (feet)
<5	125
5 – 10	100
10 – 20	75
20 – 35	50
>35	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope less than 2 percent.
- Install as soon as the clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.
- Compact the ridge when installed.
- Stabilize, seed, and mulch the portions not subject to traffic. Gravel the areas crossed by vehicles.

4.2.5.6 Maintenance

- Periodically inspect right-of-way diversions for wear and after every heavy rainfall for erosion damage.
- Immediately remove sediment from the flow area and repair the dike.
- Check outlet areas and make timely repairs as needed.
- When permanent road drainage is established and the area above the temporary right-of-way diversion is permanently stabilized, remove the dike and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

4.2.6 BMP E2.30: Level Spreader

4.2.6.1 Definition

A temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope.

4.2.6.2 Purpose

To convert concentrated runoff to a thin layer of sheet flow, which releases onto a stable receiving area. For example, an existing vegetated area or a vegetated strip (BMP 3.30).

4.2.6.3 Condition Where Practice Applies

To be constructed on undisturbed areas stabilized by existing vegetation and where concentrated flows are anticipated to occur at 0 percent grade (Figure 13).

Figure 13. Level Spreader Prior to Backfill.

4.2.6.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Earth dikes and drainage swales (BMP E2.80) call for a stable outlet for concentrated stormwater flows. The level spreader can be used for this purpose provided the runoff is relatively free of sediment. If properly constructed, the level spreader will significantly reduce the velocity of concentrated stormwater and spread it uniformly over a stable undisturbed area.

Particular care must be taken during construction to ensure that the lower lip of the structure is level and on grade. If there are any depressions in the lip, flow will tend to concentrate at these points and erosion will occur, resulting in failure of the outlet. This problem may be avoided by using a grade board or a gravel lip over which the runoff must flow when exiting the spreader. Regular maintenance is essential for this practice.

4.2.6.5 Design Criteria

- The grade of the pipe and/or ditch for the last 20 feet before entering the level spreader shall be less than or equal to 1 percent. If the grade is steeper, provide a flow dissipation device. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- An 8-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2 to 4 inch or 3/4 inch to 1.5 inch size.
- The spreader length will be determined by estimating the flow expected from the 10-year, 24-hour design storm (Q_{10}), and selecting the appropriate length from Table 8. Alternatively, use the 10 percent annual probability flow (10-year recurrence interval) using a 5-minute time step, indicated by an approved continuous runoff model. Use multiple spreaders for higher flows.

Table 8. Spreader Length Based on 10-Year, 24-Hour Storm.

Q_{10} in cfs	Minimum Length (in feet)
0 – 0.1	15
0.1 – 0.2	25
0.2 – 0.3	35
0.3 – 0.4	45
0.4 – 0.5	55

cfs cubic feet per second
Q_{10} 10-year 24-hour design storm

- The depth of the spreader as measured from the lip should be at least 8 inches and it should be uniform across the entire length.
- The discharge area below the outlet must be relatively undisturbed with a slope of less than 11 percent.

4.2.6.6 Maintenance

The spreader should be inspected after every runoff event to ensure that it is functioning correctly. The contractor should avoid the placement of any material on or prevent construction traffic across the structure. If the spreader is damaged by construction traffic, it shall be immediately repaired.

4.2.7 BMP E2.35: Check Dams

4.2.7.1 Definition

Small dams constructed across a swale or drainage ditch.

4.2.7.2 Purpose

To reduce the effective slope of the channel and, therefore, the velocity of concentrated flows; reduce erosion of the swale or ditch; and to slow water velocity to allow retention of sediments (Figure 14).

Figure 14. Rock Check Dam.

4.2.7.3 Conditions Where Practice Applies

Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible and, therefore, velocity checks are required. Check dams shall be placed at regular intervals within constructed channels that are cut down a slope.

4.2.7.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Seattle's Environmentally Critical Areas (ECA) regulations require protection for high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry. Check dams cannot be placed below the expected backwater from any of these areas during specific times of the year. Refer to SMC 25.09 for site-specific requirements.

No check dams may be placed in streams (unless approved by the State Departments of Fisheries or Wildlife as appropriate). Other permits may also be necessary.

Check dams can be constructed of either stone or gravel filled sandbags. Stone for check dams must generally be purchased. However, this cost is offset somewhat by the ease of installation.

If stone check dams are used in grass-lined channels that will be mowed, care should be taken to remove all the stone from the channel when the dam is removed. This should include any stone that has washed downstream.

4.2.7.5 Design Criteria

- Check dams can be constructed of rock or pea-gravel filled bags, or where high velocity flow is not a concern, compost socks may be used. If necessary, compost socks may be stacked.
- Check dams should be placed perpendicular to the flow of water.
- The maximum spacing between the dams shall be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam (Figure 15).
- Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or mechanical placement (no dumping of rock to form dam) to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges. The rock used must be large enough to stay in place given the expected design flow through the channel.
- Use filter fabric foundation under a rock or sand bag check dam. If a mat ditch liner is used, this is not necessary. A piece of organic or synthetic mat cut to fit will also work for this purpose.
- In the case of grass-lined ditches and swales, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones.

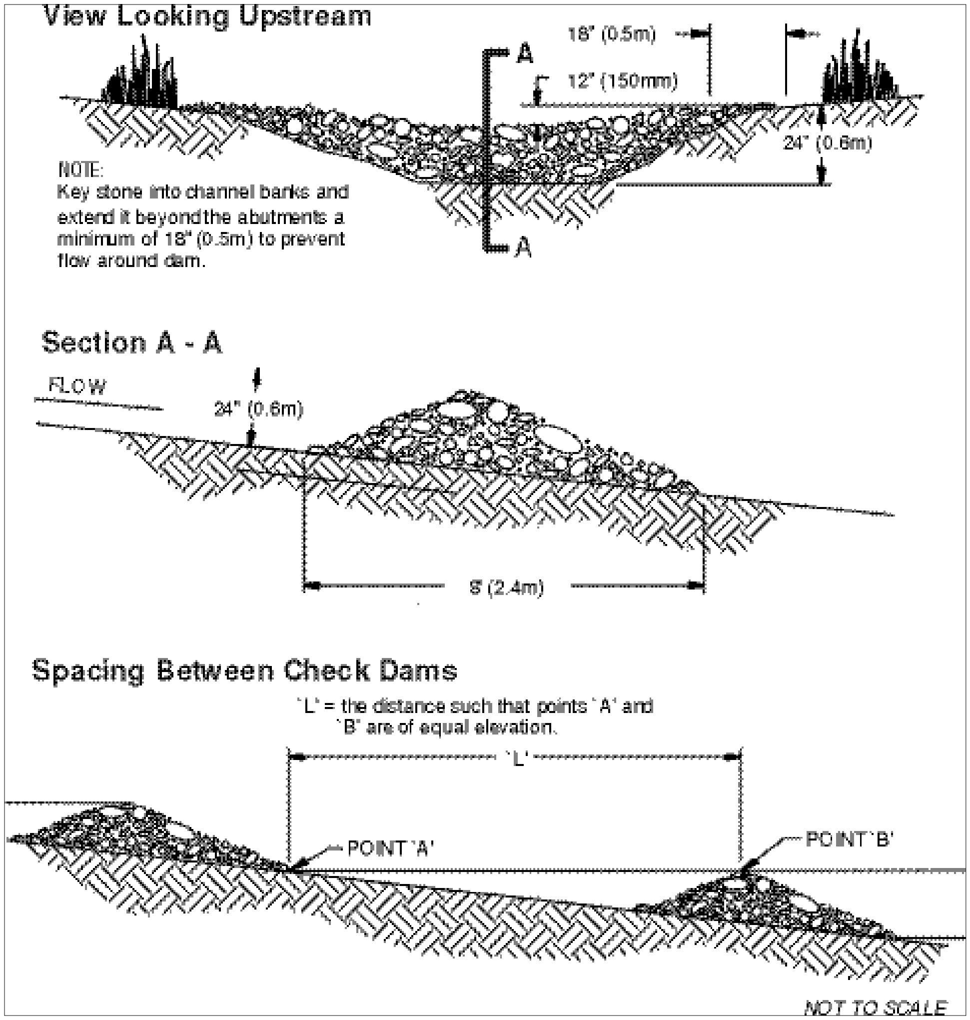


Figure 15. Check Dams.

4.2.7.6 *Maintenance*

- Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one-half the sump depth.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel.

4.2.8 BMP E2.40: Triangular Silt Dike (Geotextile-Encased Check Dam)

4.2.8.1 Definition

A triangular dike made of urethane foam sewn into a woven geosynthetic fabric.

4.2.8.2 Purpose

Triangular silt dikes may be used as check dams, for perimeter protection, for temporary soil stockpile protection, for drop inlet protection, or as a temporary earth dike (Figure 16).

Figure 16. Triangular Silt Dike.

4.2.8.3 Conditions Where Practice Applies

- May be used as temporary check dams in ditches of any dimension.
- May be used on soil or pavement with adhesive or staples.
- Triangular silt dikes have been used to build temporary:
    - Sediment ponds
    - Diversion ditches
    - Concrete wash out facilities
    - Curbing
    - Water bars
    - Level spreaders
    - Berms.

4.2.8.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

- Check dams should be located and installed as soon as construction will allow.
- Check dams should be placed perpendicular to the flow of water.
- Anticipate submergence and deposition above the triangular silt dam and erosion from high flows around the edges of the dam.

4.2.8.5 Design Criteria

This BMP is typically made of urethane foam sewn into a woven geosynthetic fabric. It is triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2–foot apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.

- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples should be No. 11 gauge wire and should be 200 millimeters (mm) to 300 mm in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.
- When used as check dams, the leading edge must be secured with rocks, sandbags, or a small key slot and staples.

4.2.8.6 Maintenance

- Triangular silt dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one-half the height of the dam.
- In the case of grass-lined ditches and swales, check dams and accumulated sediment shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- Immediately repair any damage or any undercutting of the dam.

4.2.9 BMP E2.45: Dust Control

4.2.9.1 Definition

Reducing surface and air movement of dust during land disturbing, demolition, and construction activities.

4.2.9.2 Purpose

To prevent surface and air movement of dust from exposed soil surfaces (Figure 17).

Figure 17. Using a Water Truck for Dust Control.

4.2.9.3 Conditions Where Practice Applies

In areas (including roadways) subject to surface and air movement of dust where on-site and off-site damage is likely to occur if preventive measures are not taken.

4.2.9.4 Planning Considerations

Research at construction sites has established an average dust emission rate of 1.2 tons/acre/month for active construction.

Construction activities inevitably result in the exposure and disturbance of soil. Fugitive dust is emitted both during the activities (i.e., excavation, demolition, vehicle traffic, human activity) and as a result of wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in “heavy” construction activities, such as road and street construction and subdivision, commercial and industrial development, which involve disturbance of significant areas of soil surface. Earthmoving activities are the major source, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, remember that the less soil is exposed at any one time, the less potential there will be for dust generation. Therefore, phasing a project and utilizing temporary stabilization practices upon the completion of grading can significantly reduce dust emissions. Also, limit traffic that will be on areas off the site roadways.

4.2.9.5 Design Criteria

- Minimize the period of soil exposure through use of temporary ground cover and other temporary stabilization practices (see Seeding and Mulching, BMPs E1.10 and E1.15, respectively).
- Construct natural or artificial windbreaks or windscreens. These may be designed as enclosures for small dust sources.
- Sprinkle the site with water until surface is wet. Repeat as needed. To prevent carryout of mud onto street, refer to Stabilized Construction Entrance (BMP E2.10) and Tire Wash (BMP E2.15).
- Spray exposed soil areas with approved dust palliative. Oil should not be used for dust suppression. Contact the Department of Planning and Development to determine other dust palliatives that may be used. Refer to Appendix B for information on chemical treatment.

4.2.9.6 Maintenance

- Respray area as necessary to keep dust to a minimum.\

4.2.10 Permanent Erosion Control BMPs

Permanent BMPs should be designed by an engineer and may have additional criteria for flow control and water quality treatment requirements. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.

Permanent erosion control BMPs are implemented both during and on completion of construction activities.

Permanent erosion control reduces erosion wherever practicable and can be achieved primarily by minimizing erosion by installing permanent stabilizing structures and/or materials to new construction or existing sites. For example, by adding gradient terraces to an existing or newly constructed slope, erosion will be significantly reduced by creating a set of ridges and channels that intercept runoff and direct it to a controlled outlet. The benefit is rill and gully formation will be minimized and toe of slope erosion will decrease as a result. Another benefit of permanent erosion control is that some of the following BMPs include using vegetation which may be incorporated into planning for permanent cover BMPs described in Section 4.1.6.

The standards and specifications for permanent erosion control BMPs are described below and include:

- BMP E2.50: Gradient Terraces (Section 4.2.11)
- BMP E2.55: Bioengineered Protection of Very Steep Slopes (Section 4.2.12)
- BMP E2.60: Channel Lining (Section 4.2.13).

4.2.11 BMP E2.50: Gradient Terraces

4.2.11.1 Definition

An earth embankment or a ridge-and-channel constructed with suitable spacing and with an acceptable grade.

4.2.11.2 Purpose

To reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a no erosive velocity. (This standard covers the planning and design of gradient terraces and does not apply to diversions.)

4.2.11.3 Conditions Where Practice Applies

Gradient terraces normally are limited to denuded land having a water erosion problem. They should not be constructed on deep sands or on soils that are too stony, steep, or shallow to permit practical and economical installation and maintenance. Gradient terraces may be used only where suitable outlets are or will be made available.

4.2.11.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.
- The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow.

4.2.11.5 Design Criteria

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

- The maximum spacing of gradient terraces should be determined by the following method: V.I. = xs + y

  Where: V.I. = vertical interval in feet
  x = 0.8 for Washington
  s = land slope in feet per 100 feet
  y = a soil and cover variable with values from 1.0 to 4.0[1]

- The minimum constructed cross-section should meet the design dimensions.
- **Channel Grade –** Channel grades may be either uniform or variable with a maximum grade of 6 percent. For short distances, terrace grades may be increased to improve alignment. The channel velocity should not exceed that which is nonerosive for the soil type with the planned treatment.
- **Outlet** – All gradient terraces should have adequate outlets. Such an outlet may be a grassed waterway, vegetated area, or tile outlet. In all cases the outlet must convey runoff from the terrace or terrace system to a point where the outflow will not cause damage. Vegetative cover should be used in the outlet channel.

Specifications

- Vertical spacing determined by the above methods may be increased as much as 0.5 feet or 10 percent, whichever is greater, to provide better alignment or location, to avoid obstacles, to adjust for equipment size, or to reach a satisfactory outlet (Figure 18).

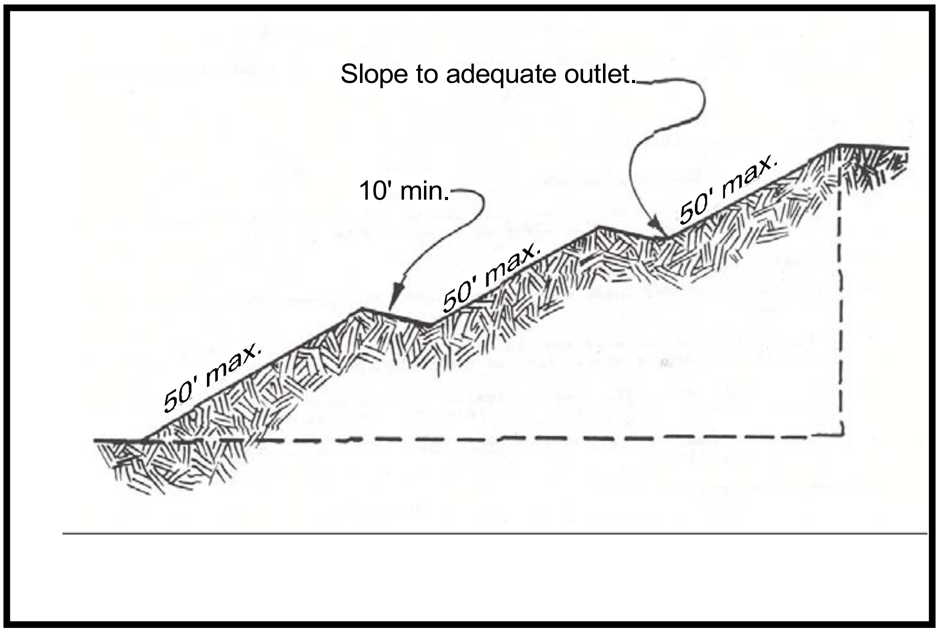


Figure 18. Gradient Terrace.

- The drainage area above the top should not exceed the area that would be drained by a terrace of equal length with normal spacing.
- **Capacity** – The terrace should have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping. Alternatively, use the 50 percent annual probability flow (2-year recurrence interval) using a 5-minute time step, indicated by an approved continuous runoff model.

- **Cross-Section** – The terrace cross-section should be proportioned to fit the land slope. The ridge height should include a reasonable settlement factor. The ridge should have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel should be 8 square feet for land slopes of 5 percent or less, 7 square feet for slopes from 5 to 8 percent, and 6 square feet for slopes steeper than 8 percent. The terrace can be constructed wide enough to be maintained using a small cat.

4.2.11.6 Maintenance

- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

4.2.12 BMP E2.55: Bioengineered Protection of Very Steep Slopes

4.2.12.1 Definition

Steep slope protection using a combination of vegetative and mechanical measures.

4.2.12.2 Purpose

To stabilize steep banks.

4.2.12.3 Conditions Where Practice Applies

Slopes of steep grade, cut and fill banks, and unstable soil conditions that cannot be stabilized using ordinary vegetative techniques.

4.2.12.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

There are a number of manufacturers who provide prefabricated bioengineered devices for the protection of steep slopes.

4.2.12.5 Design Criteria

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

The following bioengineering methods can be used after slopes have been protected by diversion of runoff (covered in BMP E2.80) or through the gradient terraces (BMP E2.50).

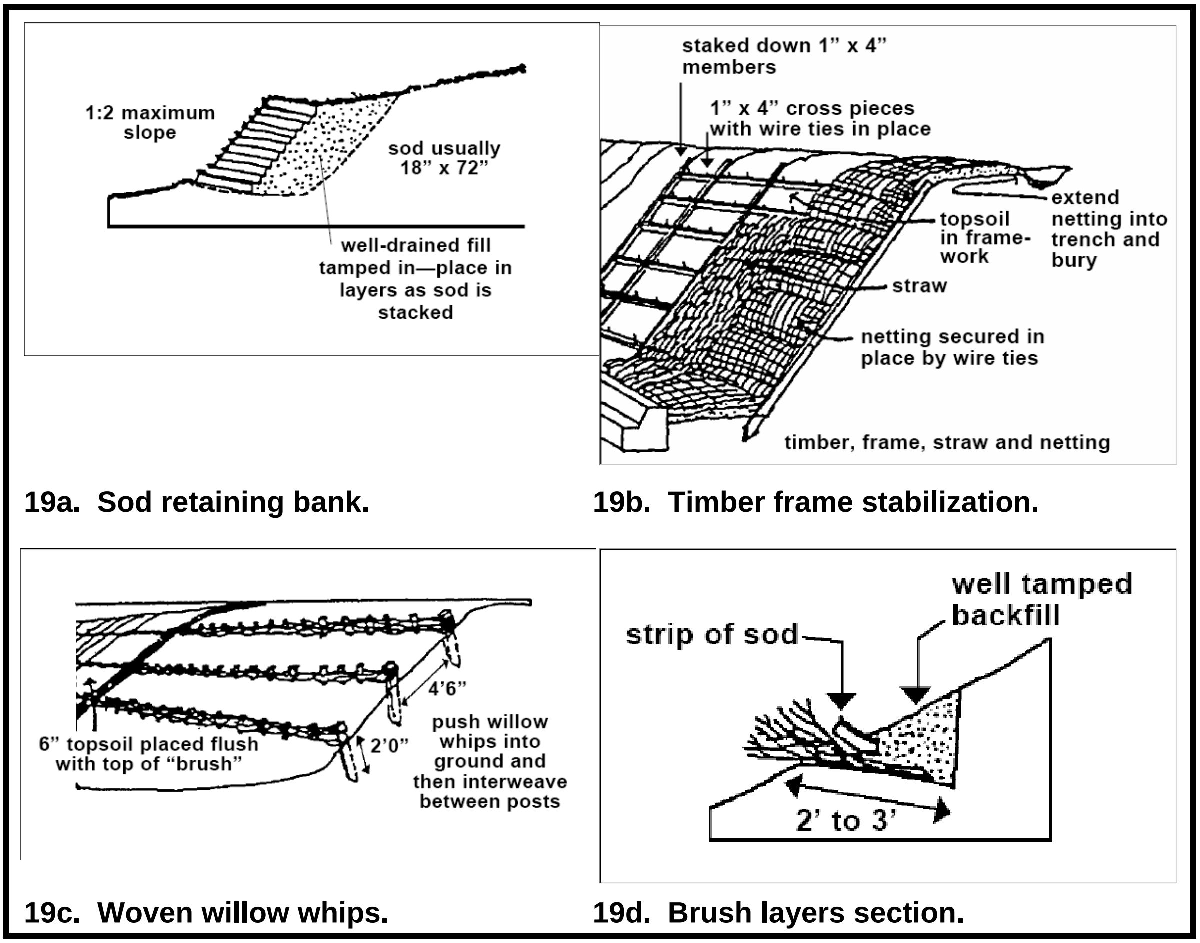
- **Sod walls** or retaining banks are used to stabilize terraces. Sod is piled by tilting it slightly toward the slope and should be backfilled with soil and compacted as they are built up. Sod walls can be as steep as 7 percent but should not be higher than 5 feet (Figure 19a).
- **Timber frame stabilization** is effective on gradients up to 45 percent and involves the following steps in construction:
    - Lay soil retarding frames of 2 by 4 inch vertical members and 1 by 4 inch horizontal members on slopes. Frames on slopes over 15 feet in length need to be anchored to slope to prevent buckling.
    - Attach 14 gauge galvanized tire wires for anchoring wire mesh.

  - Fill frames with moist topsoil and compact the soil.
  - Spread straw 6 inches deep over slope.
  - Cover straw with 14 gauge 4-inch mesh galvanized reinforced wire.
  - Secure wire mesh at least 6 feet back of top slope.
  - Plant ground cover plants through straw into topsoil (Figure 19b).

- **Woven willow whips** (Figure 19c) may be used to form live barriers for immediate erosion control. Construction:
  - 3 foot poles are spaced at 5 foot distances and driven into the slope to a depth of 2 feet.
  - 2 foot willow sticks are inserted between poles at 1 foot distances.
  - Live willow branches of 5 foot length are sunk to a depth of 1 inch and interwoven with poles and stocks.
  - Spaces between the woven 'fences' are filled with topsoil. Fences are generally arranged parallel to the slope or in a grid pattern diagonal to the direction of the slope.
- **Berm Planting:**
  - Excavate ditches from 3 to 5 feet apart along the slope and shape a berm on the downslope side. Construct ditches with 5 percent longitudinal slope.
  - Plant rooted cuttings on 3 foot centers and mulch. Suitable trees are willow, alder, birch, pine, and selected shrubs. In extremely dry situations, rooted cuttings can be planted in biodegradable plastic bags that are watered at the time of planting.
- **Brush Layers:**
  - Prepare 3 foot "niches" as shown.
  - Lay unrooted 5 foot live branches of willow or poplar at close spacing.
  - Starting at foot of slope, backfill lower ditch with excavated material from ditch above it. Operation should be carried out during dormant season (Figure 19d).

4.2.12.6 Maintenance

- Regardless of the stabilization method used, inspections should be made on a regular basis to make sure the system is functioning correctly.



19a. Sod retaining bank.

19b. Timber frame stabilization.

19c. Woven willow whips.

19d. Brush layers section.

Figure 19. Bioengineered Protection of Very Steep Slopes.

4.2.13 BMP E2.60: Channel Lining

4.2.13.1 Definition

To protect erodible channels by providing a channel liner using erosion control mats, riprap, or other armoring.

4.2.13.2 Purpose

When natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion, channel lining will slow the velocity of concentrated runoff or stabilize slopes with seepage problems and/or non-cohesive soils by placement of large, loose, angular stone and/or erosion control mats (Figures 20a and 20b).

Figure 20a. Channel Lining with Jute Matting.

Figure 20b. Channel Lining with Angular Stone.

4.2.13.3 Conditions Where Practice Applies

- No work shall be done in-stream without a Hydraulic Project Approval from the Washington State Department of Fish and Wildlife.
- When a permanent ditch or pipe system is to be installed, or an existing channel is failing due to high velocity scoring.
- In almost all cases, synthetic and organic coconut blankets are more effective than riprap for protecting channels from erosion. Blankets can be used with and without vegetation. Blanketed channels can be designed to handle any expected flow and longevity requirement. Some synthetic blankets have a predicted life span of 50 years or more, even in sunlight.
- Other reasons why blankets are better than rock include the availability of blankets over rock. In many areas of the state, rock is not easily obtainable or is very expensive to haul to a site. Blankets can be delivered anywhere. Rock requires the use of dump trucks to haul and heavy equipment to place. Blankets usually only require laborers with hand tools, and sometimes a backhoe.
- The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent or the shear stress exceeds 8 pounds per square feet.

4.2.13.4 Planning Considerations

Since riprap is used where erosion potential is high, construction must be sequenced so that the lining is put in place with the minimum possible delay.

Disturbance of areas where the lining is to be placed should be undertaken only when final preparation and placement of the lining can follow immediately behind the initial disturbance.

4.2.13.5 Design Criteria

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer’s approval.

See BMP E1.15 for information on blankets. Although this BMP is categorized as a temporary cover practice, some blankets meet the design criteria for permanent erosion control. Refer to the manufacturer’s specifications for design life expectations.

- The designer, after determining the riprap size that will be stable under the flow conditions, shall consider that size to be a minimum size and then, based on riprap gradations actually available in the area, select the size or sizes that equal or exceed the minimum size.

- Stone for riprap shall consist of field stone or quarry stone of approximately rectangular shape. The stone shall be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering and it shall be suitable in all respects for the purpose intended.
- Rubble concrete may be used provided it has a density of at least 150 pounds per cubic foot, and otherwise meets the requirements found in this BMP.
- A lining of engineering filter fabric (geotextile) shall be placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. The geotextile should be keyed in at the top of the bank.
- Filter fabric shall not be used on slopes greater than 33 percent as slippage may occur. It should be used in conjunction with a layer of coarse aggregate (granular filter blanket) when the riprap to be placed is 12 inches and larger.

4.2.13.6 Maintenance

- Riprap coverings should be inspected on a regular basis and after every large storm event.

4.2.14 Temporary or Permanent Erosion Control BMPs

There is a subset of Erosion Control BMPs that may be used as temporary controls during construction, then remain as a permanent erosion control measure. For example, an earth dike and drainage swale would provide siltation control during construction, and remain as permanent protection of downstream properties after construction.

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

The BMPs in this section include:

- BMP E2.65: Pipe Slope Drains (Section 4.2.15)
- BMP E2.70: Subsurface Drains (Section 4.2.16)
- BMP E2.75: Surface Roughening (Section 4.2.17)
- BMP E2.80: Earth Dike and Drainage Swale (Section 4.2.18)
- BMP E2.85: Outlet Protection (Section 4.2.19)
- BMP E2.90: Grass-lined Channels (Section 4.2.20)
- BMP E2.95: Turbidity Curtain (Section 4.2.21)

The requirements for maintaining permanent BMPs are included with each description; however, all temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

4.2.15 BMP E2.65: Pipe Slope Drains

4.2.15.1 Definition

A pipe extending from the top to the bottom of a cut or fill slope and discharging into a stabilized watercourse or a sediment trapping device or onto a stabilization area.

4.2.15.2 Purpose

To carry concentrated runoff down steep slopes without causing gullies, channel erosion, or saturation of slide-prone soils (Figure 21).

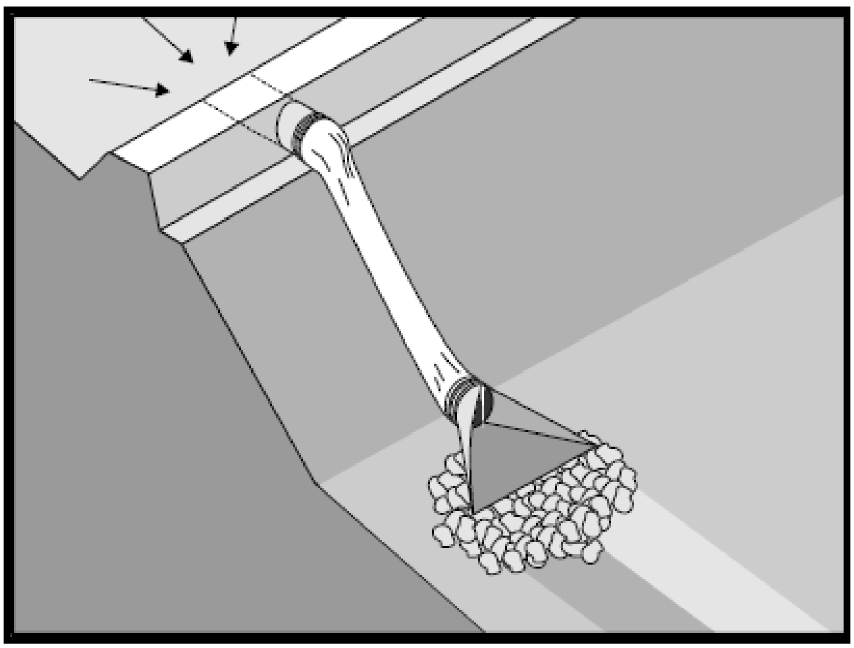


Figure 21. Schematic of a Pipe Slope Drain.

4.2.15.3 Conditions Where Practice Applies

Where a temporary measure is needed for conveying runoff down a slope without causing erosion. A permanent measure requires inclusion in the project drainage plan and must be designed by a Professional Engineer.

On highway projects, slope drains should be used at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches.

4.2.15.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

There is often a significant lag between the time a cut or fill slope is completed and the time a permanent drainage system can be installed. During this period, the slope is usually not stabilized and is particularly vulnerable to erosion. This situation also occurs on slope construction that is temporarily delayed before final grade is reached. Temporary slope drains can provide valuable protection of exposed slopes until permanent drainage structures can be installed. When used in conjunction with diversion dikes, temporary slope drains can be used to convey stormwater from the entire drainage area above a slope to the base of the slope without erosion. It is very important that these temporary structures be installed properly since their failure will often result in severe gully erosion. The entrance section must be securely entrenched, all connections must be watertight, and the conduit must be staked securely.

Additional requirements for steep slopes are included in the Environmentally Critical Area Ordinance at SMC 25.09.180.

4.2.15.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent slope drains should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements outlined below require an engineer's approval.

- The capacity for temporary drains shall be sufficient to handle a 10-year, 24-hour peak flow. Alternatively, use the 10 percent annual probability flow (10-year recurrence interval) using a 5-minute time step, indicated by an approved continuous runoff model. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using WWHM, bare soil areas should be modeled as "landscaped area." See Volume 3, Chapter 6, for additional information on stormwater modeling.
- Re-establish cover immediately on areas disturbed by installation.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- The entrance shall consist of a standard flared end section for culverts 12 inches and larger with a minimum 6-inch metal toe plate to prevent runoff from undercutting the pipe inlet. The slope of the entrance shall be at least 3 percent (Figure 22).

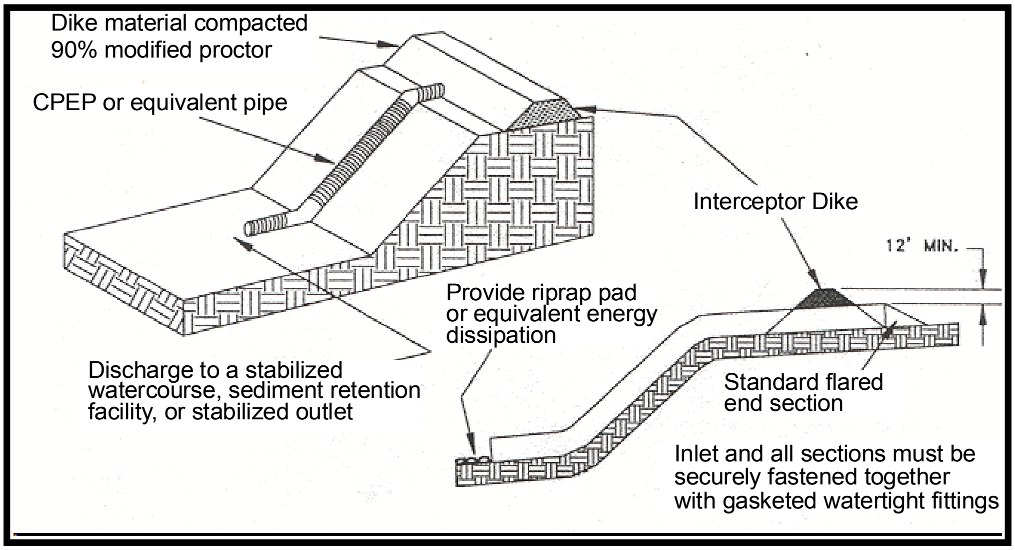


Figure 22. Pipe Slope Drain Details.

- Pipe size should be no greater than 6 inches. Intercept flow frequently by using multiple pipe slope drains. Multiple pipes should be no closer than 10 feet.
- The soil around and under the pipe and entrance section shall be thoroughly compacted to prevent undercutting.
- The flared inlet section shall be securely connected to the slope drain and have watertight connecting bands.
- Slope drain sections shall be securely fastened together and have gasketed watertight fittings, and be securely anchored into the soil.
- Thrust blocks should be installed any time 90 degree bends are utilized. Depending on size of pipe and flow, these can be constructed with sand bags, straw bales staked in place, “t” posts and wire, or ecology blocks.
- Pipe needs to be secured along its full length to prevent movement. This can be done with steel “t” posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10 to 20 feet of pipe length or so, depending on the size of the pipe and quantity of water diverted.
- Earth dikes shall be used to direct runoff into a slope drain. The height of the dike shall be at least 1 foot higher at all points than the top of the inlet pipe.
- Any excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.
- The area below the outlet must be stabilized with a riprap apron (see BMP E2.85 Outlet Protection, for the appropriate outlet material).

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Refer to the City of Seattle Standard Specifications for all material specifications (http://www.seattle.gov/util/Engineering/Standard_Plans_&_Specs/index.asp).

4.2.15.6 Maintenance

- Check inlet and outlet points regularly, especially after heavy storms. The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, reinforce the headwall with compacted earth or sand bags. The outlet point should be free of erosion and installed with appropriate outlet protection (see BMP E2.85).
- For permanent installations, inspect pipe periodically for vandalism and physical distress such as slides and wind-throw.
- Normally the pipe slope is so steep that clogging is not a problem with smooth wall pipe; however, debris may become lodged in the pipe.

4.2.16 BMP E2.70: Subsurface Drains

4.2.16.1 Definition

A perforated conduit such as a pipe, tubing, or tile installed beneath the ground to intercept and convey ground water.

4.2.16.2 Purpose

To provide a dewatering mechanism for draining excessively wet, sloping soils—usually consisting of an underground-perforated pipe that will intercept and convey ground water.

4.2.16.3 Conditions When Practice Applies

- Wherever excessive water must be removed from the soil. The soil must be deep and permeable enough to allow an effective system to be installed.

4.2.16.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Subsurface drainage systems are of two types; relief drains and interceptor drains. Relief drains are used either to lower the water table in order to improve the growth of vegetation, or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern.

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout.

4.2.16.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

- The depth of an interceptor drain is determined primarily by the depth to which the water table is to be lowered or the depth to a confining layer.

For practical reasons, the maximum depth is usually limited to 6 feet, with a minimum cover of 2 feet to protect the conduit.

- The soil should have depth and sufficient permeability to permit installation of an effective drainage system at a depth of 2 to 6 feet.
- An adequate outlet for the drainage system must be available either by gravity or by pumping.
- The quantity and quality of discharge needs to consider the ultimate receiving water (additional detention may be required).
- This standard does not apply to subsurface drains for building foundations or deep excavations.
- The capacity of an interceptor drain is determined by calculating the maximum rate of ground water flow to be intercepted. Therefore, it is good practice to make completed subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.
- Subsurface drains shall be sized for the required capacity without pressure flow. The minimum diameter for a subsurface drain shall be 4 inches.
- The minimum velocity required to prevent silting is 1.4 ft/sec. The line shall be graded to achieve at least this velocity. The maximum allowable velocity using a sand-gravel filter or envelope is 9 ft/sec.
- Filter material and fabric shall be used around all drains for proper bedding and filtration of fine materials. Envelopes and filters should surround the drain to a minimum of 3-inch thickness.
- The outlet of the subsurface drain shall empty into a sediment trap or pond. If free of sediment, it can empty into a receiving water, swale, or stable vegetated area adequately protected from erosion and undermining.
- The strength and durability of the pipe shall meet the requirements of the site in accordance with the manufacturer's specifications.
- Secure an animal guard to the outlet end of the pipe to keep out rodents.
- Use outlet pipe of corrugated metal, cast iron, or heavy-duty plastic without perforations and at least 10 feet long. Do not use an envelope or filter material around the outlet pipe, and bury at least two-thirds of the pipe length.
- When outlet velocities exceed those allowable for the receiving water, outlet protection must be provided.

Construction Specifications

- The trench shall be constructed on a continuous grade with no reverse grades or low spots.
- Soft or yielding soils under the drain shall be stabilized with gravel or other suitable material.
- Deformed, warped, or otherwise unsuitable pipe shall not be used.
- Filter material shall be placed as specified with at least 3 inches of material on all sides of the pipe.
- Backfilling shall be done immediately after placement of the pipe. No sections of pipe shall remain uncovered overnight or during a rainstorm. Backfill material shall be placed in the trench in such a manner that the drainpipe is not displaced or damaged.

4.2.16.6 Maintenance

- Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment.
- The outlet shall be kept clean and free of debris.
- Surface inlets shall be kept open and free of sediment and other debris.
- Trees located too close to a subsurface drain often clog the system with their roots. If a drain becomes clogged, relocate the drain or remove the trees as a last resort. Drain placement should be planned to minimize this problem.
- Where heavy vehicles cross drains, the line shall be checked to ensure that it is not crushed.

4.2.17 BMP E2.75: Surface Roughening

4.2.17.1 Definition

Provision of a rough soil surface with horizontal depressions created by operating a tiller or other suitable equipment on the contour or by leaving slopes in a roughened condition by not fine grading them.

4.2.17.2 Purpose

To aid in establishment of vegetative cover, reduce runoff velocity, increase infiltration, and provide for sediment trapping.

4.2.17.3 Conditions Where Practice Applies

- All slopes steeper than 18 percent, and greater than 5 vertical feet, require surface roughening; either stair-step grading, grooving, furrowing, or tracking if they are to be stabilized with vegetation.
- Areas with grades steeper than 18 percent should be roughened to a depth of 2 to 4 inches prior to seeding.
- Areas that will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place.
- Slopes with a stable rock face do not require roughening.
- Slopes where mowing is planned should not be excessively roughened.

4.2.17.4 Planning Considerations

> The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

Graded areas with smooth, hard surfaces give a false impression of “finished grading” and a job well done. It is difficult to establish vegetation on such surfaces due to reduced water infiltration and the potential for erosion. Rough slope surfaces with uneven soil and rocks left in place may appear unattractive or unfinished at first, but they encourage water infiltration, speed the establishment of vegetation, and decrease runoff velocity.

Rough, loose soil surfaces give lime, fertilizer, and seed some natural coverage. Niches in the surface provide microclimates that generally provide a cooler and more favorable moisture level than hard flat surfaces; this aids seed germination.

There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope.

Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each "step" catches material that sloughs from above, and provides a level site where vegetation can become established. Stairs should be wide enough to work with standard earth moving equipment.
- Areas that will be mowed (these areas should have slopes less steep than 18 percent) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all, but is not as effective as other forms of roughening, as the soil surface is severely compacted and runoff is increased.

4.2.17.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

Graded areas with slopes greater than 18 percent but less than 25 percent should be roughened before seeding (Figure 23). This can be accomplished in a variety of ways, including "track walking," or driving a crawler tractor up and down the slope, leaving a pattern of cleat imprints parallel to slope contours.

Graded areas steeper than 25 percent should be stair-stepped with benches as shown in Figure 23. The stair-stepping will help vegetation become established and also trap soil eroded from the slopes above.

4.2.17.6 Maintenance

- Areas graded in this manner should be seeded as quickly as possible.
- Regular inspections should be made of the area. If rills appear, they should be re-graded and re-seeded immediately.

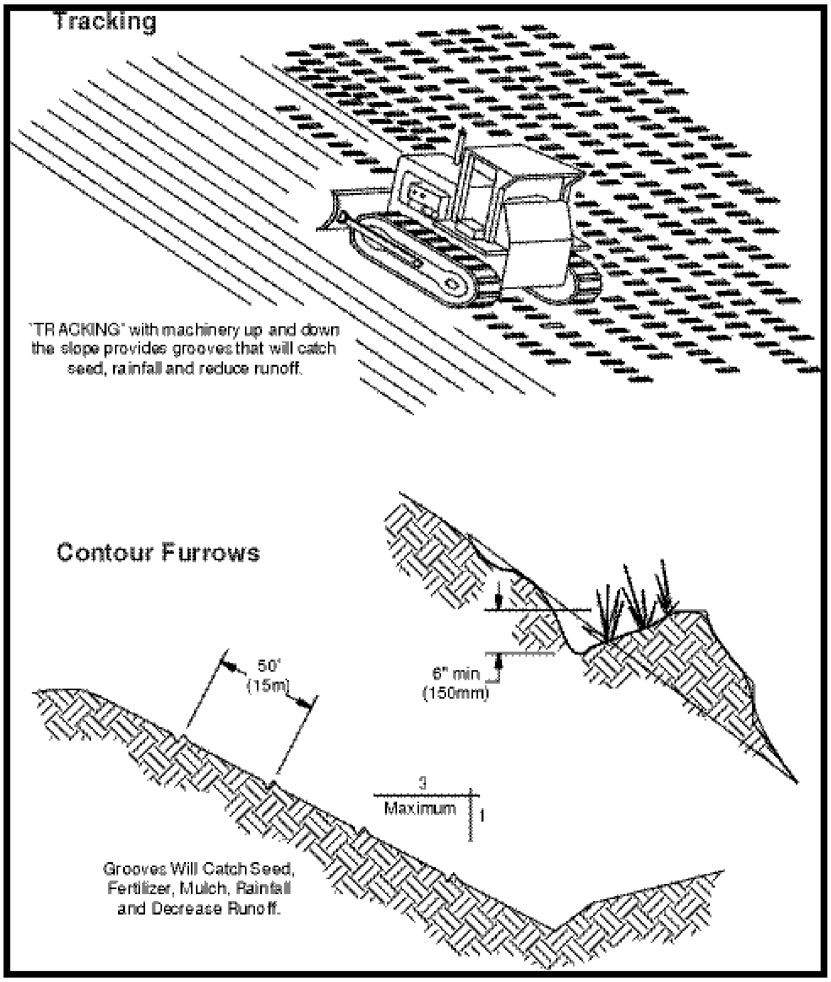


Figure 23. Surface Roughening by Tracking and Contour Furrows.

4.2.18 BMP E2.80: Earth Dike and Drainage Swale

4.2.18.1 Definition

A ridge of compacted soil or a swale with vegetative lining located at the top or base of a sloping disturbed area.

4.2.18.2 Purpose

To intercept storm runoff from drainage areas above unprotected slopes and direct it to a stabilized outlet.

4.2.18.3 Conditions Where Practice Applies

Where the volume and velocity of runoff from exposed or disturbed slopes must be reduced. When an earth dike/drainage swale is placed above a disturbed slope, it reduces the volume of water reaching the disturbed area by intercepting runoff from above (Figure 24). When it is placed horizontally across a disturbed slope, it reduces the velocity of runoff flowing down the slope by reducing the distance that the runoff can flow directly downhill.

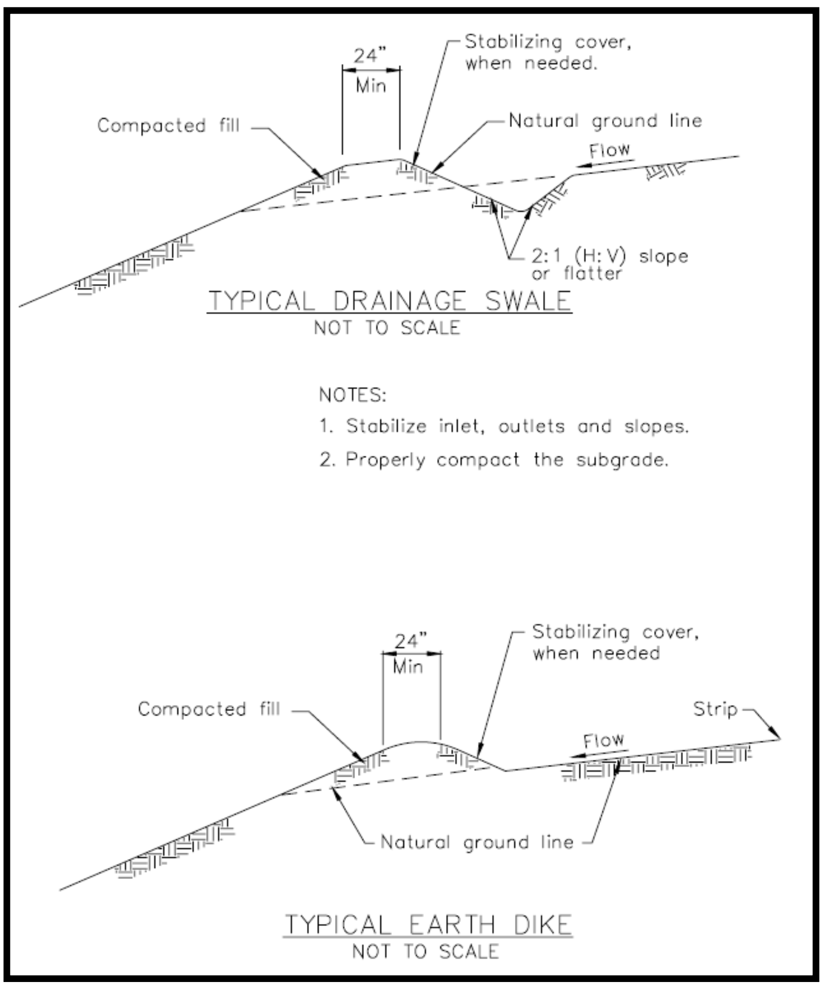


Figure 24. Earth Dike and Drainage Swale.

4.2.18.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

A temporary diversion dike or swale is intended to divert overland sheet flow to a stabilized outlet or a sediment trapping facility during establishment of permanent stabilization on a sloping disturbed area. When used at the top of a slope, the structure protects exposed slopes by keeping upland runoff away. When used at the base of a slope, the structure protects adjacent and downstream areas by diverting sediment-laden runoff to a sediment trapping facility.

If the dike or swale is going to remain in place for longer than 15 days, it shall be stabilized with temporary or permanent vegetation. The slope behind the dike or swale is also an important consideration. The dike or swale must have a positive grade to assure drainage, but if the slope is too great, precautions including channel protection and check dams must be taken to prevent erosion due to high velocity of flow.

This practice is considered an economical one because it uses material available on the site and can usually be constructed with equipment needed for site grading. Stabilizing the dike or swale with vegetation can extend the useful life of the practice.

4.2.18.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

- Review construction for areas where overtopping may occur.
- Sub-basin tributary area should be one acre or less.
- Earth dikes shall meet the criteria in Table 9.
- Drainage swales shall meet the criteria in Table 10.
- An 8- or 12-inch diameter compost sock may also be used.

4.2.18.6 Maintenance

- The measure should be inspected after every major storm and repairs made as necessary. Damage caused by construction traffic or other activity must be repaired before the end of each working day.

Table 9. Design Criteria for Earth Dike.

Feature	Requirement
Top Width	2 foot minimum
Height	18 inch minimum measured from upslope toe and at a compaction of 90 percent ASTM D698 standard proctor
Side Slopes	25 percent or flatter
Grade	Topography dependent, except that dike shall be limited to grades between 0.5 and 1.0 percent
Horizontal Spacing of Earth Dikes	• Slopes less than 5 percent = 300 feet • Slopes 5-10 percent = 200 feet • Slopes 10-40 percent = 100 feet
Stabilization	• Slopes = less than 5 percent. Seed and mulched construction (see BMPs E1.10 and E1.15) • Slopes = 5 to 40 percent. Dependent on runoff velocities and dike materials • Stabilization should be done immediately using either sod or riprap to avoid erosion
Outlet	The upslope side of the dike shall provide positive drainage to the dike outlet. No erosion shall occur at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
Other	Minimize construction traffic over temporary dikes

Table 10. Design Criteria for Drainage Swale.

Feature	Requirement
Bottom Width	2 foot minimum. Bottom shall be level.
Depth	1 foot min.
Side Slopes	25 percent or flatter
Grade	5 percent maximum with positive drainage to suitable outlet such as a sediment trap.
Stabilization	Seed as per BMP E1.10 temporary seeding or E2.75. Riprap 12 inches thick pressed into bank and extending at least 8 inches vertical from the bottom.
Stabilization	Slope of disturbed area: Less than 5 percent = 300 feet 5-10 percent = 200 feet 10-40 percent = 100 feet
Outlet	Level spreader or riprap to stabilized outlet/sedimentation pond.

4.2.19 BMP E2.85: Outlet Protection

4.2.19.1 Definition

Structurally lined aprons or other acceptable energy dissipating devices placed at the outlets of pipes or paved channel sections.

4.2.19.2 Purpose

To prevent scour at stormwater outlets, and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

4.2.19.3 Condition Where Practice Applies

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other conveyances, and where runoff is conveyed to a natural or man-made drainage feature such as a stream, wetland, or ditch.

4.2.19.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

An outfall is defined as a concentrated discharge point that directs collected surface water flows into an open drainage feature, natural or man-made. These drainage features include ditches, channels, swales, closed depressions, wetlands, streams, rivers, ponds, lakes, or other open bodies of water. In nearly every case, the outfall will consist of a pipe discharging flows from a storm pipe system, a culvert, or a detention facility.

4.2.19.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer’s approval.

- This section provides general design criteria and installation guidelines for construction site applications. Permanent applications may have additional requirements, as specified in Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.
- No outfall should be allowed without proper permits and approvals.

- The receiving water at the outlet of a culvert shall be protected from erosion by rock lining the downstream and extending up the channel sides above the maximum tail water elevation.
- For large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened as much as four times the diameter of the culvert.
- Standard wing walls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection.
- Organic or synthetic erosion mats, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. However, materials can be chosen using manufacturer product specifications and cross-checked with the City of Seattle Standard Specifications for erosion control materials (Section 9-14).
- With low flows, vegetation (including sod) can be effective, riprap outlet protection is also appropriate in some situations.
- For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used with filter fabric or erosion control mats under riprap to prevent scour and channel erosion.

4.2.19.6 Maintenance

Rock may need to be added if sediment builds up in the pore spaces of the outlet pad.

4.2.20 BMP E2.90: Grass-Lined Channels

4.2.20.1 Definition

A channel with grass lining.

4.2.20.2 Purpose

To provide a channel with a vegetative lining for conveyance of runoff.

4.2.20.3 Conditions Where Practice Applies

This practice applies to construction sites where concentrated runoff needs to be contained to prevent erosion or flooding.

- When a vegetative lining can provide sufficient stability for the channel cross section and at lower velocities of water (normally dependent on grade). This means that the channel slopes are generally less than 4 percent and space is available for a relatively large cross section.
- Typical uses include roadside ditches, channels at property boundaries, outlets for diversions, and other channels and drainage ditches in low areas.
- Channels that will be vegetated should be installed before major earthwork and hydroseeded with a bonded fiber matrix (BFM). The vegetation should be well established (i.e., 75 percent cover) before water is allowed to flow in the ditch. With channels that will have high flows, erosion control mats should be installed over the hydroseed. If vegetation cannot be established from seed before water is allowed in the ditch, sod should be installed in the bottom of the ditch in lieu of hydromulch and mats.

4.2.20.4 Planning Considerations

The City requires that all new, replaced, and disturbed topsoil is amended prior to completion of the project. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for guidance on post-construction soil quality and depth requirements.

- Locate the channel where it can conform to the topography and other features such as roads, using the natural drainage systems to the greatest extent possible.
- Avoid sharp changes in alignment or bends and changes in grade.
- To the extent practicable, do not reshape the landscape to fit the drainage channel.
- Provide outlet protection at culvert ends and at channel intersections.

4.2.20.5 Design Criteria

Temporary measures that may also remain as a permanent erosion control are typically implemented during construction activities.

Permanent BMPs should be designed by an engineer and may have additional criteria for flow and water quality treatment requirements. Variations or alterations to the minimum BMP requirements require an engineer's approval.

- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 3 feet/second. The channel shall not be overtopped by the peak runoff from a 10-year, 24-hour storm. Alternatively, use the 10 percent annual probability flow (10-year recurrence interval) using a 5-minute time step, indicated by an approved continuous runoff model. The hydrologic analysis shall use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis shall use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using WWHM, bare soil areas should be modeled as "landscaped area." See Volume 3, Chapter 6, for additional information on stormwater modeling.
- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, consult Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for additional information on channel conveyance and stability considerations.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or mats.
- If design velocity of a channel to be vegetated by seeding exceeds 2 feet per second, a temporary channel liner is required. Geotextile or special mulch protection such as fiberglass roving or straw and netting provide stability until the vegetation is fully established. See Figure 25.
- Check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4 percent. The area beneath the check dams shall be seeded and mulched immediately after dam removal.
- If vegetation is established by sodding, the permissible velocity for established vegetation may be used and no temporary liner is needed.
- Do not subject grass-lined channel to sedimentation from disturbed areas. Use sediment-trapping BMPs upstream of the channel.
- V-shaped grass channels generally apply where the quantity of water is small, such as in short reaches along roadsides. The V-shaped cross

section is least desirable because it is difficult to stabilize the bottom where velocities may be high.

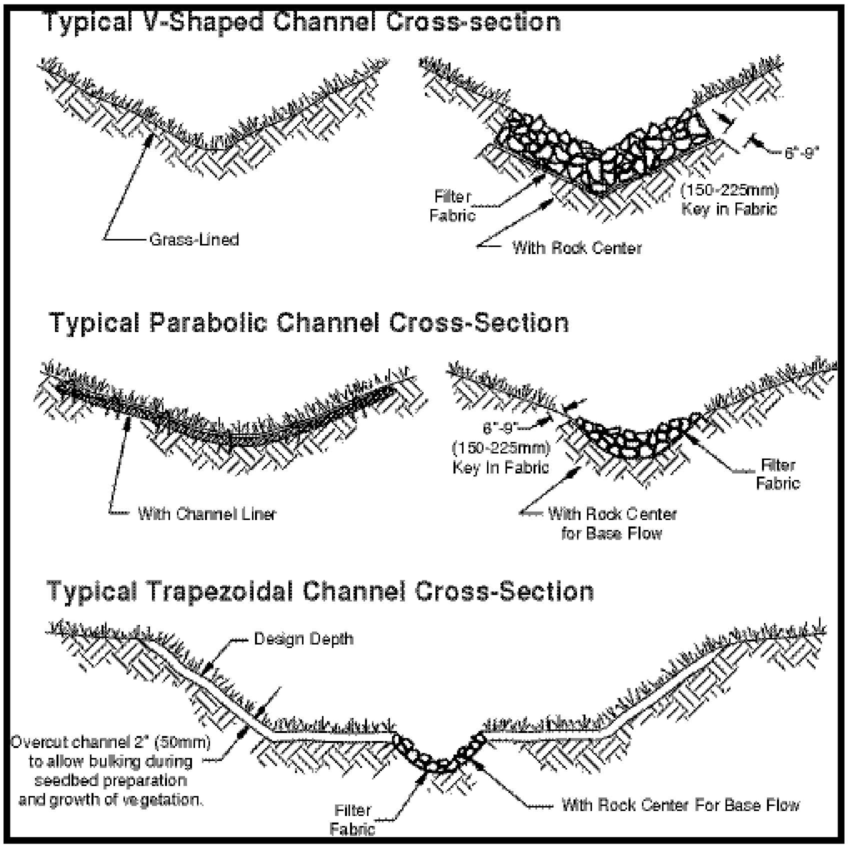


Figure 25. Typical Grass-Lined Channel.

- Trapezoidal grass channels are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. (Note: it is difficult to construct small parabolic shaped channels.)
- Subsurface drainage, or riprap channel bottoms, may be necessary on sites subject to prolonged wet conditions due to long duration flows or a high water table.
- Grass channels, at a minimum, should carry peak runoff for temporary construction drainage facilities from the 10-year, 24-hour storm without eroding. Alternatively, use the 10 percent annual probability flow (10-year recurrence interval) using a 5-minute time step, indicated by an approved continuous runoff model. Where flood hazard exists, increase the capacity according to the potential damage.
- Grassed channel side slopes generally are constructed 18 percent or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

4.2.20.6 Maintenance

- During the establishment period, check grass-lined channels after every rainfall.
- After grass is established, periodically check the channel; check it after every heavy rainfall event. 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.

Remove all significant sediment accumulations to maintain the designed carrying capacity. Keep the grass in a healthy, vigorous condition at all times, since it is the primary erosion protection for the channel.

4.2.21 BMP E2.95 Turbidity Curtain

4.2.21.1 Definition

A turbidity curtain is a plastic or other appropriate barrier used to isolate the near shore work area. The barriers are intended to confine the suspended sediment.

4.2.21.2 Purpose

The curtain is a floating barrier, and thus does not prevent water from entering the isolated area; rather, it prevents suspended sediment from getting out.

4.2.21.3 Conditions Where Practice Applies

Turbidity curtains are used when construction activities adjoin quiescent waters (e.g., lakes, ponds, and slow flowing creeks) where sediment discharge to the receiving water is unavoidable. The curtain is designed to deflect and contain sediment within a limited area and provide sufficient retention time so that the sediment particles will fall out of suspension.

4.2.21.4 Planning Considerations

Turbidity curtains should not be used in flowing water; they are best suited for use in ponds, lakes, and very slow-moving creeks.

In wave and/or tidal conditions, the curtain should extend to a depth that does not stir up sediment by hitting the bottom repeatedly. If it is desirable for the curtain to reach the bottom in an active-water situation, a pervious filter fabric may be used for the bottom 1 foot.

Turbidity curtains should not be placed across the width of a channel.

Consider the removal procedure carefully. If may create more of a sediment problem through re-suspension of the particles or by accidental dumping of material.

4.2.21.5 Design Criteria

Turbidity curtains should be oriented parallel to the direction of flow and extend the entire depth of the watercourse in calm-water situations.

The top of the curtain should consist of flexible flotation buoys, and the bottom should be held down by a load line incorporated into the curtain fabric. The fabric should be a brightly colored impervious mesh.

Place one anchor at least every 100 feet, or as needed, then tow the fabric out in a furled condition, and connect to the anchors using the flotation devices, not to the bottom of the curtain. Once in place, cut the furling lines and allow the bottom of the curtain to sink.

Particles should always be allowed to settle for a minimum of 6 to 12 hours prior to their removal or prior to removal of the turbidity curtain.

4.2.21.6 Maintenance

The curtain should be inspected for holes or other problems, and any repairs needed should be made promptly.

After removing sediment, allow remaining suspended particles to settle for 6 to 12 hours before removing the sediment curtain.

To remove, install furling lines along the curtain, detach from anchors, and tow out of the water.

4.3 Sediment Control Practices

Sediment retention practices for construction activities are temporary controls only. Permanent sediment retention requires following a separate process for flow and, typically, treatment facilities as outlined in Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.

Temporary sediment retention BMPs are described in the sections below and include:

- BMP E3.10: Filter Fence (Section 4.3.1)
- BMP E3.15: Brush Barrier (Section 4.3.2)
- BMP E3.20: Gravel Filter Berm (Section 4.3.3)
- BMP E3.25: Storm Drain Inlet Protection (Section 4.3.4)
- BMP E3.30: Vegetated Strip (Section 4.3.5)
- BMP E3.35: Straw Wattles, Compost Socks, and Compost Berms (Section 4.3.6)
- BMP E3.40: Sediment Trap (Section 4.3.7)
- BMP E3.45: Temporary Sediment Pond (or Basin) (Section 4.3.8)
- BMP E3.50: Portable Sediment Tank (Section 4.3.9)
- BMP E3.55: Construction Stormwater Chemical Treatment (Section 4.3.10)
- BMP E3.60: Construction Stormwater Filtration (Section 4.3.11)
- BMP E3.65: Cleaning Inlets and Catch Basins (Section 4.3.12)
- BMP E3.70: Street Sweeping and Vacuuming (Section 4.3.13).

The requirements for maintaining these BMPs are included with each description; however, all temporary sediment retention practices shall be maintained and repaired as needed to ensure continued performance of their intended function.

Temporary BMPs must be removed within 5 business days after final site stabilization is achieved, or after they are no longer needed, whichever is later. In either case, trapped sediment must be removed or stabilized on site and the disturbed areas permanently stabilized.

4.3.1 BMP E3.10: Filter Fence

4.3.1.1 Definition

A temporary sediment barrier consisting of a filter fabric stretched across and attached to supporting posts and entrenched. The filter fence is constructed of stakes and synthetic filter fabric with a rigid wire fence backing where necessary for support.

4.3.1.2 Purpose

Filter fence is used to intercept and detain small amounts of sediment under sheet flow conditions from disturbed areas during construction operations in order to prevent sediment from leaving the site; and to decrease the velocity of sheet flows (Figure 26).

Figure 26. Filter Fence Installed Adjacent to a Roadway.

4.3.1.3 Conditions Where Practice Applies

Filter fence may be used downslope of all disturbed areas and must be provided just upstream of the point(s) of discharge of runoff from a site, before the flow becomes concentrated. They may also be used below disturbed areas where runoff may occur in the form of sheet and rill erosion; wherever runoff has the potential to impact downstream resources.

4.3.1.4 Planning Considerations

Laboratory work at the Virginia Highway and Transportation Research Council has shown that filter fence can trap a much higher percentage of suspended sediments than can straw bales, and is a preferred method. They must be properly installed to fully function. The installation methods outlined here can improve performance.

4.3.1.5 Design Criteria

Refer to Figure 27 for design details.

- The drainage area must be 1 acre or less or the fence must be used in combination with sediment basin on a larger site.
- Maximum slope steepness on the site (perpendicular to fence line) is 45 percent.
- Maximum sheet or overland flow path length to the fence is 100 feet.
- Concentrated flows shall not be greater than 0.5 cubic feet per second.
- Selection of a filter fabric is based on soil conditions at the construction site (which affect the apparent opening size [AOS] fabric specification) and characteristics of the support fence (which depend on the choice of tensile strength). The designer shall specify a filter fabric that retains the soil found on the construction site yet will have openings large enough to permit drainage and prevent clogging.
- The material used in a filter fabric fence must have sufficient strength to withstand various stress conditions and the ability to pass flow through must be balanced with the material's ability to trap sediments.
- Non-woven and regular strength slit film fabrics shall be supported with wire mesh. Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 degrees Fahrenheit (°F) to 120°F.

Selection of the AOS:

- Because of the properties of soils in the Puget Sound basin, field work must determine the optimum AOS for filter fence installations. Many soils in this area contain both cobbles and fines. If a Soil Conservation Service (SCS) standard soil description is used (e.g., Alderwood gravelly sandy loam), the AOS specified will not be sufficient to trap the finer particles of soil. Including gravels and larger sizes skews the results towards an AOS that is too small to capture suspended settleable solids and reduce Total Suspended Solids (TSS). Monofilament and non-woven geotextiles must have a minimum AOS of 70 when used in glacial soils. Composites and slit film fabrics must be extra-strength to perform similarly; in their case the AOS range may be from 40 to 60. In areas where Mazama ash is plentiful in the soil profile, a larger AOS will be necessary, or, fabric with an AOS of 70 should be used for outwash soils.

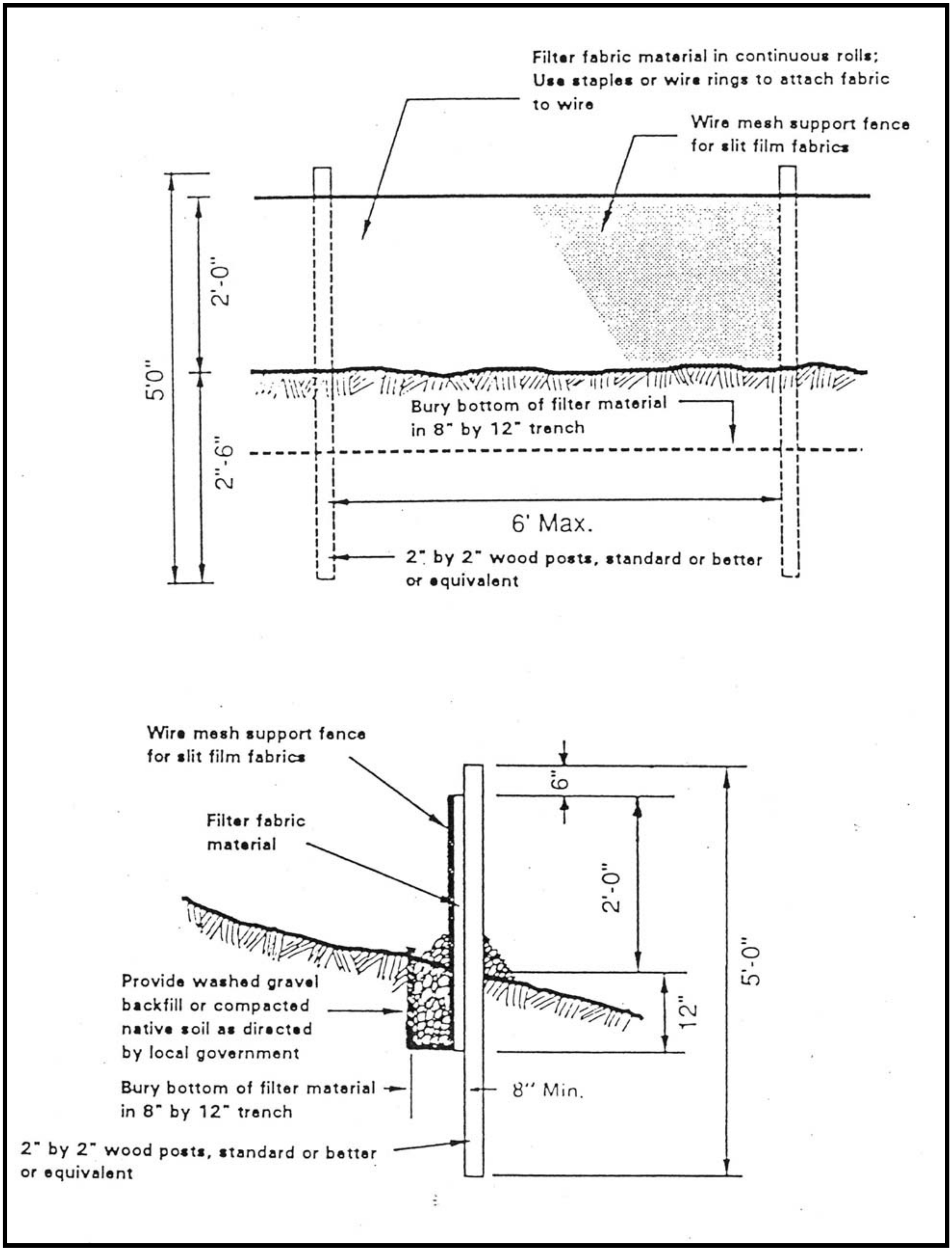


Figure 27. Silt Fence Details.

- For all other soil types, the AOS should be determined by first passing soil through a #10 sieve (2.0 millimeters). Based on the amount of the remaining soil, by weight, which passes through a U.S. standard sieve No. 200, select the AOS to retain 85 percent of the soil. Where direct discharge to a stream, lake, or wetland will occur.

The following design details should be included with a Large Project Stormwater Pollution Control Plan (Section 2.3):

- The filter fabric shall be purchased in a continuous roll cut to the length of the barrier to avoid use of joints. When joints are necessary, filter cloth shall be spliced together only at a support post, with a minimum 6-inch overlap, and both ends shall be securely fastened to the post.
- Posts shall be spaced a maximum of 6 feet apart and driven securely into the ground a minimum of 30 inches (where physically possible).
- A trench shall be excavated approximately 8 inches wide and 12 inches deep along the line of posts and upslope from the barrier. The trench shall be constructed to follow the contour.
- When slit film filter fabric is used, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires, or hog rings. The wire shall extend into the trench a minimum of 4 inches and shall not extend more than 36 inches above the original ground surface.
- Slit film filter fabric shall be wired to the fence, and 20 inches of the fabric shall extend into the trench. The fabric shall not extend more than 36 inches above the original ground surface. Filter fabric shall not be stapled to existing trees. Other types of fabric may be stapled to the fence.
- When extra-strength or monofilament fabric and closer post spacing are used, the wire mesh support fence may be eliminated. In such a case, the filter fabric is stapled or wired directly to the posts. Extra care should be used when joining or overlapping these stiffer fabrics.
- Use properly compacted native material. This is the preferred alternative because the soil forms a more continuous contact with the trench below, and use of native materials cuts down on the number of trips that must be made on and off-site.
- Filter fabric fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized. Retained sediment must be removed and properly disposed of, or mulched and seeded.

4.3.1.6 Maintenance

- Inspect immediately after each rainfall, and at least daily during prolonged rainfall. Repair as necessary.

- Sediment must be removed when it reaches approximately one-third the height of the fence.
- Any sediment deposits remaining in place after the filter fence is no longer required shall be spread to conform to the existing grade, prepared and seeded.

4.3.2 BMP E3.15: Brush Barrier

4.3.2.1 Definition

A temporary sediment barrier constructed at the perimeter of a disturbed area from materials obtained from clearing and grubbing the project site.

4.3.2.2 Purpose

To intercept and retain sediment from limited disturbed areas.

4.3.2.3 Conditions Where Practice Applies

Downslope of disturbed areas of less than one-quarter acre subject to sheet and rill erosion, where enough brush material is available for construction of such a barrier. Note: This does not replace a sediment trap or pond.

4.3.2.4 Planning Considerations

Organic litter and spoil material from site clearing operations is usually hauled away to be dumped elsewhere. Much of this material can be used effectively on the construction site itself. During clearing and grubbing operations, equipment can push or dump the mixture of limbs, small vegetation, and root mat along with minor amounts of soil and rock into windrows along the toe of a slope where erosion and accelerated runoff are expected. Anchoring a filter fabric over the berm enhances the filtration ability of the barrier. Because brush barriers are fairly stable and composed of natural materials, maintenance requirements are small. Material containing large amounts of wood chips should not be used because of the potential for leaching from the chips.

4.3.2.5 Design Criteria

- Height 2 feet (minimum) to 5 feet (maximum).
- Width 5 feet at base (minimum) to 15 feet (maximum).
- Filter fence fabric anchored over the brush barrier will enhance its filtration capacity.
- Further design details are illustrated in Figure 28.

4.3.2.6 Maintenance

- Brush barriers generally require little maintenance, unless there are very heavy deposits of sediment. Occasionally, tearing of the fabric may occur.
- When the barrier is no longer needed, the fabric can be removed to allow natural establishment of vegetation within the barrier, if desired. The barrier will rot away over time.

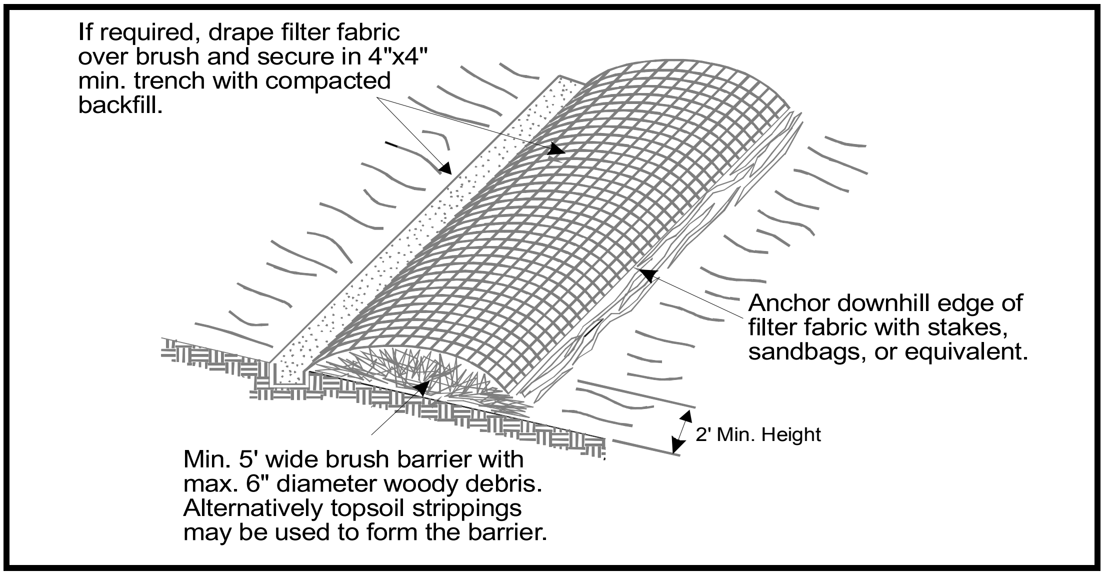


Figure 28. Brush Barrier.

4.3.3 BMP E3.20: Gravel Filter Berm

4.3.3.1 Definition

A raised gravel berm or mound constructed in traffic areas.

4.3.3.2 Purpose

To keep sediment away from traffic areas by filtering runoff through gravel or crushed rock.

4.3.3.3 Conditions Where Practice Applies

- This BMP should be placed on private property only and is not allowed in the public right-of-way.
- Where a temporary measure is needed to retain sediment from traffic areas within the project site.

4.3.3.4 Design Criteria

- Berm material shall be 3/4 to 3 inches in size, washed, well-graded gravel or crushed rock with less than 5 percent fines.
- Spacing of berms, perpendicular to the flow of traffic:
  - Every 300 feet on slopes less than 5 percent
  - Every 200 feet on slopes between 5 and 10 percent
  - Every 100 feet on slopes greater than 10 percent.
- Berm dimensions:
  - 1 foot high with 18 percent side slopes
  - 8 linear feet per 1 cubic feet per second runoff based on the 10-year, 24-hour design storm.

4.3.3.5 Maintenance

- Regular inspection is required; sediment shall be removed and filter material replaced when it becomes clogged.

4.3.4 BMP E3.25: Storm Drain Inlet Protection

4.3.4.1 Definition

A sediment filter or an excavated impounding area around a storm drain or catch basin.

4.3.4.2 Purpose

To prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

4.3.4.3 Conditions Where Practice Applies

All methods for storm drain inlet protection are prone to plugging and require a high frequency of maintenance.

Conditions include when storm drain inlets are operational before permanent stabilization of the disturbed drainage area. Protection should be provided for all storm drain inlets downslope, and within 500 feet or a block, whichever is further, of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap.

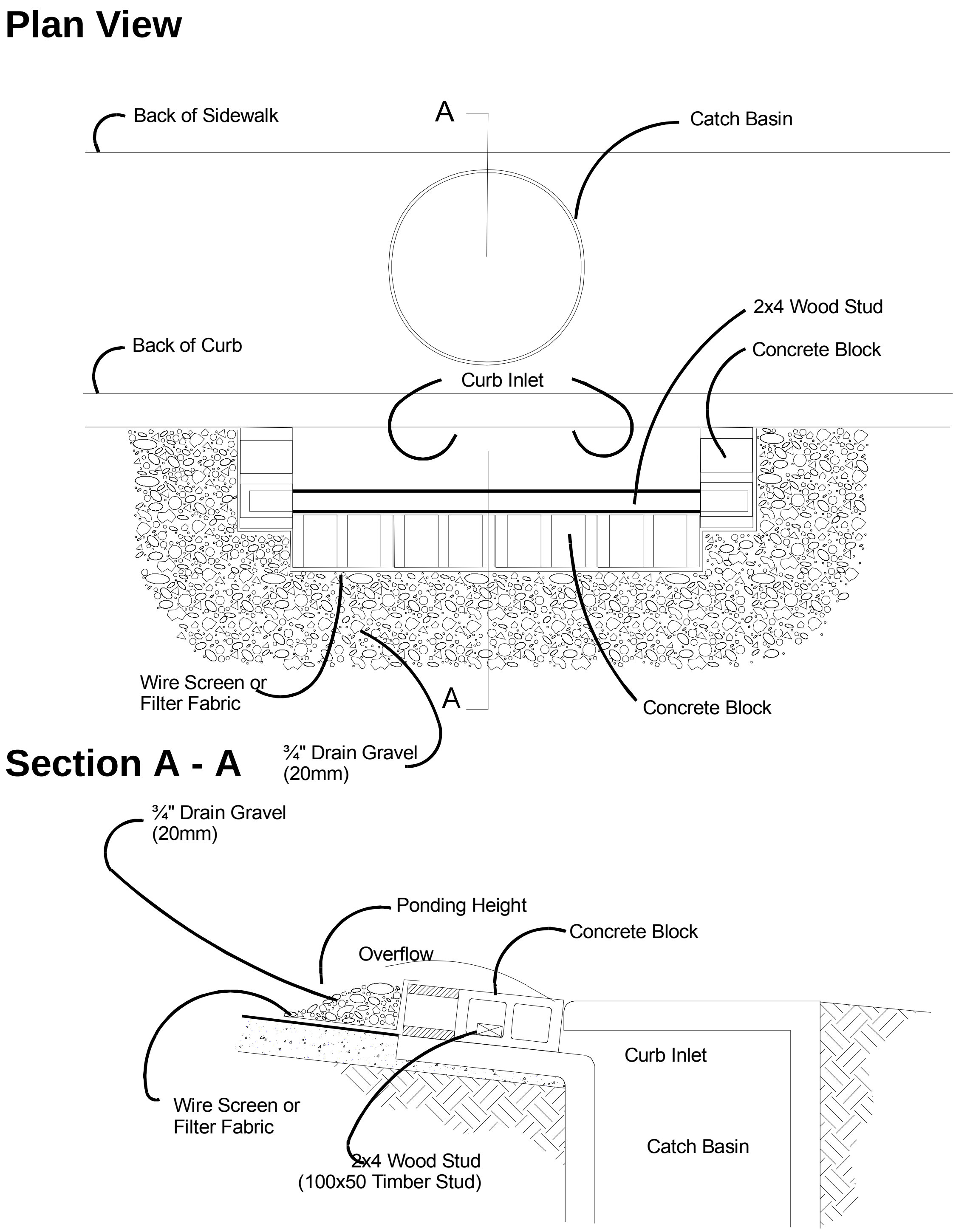
Drainage areas should be limited to 1 acre or less. Emergency overflows may be required where stormwater ponding would cause a hazard. If an emergency overflow is provided, additional end-of-pipe treatment may be required. Different types of structures are applicable to different conditions:

- **Structures less than 12 inches deep** – use other methods to protect the inlet (BMP E3.70 Street Sweeping and Vacuuming).
- **Storm drain or catch basin filter sock –** applicable on private properties or the public right-of-way, for structures greater than 12 inches deep.
- **Block and Gravel Curb Inlet Protection** – applicable for private properties only, on a paved surface. Sturdy, but limited filtration. Consists of a barrier formed around an inlet with concrete blocks and gravel (Figure 29).
- **Curb and Gutter Barrier** – applicable for private properties only, using a sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape (Figure 30). An 8- or 12-inch diameter compost sock may also be used in temporary, low-velocity applications.

4.3.4.4 Planning Considerations

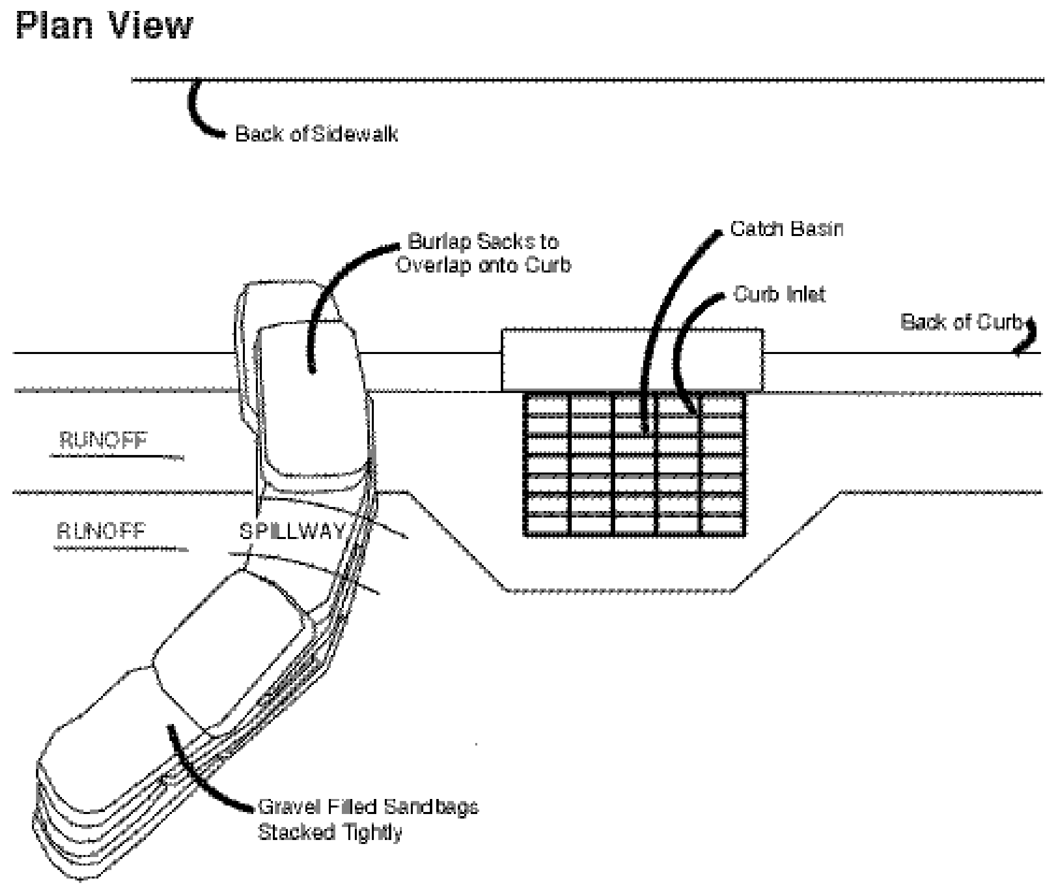
Clean out the stormwater drain or catch basin prior to implementing this BMP.

This BMP shall be removed within 5 business days after final site stabilization is achieved, or after it is no longer needed, whichever is longer (BMP E3.65).



NOTES:
1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 29. Block and Gravel Curb Inlet Protection.



NOTES:
1. Place curb type sediment barriers on gently sloping street segments, where water can pond and allow sediment to separate from runoff.
2. Sandbags of either burlap or woven 'geotextile' fabric are filled with gravel, layered, and packed tightly.
3. Leave a one sandbag gap in the top row to provide a spillway for overflow.
4. Inspect barriers and remove sediments after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 30. Curb and Gutter Barrier.

Storm drains made operational before their drainage area is stabilized can convey large amounts of sediment to natural drainage ways. In cases of extreme sediment loading, the storm drain itself may clog and lose a major portion of its capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

Several types of inlet filters and traps have different applications that depend on site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the Department of Planning and Development. Note that these various inlet protection devices are for drainage areas of less than 1 acre. Runoff from larger disturbed areas should be routed through a Temporary Sediment Trap or Pond (see BMPs E3.45 and E3.50).

The best way to prevent sediment from entering the storm drain is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

4.3.4.5 Design Criteria

- Grates and spaces of all inlets must be secured to prevent seepage of sediment-laden water.
- All catch basin protection measures should include sediment sumps of 1 to 2 feet in depth, with 25 percent side slopes.
- Installation procedure for drain or catch basin filter sock:
  - For structures greater than 12 inches deep, the filter sock can be laid into the inlet as long as the overflow opening is in the direction of the outlet pipe.
  - Trim and remove filter sock material that extends beyond the grate.
  - Must have dewatering provisions.
  - High-flow bypass that will not clog under normal use at a construction site.
- Installation procedure for block and gravel curb inlet protection:
  - Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
  - Place a piece of lumber through the outer holes of each spacer block to align the front blocks.
  - Place blocks on their sides across the front of the inlet and abutting the spacer blocks.
  - Place wire mesh with 1/2-inch openings over the outside vertical face.
  - Pile coarse aggregate against the wire to the top of the barrier.
- Installation procedure for curb and gutter sediment barrier:
  - Construct a horseshoe shaped berm.
  - Create a face with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.

4.3.4.6 Maintenance

- Inspections should be made on a regular basis, especially after large storm events. Inlet protection devices shall be cleaned or removed and replaced when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer.
- Do not wash sediment into storm drains while cleaning. Spread all excavated material evenly over the surrounding land area or stockpile and stabilize as appropriate.

4.3.5 BMP E3.30: Vegetated Strip

4.3.5.1 Definition

A vegetated area located downslope of a disturbed area that is capable of filtering coarse sediment from runoff and slowing runoff velocities.

4.3.5.2 Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

4.3.5.3 Conditions Where Practice Applies

- Vegetated strips may be used downslope of all disturbed areas, placed parallel to the toe of slope.
- Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment pond, is when the following strip flow path length can be achieved with the associated average slope (see Table 11):

Table 11. Vegetated Strip Implementation Criteria.

Maximum Average Downslope (percent)	Minimum Vegetated Strip Flow path Length (feet)
33	100
25	115
14	150
9	200
5	250

4.3.5.4 Design Criteria

- The vegetated strip shall consist of a minimum of a 25-foot wide continuous strip of dense vegetation with permeable topsoil. Grass covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
- The slope within the strip shall not exceed 14 percent.
- The uphill boundary of the vegetated strip shall be delineated with clearing limits.

4.3.5.5 Maintenance

- Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.
- If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, sod must be installed.
- If there are indications that concentrated flows are traveling across the buffer, surface water controls must be installed to reduce the flows entering the buffer, or additional perimeter protection must be installed.

4.3.6 BMP E3.35: Straw Wattles, Compost Socks, and Compost Berms

4.3.6.1 Definition

Straw wattles are temporary erosion and sediment control barriers consisting of straw that is wrapped in biodegradable tubular plastic or similar encasing material. Compost socks are a similar net tube (available in biodegradable mesh, or non-biodegradable mesh for installations longer than 6 months) filled with compost. Compost berms are triangular cross-section rows of compost that can serve a similar function as wattles or socks.

4.3.6.2 Purpose

They reduce the velocity and can spread the flow of rill and sheet runoff, and can capture and retain sediment. Straw wattles are typically 8 to 10 inches in diameter and 25 to 30 feet in length. The wattles are placed in shallow trenches and staked along the contour of disturbed or newly constructed slopes (Figure 31). Compost socks and berms typically do not require trenching.

Figure 31. Straw Wattles or Compost Sock for Inlet Protection.

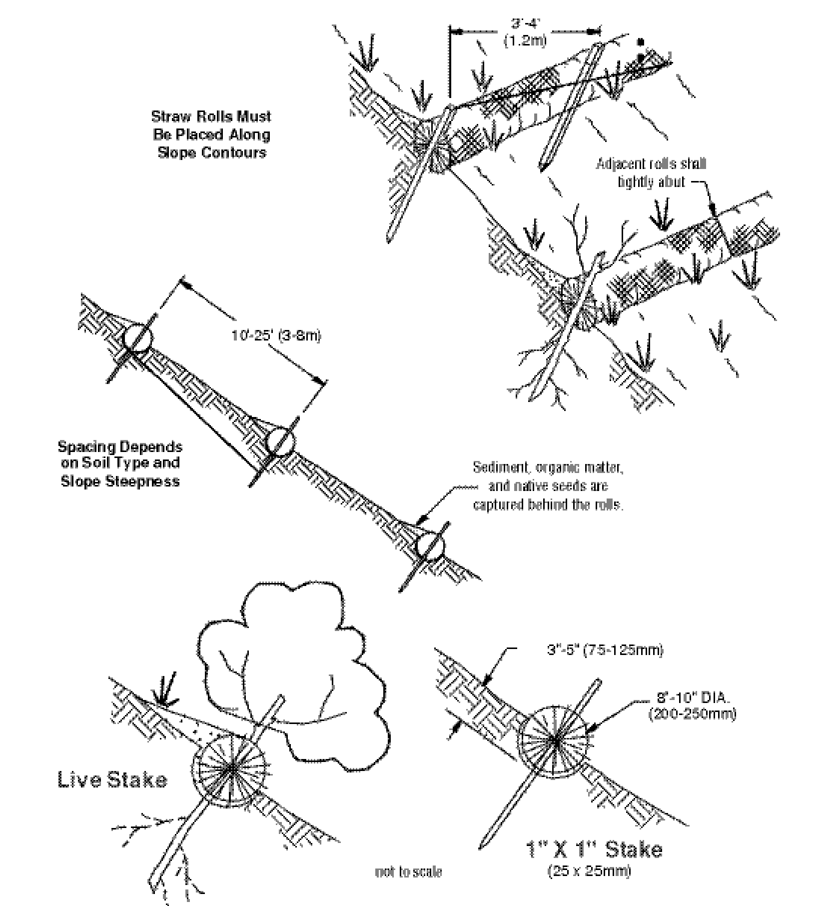
4.3.6.3 Conditions Where Practice Applies

- Disturbed areas that require immediate erosion protection.
- Exposed soils during the period of short construction delays, or over winter months.
- On slopes requiring stabilization until permanent vegetation can be established.
- For inlet protection or elsewhere on top of pavement to filter or direct flow.
- As an alternative to silt fence for perimeter control.

- Compost socks and straw wattles are effective for 1 to 2 seasons. Berms are effective for 1 to 2 weeks, or longer if vegetated and/or protected by fencing.
- If conditions are appropriate, straw wattles and compost socks can be staked to the ground using willow cuttings for added revegetation. Compost socks can also be filled with a compost/seed mix to provide temporary or permanent vegetation. Use biodegradable socks for permanent installations.

4.3.6.4 Design Criteria

- It is critical that straw wattles and compost socks are installed perpendicular to the flow direction and parallel to the slope contour (Figure 32). Also, rilling can occur beneath straw wattles if not properly entrenched and water can pass between straw wattles and compost socks if not tightly abutted together.



NOTE:
1. Straw roll installation requires the placement and secure staking of the roll in a trench, 3”-5” (75-125 mm) deep, dug on contour. Runoff must not be allowed to run under or around roll.

Figure 32. Straw Wattle Details.

- In most conditions, compost socks do not require trenching (because of their superior ground contact). Straw wattles do require trenching.
- For straw wattles, narrow trenches should be dug across the slope on contour to a depth of 3 to 5 inches on clay soils and soils with gradual slopes. Construct trenches at contour intervals of 3 to 30 feet apart depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Start building trenches and installing wattles from the base of the slope and work up. Excavated material should be spread evenly along the uphill slope and compacted using hand tamping or other methods.
- Install the straw wattles snugly into the trenches and abut tightly end to end. Do not overlap the ends. Install stakes at each end of the wattle, and at 4-foot centers along entire length of wattle. If required, install pilot holes for the stakes using a straight bar to drive holes through the wattle and into the soil.
- On loose soils, steep slopes, and areas with high rainfall, the trenches should be dug to a depth of 5 to 7 inches, or 1/2 to 2/3 of the thickness of the wattle.
- At a minimum, wooden stakes should be approximately 3/4 inches square and 24 inches long. Willow cuttings or 3/8-inch rebar can also be used for stakes. Stakes should be driven through the middle of the straw wattle or compost sock, leaving 2 to 3 inches of the stake protruding above the wattle or sock.
- Compost socks are usually placed on the prepared surface, without trenching, so long as no rilling exists on that surface. If the surface is sloped, stake through the sock at 10-foot intervals, or more closely on steeper slopes. After staking, walk down the top of the sock to press it onto the ground surface.
- Compost berms can serve the same functions as straw wattles or compost socks. Compost berms are typically 1 foot high by 2 feet wide at the base, or 18 inches high and 3 feet wide.
- Compost berms should be protected from foot or vehicle traffic by a fence, or otherwise immediately seeded to provide stability. Short-term (1 to 2 week) applications may not require protection and stabilization.

4.3.6.5 Maintenance

- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.

- Straw wattles and compost socks can be compressed by vehicle traffic, creating an overflow point that must be repaired.
- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

4.3.7 BMP E3.40: Sediment Trap

Sizing is perhaps less important than constant maintenance for this BMP because it is a temporary control. Inspections must be made and sediment removed regularly for sediment traps to function well.

4.3.7.1 Definition

A small temporary ponding area, with a gravel outlet, formed by excavation and/or by constructing an earthen embankment.

4.3.7.2 Purpose

To collect and store sediment from project sites cleared and/or graded during construction. It is intended for use in relatively small drainage basins, with no unusual drainage features, and projected quick build-out time. It should help in reducing silt-laden runoff which clogs off-site conveyance systems and destroys habitat, particularly in streams.

The trap is a **temporary** measure (with a design life of approximately 6 months) and is to be maintained until the project site is permanently protected against erosion by vegetation and/or structures.

4.3.7.3 Conditions Where Practice Applies

Proposed building sites where the tributary drainage basin is **less than 3 acres**.

4.3.7.4 Planning Considerations

Prior to leaving a project site where the tributary drainage is 3 acres or less, stormwater runoff must pass through a sediment pond or other appropriate sediment removal BMP (refer to Table 1 for other approved stormwater controls).

If the contributing drainage area is greater than 3 acres, refer to Sediment Ponds (see BMP E3.45), or subdivide the tributary drainage area.

Sediment must be periodically removed from the trap. Plans shall detail how this sediment is to be disposed of, such as by use in fill areas on-site, or removal to an approved off-site dump. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Alternative Methods. Consider using a temporary aboveground storage tank (e.g., Baker Tank) for temporary storage. If a tank cannot be used, consider using a pond with pumping capabilities to another temporary holding structure. Refer to BMP E3.50 Portable Sediment Tank.

Wherever possible, sediment-laden water should be discharged into onsite, relatively level, vegetated areas (refer to BMP E3.30 Vegetated Strip).

Safety

Sediment traps and ponds should be limited to project sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities.

Sediment traps and ponds are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the pond is required, the type of fence and its location shall be shown in the Construction Stormwater Pollution Control Plan.

4.3.7.5 Design Criteria

If permanent runoff control facilities are part of the project, they should be used for sediment retention. Refer to Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual for additional requirements.

To determine the sediment trap geometry, first calculate the design surface area (SA) of the trap, measured at the invert of the weir (Figure 33). Use the following equation:

$$SA = FS(Q_2/Vs)$$

where

Q_2 = Design inflow based on the peak discharge from the developed 2-year runoff event from the contributing drainage area as computed in the hydrologic analysis. The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. The design flows may be determined using either single-event or continuous simulation hydrologic modeling. If continuous simulation methods are used, use the 50 percent annual probability or 10 percent annual probability flows (2-year or 10-year recurrence interval respectively) as outlined above, as modeled using a 15-minute time step or less. If no hydrologic analysis is required for the other portions of the site design (conveyance, flow control, and/or water quality control), the Rational Method may be used for sediment trap design. See Volume 3, Chapter 6, for additional guidelines.

Vs = the settling velocity of the soil particle of interest. The 0.02 millimeter (mm) (medium silt) particle with an assumed density of 2.65 grams per cubic centimeter (g/cm^3) has been selected as the particle of interest and has a settling velocity (Vs) of 0.00096 feet per second (ft/sec).

FS = A safety factor of 2 to account for non-ideal settling.

Therefore, the equation for computing surface area becomes:

$SA \quad = \quad 2 \times Q_2/0.00096$ or
2,080 square feet per cfs of inflow

Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

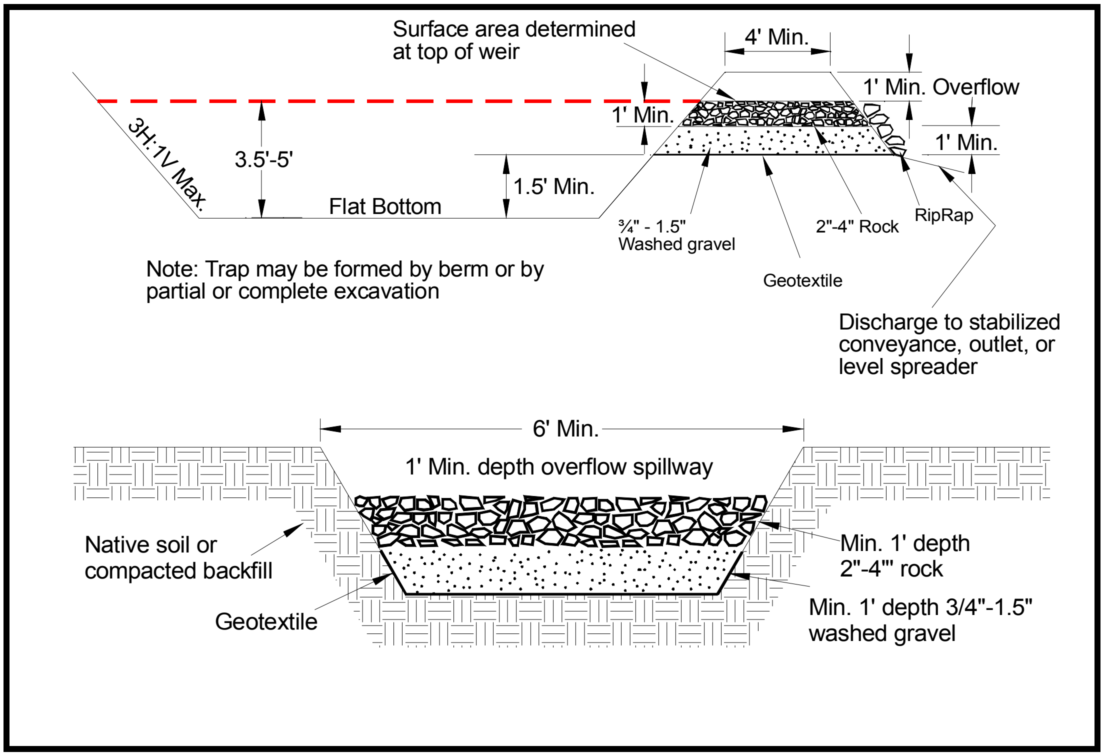


Figure 33. Cross Section of Sediment Trap and Outlet.

To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent mark 1 foot above the bottom of the trap.

4.3.7.6 Maintenance

- The sediment trap must be **continually** monitored and **regularly** maintained. The size of the trap is less important to its effectiveness than is regular sediment removal. Sediment should be removed from the trap when it reaches approximately 1 foot in depth (assuming a 1-1/2 foot sediment accumulation depth). Regular inspections should be made and additional inspections should be made after each large runoff-producing storm.
- All temporary and permanent erosion and sediment control practices shall be maintained and repaired as needed to assure continued performance of their intended function.

- All temporary erosion and sediment control measures shall be removed within 5 business days after final site stabilization is achieved, or after the temporary BMPs are no longer needed, whichever is longer. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal shall be permanently stabilized.

4.3.8 BMP E3.45: Temporary Sediment Pond (or Basin)

> Sizing is perhaps less important than constant maintenance for this BMP because it is a temporary control. Inspections must be made and sediment removed regularly for sediment traps to function well.

4.3.8.1 Definition

A temporary pond basin with a controlled stormwater release structure formed by constructing an embankment of compacted soil across a drainage way, or other suitable locations.

4.3.8.2 Purpose

To collect and store sediment from sites cleared and/or graded during construction or for extended periods of time before reestablishment of permanent vegetation and/or construction of structures. It is intended to help prevent erosion on the site, which results in silt-laden runoff. The basin is a temporary measure (with a design life less than 1 year) and is to be maintained until the site area is permanently protected against erosion.

4.3.8.3 Conditions Where Practice Applies

Prior to leaving a construction site where the tributary drainage is 3 acres or more, stormwater runoff must pass through a sediment pond or other appropriate sediment removal BMP (refer to Table 1 for other approved stormwater controls).

Safety

Sediment traps and ponds must be installed only on sites where failure of the structure would not result in loss of life, damage to homes or buildings, or interruption of use or service of public roads or utilities. Also, sediment traps and ponds are attractive to children and can be very dangerous. Local ordinances regarding health and safety must be adhered to. If fencing of the pond is required, the type of fence and its location shall be shown on the ESC plan.

4.3.8.4 Planning Considerations

Construction Stormwater Control Plan. Indicate the ultimate discharge point or collection point for pond discharges on the plan sheet that clearly identifies the location(s) of stormwater discharges.

Dam Safety. Structures having a maximum storage capacity at the top of the dam of 10 acre-feet (435,6000 cubic feet) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC).

Effectiveness. Sediment basins are at best only 70 to 80 percent effective in trapping sediment that flows into them. Therefore, they should be used in conjunction with erosion control practices such as temporary seeding, mulching, diversion dikes, etc. to reduce the amount of sediment flowing into the basin. Sediment basins are most effective when designed with a series of chambers.

Alternative Methods. Consider using a temporary aboveground storage tank (e.g., Baker Tank) for temporary storage (refer to BMP E3.50 Portable Sediment Tank). If a tank cannot be used, consider using a pond with pumping capabilities to another temporary holding structure.

Location. To improve the effectiveness of the basin, it should be located so as to intercept the largest possible amount of runoff from the disturbed area. The best locations are generally low areas below disturbed areas. Drainage into the basin can be improved by the use of diversion dikes and ditches. The basin must not be located in a stream but should be located to trap sediment-laden runoff **before** it enters the stream. The basin should **not** be located where its failure would result in the loss of life or interruption of the use or service of public utilities or roads.

Multiple Use. Sediment basins may be designed as permanent structures to remain in place after construction is completed for use as stormwater detention ponds. Wherever these structures are to become permanent, or if they exceed the size limitations of the design criteria, they must be designed as permanent ponds by a professional engineer licensed in the State of Washington.

4.3.8.5 Design Criteria

If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of 2 feet above final grade. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized. The infiltration pretreatment facility should be fully constructed and used with the sedimentation basin to help prevent clogging (Figure 34).

Determining Pond Geometry

Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year runoff event (Q_2). The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. The design flows may be determined using either single-event or continuous simulation hydrologic modeling. If continuous simulation methods are used, use the 50 percent annual probability or 10 percent annual probability flows (2-year or 10-year recurrence interval respectively) as outlined above, as modeled using a 15-minute time step or less. If no hydrologic analysis is required for the other portions of the site design (conveyance, flow control, and/or water quality control), the Rational Method may be used for sediment trap design. See Volume 3, Chapter 6, for additional guidelines.

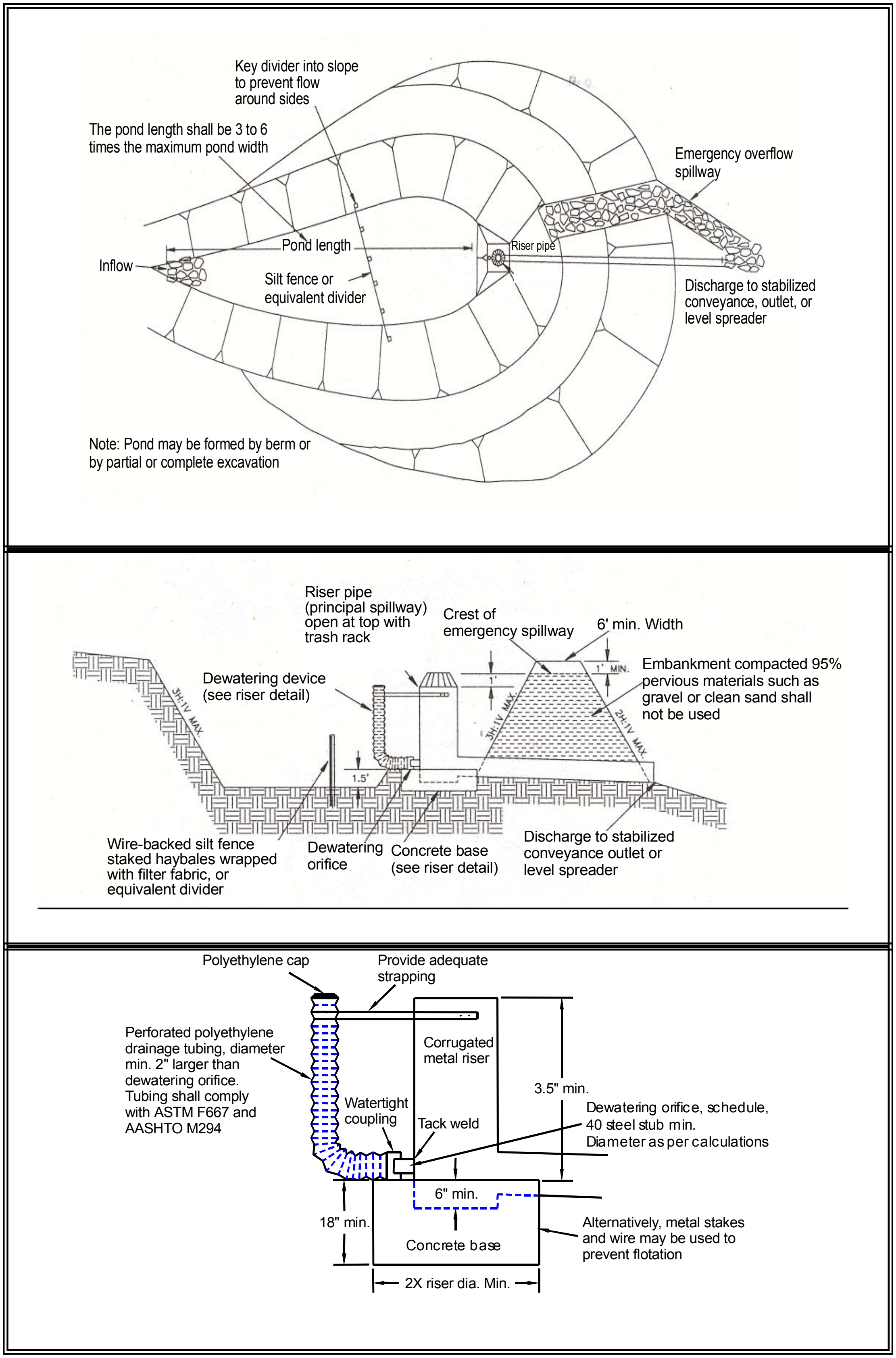


Figure 34. Sediment Pond Plan View, Cross Section, and Riser Detail.

Determine the required surface area at the top of the riser pipe with the equation:

$$SA = 2 \times Q_2/0.00096 \quad \text{or}$$
2,080 square feet per cfs of inflow

The basic geometry of the pond can now be determined using the following design criteria:

- Required surface area SA (from Step 2 above) at top of riser.
- Minimum 3.5-foot depth from top of riser to bottom of pond.
- Maximum 18 percent interior side slopes and maximum 25 percent exterior slopes. The interior slopes can be increased to a maximum of 25 percent if fencing is provided at or above the maximum water surface.
- One foot of freeboard between the top of the riser and the crest of the emergency spillway.
- Flat bottom.
- Minimum 1-foot deep spillway.
- Length-to-width ratio between 3:1 and 6:1.
- Sizing of Discharge Mechanisms.

The outlet for the basin consists of a combination of principal and emergency spillways. These outlets must pass the peak runoff expected from the contributing drainage area for a 100-year storm. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year storm. However, an attempt to provide a separate emergency spillway should always be made. The runoff calculations should be based on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year storm elevation because of its potential to become clogged; therefore, available spillway storage must begin at the principal spillway riser crest.

The principal spillway designed by the procedures contained in this standard will result in some reduction in the peak rate of runoff. However, the riser outlet design will not adequately control the basin discharge to the predevelopment discharge limitations as stated in flow requirements in Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual. However, if the basin for a permanent stormwater detention pond is used for a temporary sedimentation basin, the control structure for the permanent pond can be used to maintain predevelopment discharge limitations. The size of the basin, the expected life of the construction project, the anticipated downstream effects and the anticipated weather conditions during construction, should be considered to determine the need of additional discharge control. See Figure 35 for riser inflow curves.

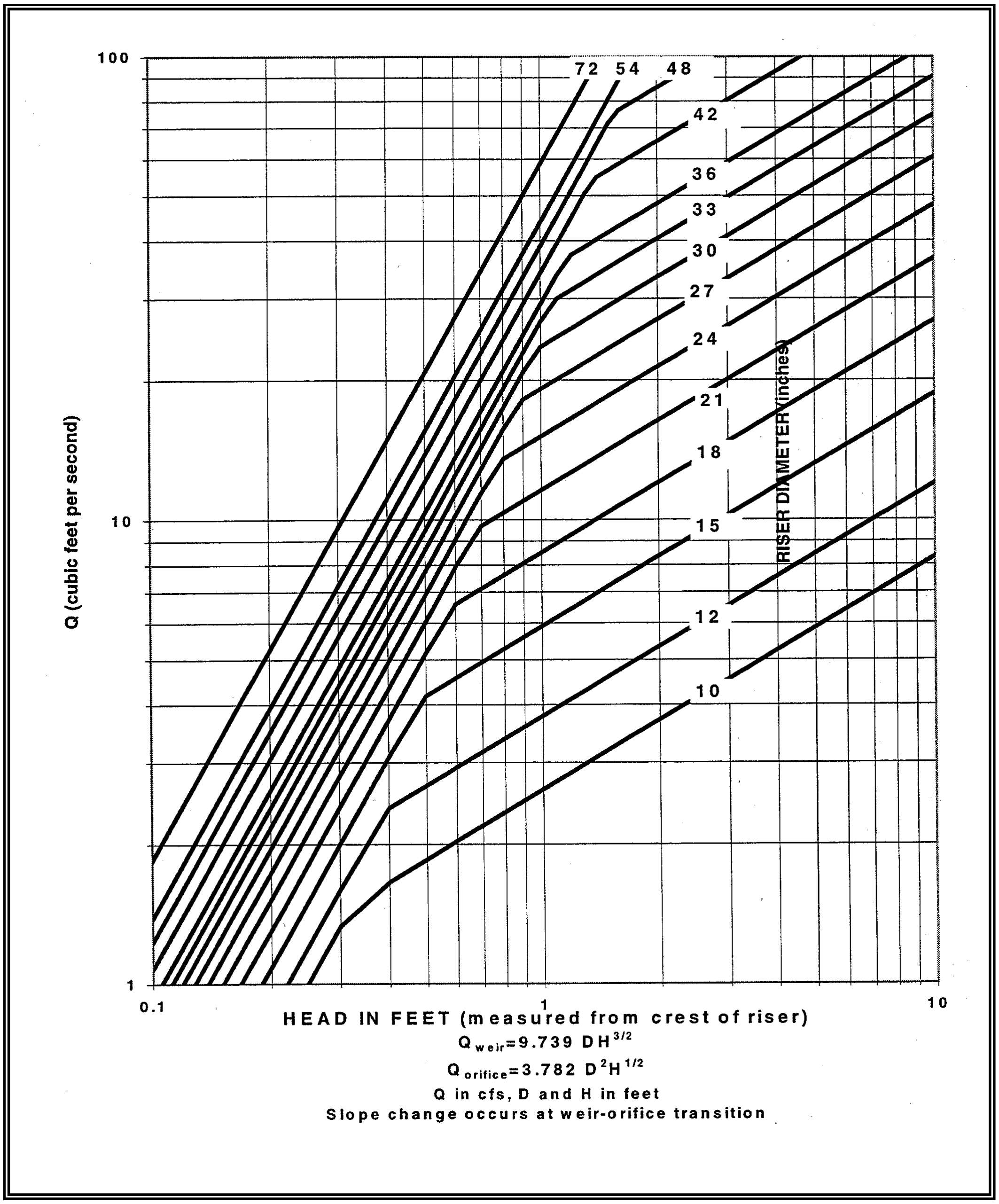


Figure 35. Riser Inflow Curves.

Principal Spillway: Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the pre-developed 10-year peak flow (Q_{10}). If using continuous simulation hydrologic modeling, use the 10 percent annual probability flow (10-year recurrence interval) using a 15-minute time step or less. Use Figure 35 to determine the required diameter (h = 1 foot). *Note: A permanent control structure may be used instead of a temporary riser.*

Emergency Overflow Spillway: Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow. If continuous simulation methods are used, use the 1 percent annual probability flow (100-year recurrence interval) using a 15-minute time step or less.

Dewatering Orifice: Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s (2h)^{0.5}}{0.6\text{x}3600Tg^{0.5}}$$

where A_O = orifice area (square feet)
A_S = pond surface area (square feet)
h = head of water above orifice (height of riser in feet)
T = dewatering time (24 hours)
g = acceleration of gravity (32.2 feet/second^2)

Convert the required surface area to the required diameter D of the orifice:

$$D = 24\text{x}\sqrt{\frac{A_o}{\pi}} = 13.54\text{x}\sqrt{A_o}$$

The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. The size and number of perforations in the tubing should be large enough so that the tubing does not restrict flow. The orifice should control the flow rate.

Additional Design Specifications

The pond shall be divided into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of 1 foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by 4-inch square pieces of treated lumber can be used as a divider. Alternatively, staked straw bales wrapped with filter fabric (geotextile) may be used. If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

To aid in determining sediment depth, 1 foot intervals shall be prominently marked on the riser.

If an embankment of more than 6 feet is proposed, the pond must comply with the dam safety criteria contained in Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual.

- The most common structural failure of sedimentation basins is caused by piping. Piping refers to two phenomena: (1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels; and (2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.
- The most critical construction sequences to prevent piping will be:
  - Tight connections between riser and barrel and other pipe connections.
  - Adequate anchoring of riser.
  - Proper soil compaction of the embankment and riser footing.
  - Proper construction of anti-seep devices.

4.3.8.6 Maintenance

- Sediment shall be removed from the pond when it reaches 1 foot in depth.
- Any damage to the pond embankments or slopes shall be repaired.

4.3.9 BMP E3.50: Portable Sediment Tank

4.3.9.1 Definition

A portable sediment tank is a compartmental tank brought temporarily to a construction site. Sediment-laden water is pumped into the tank to trap and retain sediment.

4.3.9.2 Purpose

A portable sediment tank is used for temporary storage of sediment-laden water and to trap and retain sediment prior to discharging to an appropriate discharge point.

4.3.9.3 Conditions Where Practice Applies

A portable sediment tank should be used on sites where excavations are deep and space is limited, or wherever the tank can be located per the manufacturer's specifications and with an appropriate discharge point.

4.3.9.4 Planning Considerations

Using a portable sediment tank is the preferred method to minimize potential impacts to the project site. The tank configuration, size, location, and discharge point must be presented in the Construction Stormwater Pollution Control Plan and approved by DPD.

Follow the manufacturer's or vendor's specifications for choosing the appropriate location. In addition, the tank should be located for ease of clean-out and disposal of trapped sediment, and to minimize the interference with construction activities and pedestrian traffic.

If a permit is obtained for discharge to the combined system, conduct all discharge activities in accordance with permit requirements, including when it can be discharged and the discharge flow rate.

4.3.9.5 Design Criteria

Sediment tanks must have a minimum depth of 2 feet and shall be designed to allow for emergency flow to an approved discharge point. As noted above, tank configuration and size must be presented in the Construction Stormwater Pollution Control Plan and approved by DPD. For planning purposes, the following formula should be used in determining the minimum storage volume of the sediment tank. Additional storage volume may be required by DPD:

Pump Discharge in gallons per minute (gpm) x 16 = cubic feet storage

Container designs can vary from cylindrical tanks to rectangular boxes, depending on the manufacturer. Any tank configuration can be used if the storage volume is adequate and approval is obtained from DPD.

Effectiveness

The pollution removal efficiency of the sediment tank can be increased by using flocculation chemicals, such as alum (aluminum sulfate) in the tank. Flocculation will allow very small suspended particles to settle out and decrease the time it takes for larger particles to settle out. Flocculation tank setup is considerably more complicated as the rate of flocculent addition must be carefully monitored.

For sites that do not require coverage under Ecology's General Construction Permit, formal written approval from DPD is required to use chemical treatment such as flocculation chemicals, regardless of site size. Any proposed chemicals and the method of use must also be formally approved by the Department of Ecology. Refer to BMP E3.55 and Appendix B for more information on chemical treatment.

Alternatives

An alternative to a portable sediment tank is a tank constructed using steel drums, sturdy wood, or other material suitable for handling the pressure exerted by the volume of the water.

- Sediment tanks will have a minimum depth of 2 feet.
- The tank shall be located for easy clean-out and disposal of the trapped sediment and to minimize the interference with construction activities.
- Once the water level nears the top of the tank, the pump must be shut off while the tank drains and additional capacity is made available.
- Clean-out the tank once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the cleanout point.
- An appropriate discharge point must be selected, and approved by DPD.

4.3.9.6 Maintenance

- Follow the manufacturer's or vendor's specifications.
- During construction, inspect BMPs daily during the work week with additional inspections scheduled during storm events. Make any required repairs immediately.
- Inspect filtering or control devices frequently. Repair or replace them to ensure that the structure functions as designed.
- Clean-out the tank once one-third of the original capacity is depleted due to sediment accumulation. The tank shall be clearly marked showing the

clean-out point. Removed sediment may be disposed of onsite if no contamination is present. Contaminated sediment must be disposed of according to local governing agency requirements.

- Systems should be filled in or otherwise removed when permanent dewatering controls are in place and connected to an approved treatment and receiving system.

4.3.10 BMP E3.55: Construction Stormwater Chemical Treatment

4.3.10.1 Definition

The use of chemicals, such as Polyacrylamide, to remove contaminants from stormwater.

4.3.10.2 Purpose

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. Sedimentation ponds are effective at removing larger particulate matter by gravity settling, but are ineffective at removing smaller particulates such as clay and fine silt.

Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 millimeters). Chemical treatment may be used to reduce the turbidity of stormwater runoff.

4.3.10.3 Conditions Where Practice Applies

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water.

For sites that do not require coverage under Ecology's General Construction Permit, formal written approval from the Department of Planning and Development is required to use chemical treatment regardless of site size. Any proposed chemicals and the method of use must also be formally approved by the Department of Ecology. Refer to Appendix B for more information on chemical treatment.

4.3.10.4 Planning Considerations

This BMP must be used in conjunction with BMP E3.45 Temporary Sediment Pond (or Basin) and/or BMP E3.50 Portable Sediment Tank. Systems incorporating construction stormwater chemical treatment must be designed by a professional engineer.

4.3.10.5 Design Criteria

Chemicals used for temporary stormwater treatment at construction sites must be formally approved by the Department of Ecology prior to use. As such, formal approval from the Department of Planning and Development is based on Ecology's protocols. For a list of treatment chemicals that have been evaluated and are currently approved for use by the Department of Ecology (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html).

Using a chemical from Ecology's list does not relieve the applicant from responsibility for meeting all water quality standards for discharges from a site.

Treatment System Design Considerations

The design and operation of a chemical treatment system should take into consideration the factors that determine optimum, cost-effective performance. It may not be possible to fully incorporate all of the classic concepts into the design because of practical limitations at construction sites. Nonetheless, it is important to recognize the following:

- The right chemical must be used at the right dosage. A dosage that is either too low or too high will not produce the lowest turbidity. There is an optimum dosage rate. This is a situation where the adage "adding more is always better" is not the case.
- The coagulant must be mixed rapidly into the water to insure proper dispersion.
- A flocculation step is important to increase the rate of settling, to produce the lowest turbidity, and to keep the dosage rate as low as possible.
- Too little energy input into the water during the flocculation phase results in flocs too small and/or insufficiently dense. Too much energy can rapidly destroy floc as it is formed.
- Since the volume of the basin is a determinant in the amount of energy per unit volume, the size of the energy input system can be too small relative to the volume of the basin.
- Care must be taken in the design of the withdrawal system to minimize outflow velocities and to prevent floc discharge. The discharge should be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge.

Treatment System Design

Chemical treatment systems shall be designed as batch treatment systems using either sediment ponds (basins) or portable sediment tanks. Flow-through continuous treatment systems are not allowed at this time.

A chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), a storage pond, pumps, a chemical feed system, treatment cells, and interconnecting piping.

The treatment system shall use a minimum of two lined treatment cells.

Multiple treatment cells allow for clarification of treated water while other cells are being filled or emptied. Treatment cells may be ponds or tanks.

Ponds with constructed earthen embankments greater than 6 feet high require special engineering analyses. Portable tanks may also be suitable for some sites.

The following equipment should be located in an operations shed:

- The chemical injector
- Secondary containment for acid, caustic, buffering compound, and treatment chemical
- Emergency shower and eyewash
- Monitoring equipment which consists of a pH meter and a turbidimeter.

Sizing Criteria

The combination of the storage pond or other holding area and treatment capacity should be large enough to treat stormwater during multiple day storm events. It is recommended that at a minimum the storage pond or other holding area should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event. Bypass should be provided around the chemical treatment system to accommodate extreme storm events. Runoff volume shall be calculated using the methods presented in Volume 3, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual. If no hydrologic analysis is required for the site, the Rational Method may be used.

Primary settling should be encouraged in the storage pond. A forebay with access for maintenance may be beneficial.

There are two opposing considerations in sizing the treatment cells. A larger cell is able to treat a larger volume of water each time a batch is processed. However, the larger the cell the longer the time required to empty the cell. A larger cell may also be less effective at flocculation and therefore require a longer settling time. The simplest approach to sizing the treatment cell is to multiply the allowable discharge flow rate times the desired drawdown time. A 4-hour drawdown time allows one batch per cell per 8-hour work period, given 1 hour of flocculation followed by 2 hours of settling.

The permissible discharge rate governed by potential downstream effect can be used to calculate the recommended size of the treatment cells. The following discharge flow rate limits shall apply:

- The discharge flow rate shall not exceed 50 percent of the peak flow rate of the 2-year, 24-hour event for all storm events up to the 10-year, 24-hour event. Alternatively, use the 50-percent annual probability and 10 percent annual probability flows (2- and 10-year recurrence interval respectively) using a 5-minute time step, indicated by an approved continuous runoff model.

- If discharge is occurring during a storm event equal to or greater than the 10-year, 24-hour event, the allowable discharge rate is the peak flow rate of the 10-year, 24-hour event. (Alternatively, use the 10 percent annual probability flow [10-year recurrence interval] using a 5-minute time step, indicated by an approved continuous runoff model.)
- If the discharge is to the combined system, the allowable discharge rate may be limited by its capacity. It may be necessary to clean the system prior to the start of the discharge to prevent scouring solids from the drainage system.

4.3.10.6 Maintenance

> For sites that require coverage under Ecology's General Construction Permit, refer to Ecology's manual for operational and compliance monitoring, and discharge testing requirements.

- Each contractor who intends to use chemical treatment shall be trained by an experienced Certified Erosion and Sediment Control Lead. Refer to BMP C1.10 Certified Erosion and Sediment Control Lead.
- Sediment shall be removed from the storage or treatment cells as necessary. Typically, sediment removal is required at least once during a wet season and at the decommissioning of the cells. Sediment remaining in the cells between batches may enhance the settling process and reduce the required chemical dosage.

4.3.11 BMP E3.60: Construction Stormwater Filtration

4.3.11.1 Definition

Use of a filter to remove sediment from stormwater runoff.

4.3.11.2 Purpose

Filtration removes sediment from runoff originating from disturbed areas of the site.

4.3.11.3 Conditions Where Practice Applies

Traditional BMPs used to control soil erosion and sediment loss from sites under development may not be adequate to ensure compliance with the water quality standard for turbidity in the receiving water. Filtration may be used in conjunction with gravity settling to remove sediment as small as fine silt (0.5 micrometers). The reduction in turbidity will be dependent on the particle size distribution of the sediment in the stormwater. In some circumstances, sedimentation and filtration may achieve compliance with the water quality standard for turbidity.

Unlike chemical treatment, the use of construction stormwater filtration does not require approval from Ecology. Filtration may also be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.

4.3.11.4 Design Criteria

Filtration with sand media has been used for over a century to treat water and wastewater. The use of sand filtration for treatment of stormwater has developed recently, generally to treat runoff from streets, parking lots, and residential areas. The application of filtration to construction stormwater treatment is currently under development.

Two types of filtration systems may be applied to construction stormwater treatment: rapid and slow. Rapid sand filters are the typical system used for water and wastewater treatment. They can achieve relatively high hydraulic flow rates, on the order of 2 to 20 gallons per minute per square foot (gpm/sf), because they have automatic backwash systems to remove accumulated solids. In contrast, slow sand filters have very low hydraulic rates, on the order of 0.02 gpm/sf, because they do not have backwash systems. To date, slow sand filtration has generally been used to treat stormwater. Slow sand filtration is mechanically simple in comparison to rapid sand filtration but requires a much larger filter area.

Filtration Equipment

Sand media filters are available with automatic backwashing features that can filter to 50 micrometer (μm) particle size. Screen or bag filters can filter down to

5 µm. Fiber wound filters can remove particles down to 0.5 µm. Filters should be sequenced from the largest to the smallest pore opening. Sediment removal efficiency will be related to particle size distribution in the stormwater.

Treatment Process Description

Stormwater is collected at interception point(s) on the site and is diverted to a sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The stormwater is pumped from the trap, pond, or tank through the filtration system in a rapid sand filtration system. Slow sand filtration systems are designed as flow through systems using gravity. If large volumes of concrete are being poured, pH adjustment may be necessary.

4.3.11.5 Maintenance

- Rapid sand filters typically have automatic backwash systems triggered by a pre-set pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the stormwater stored in the holding pond or tank, backwash return to the pond or tank may be appropriate. However, land application or another means of treatment and disposal may be necessary.
- Screen, bag, and fiber filters must be cleaned and/or replaced when they become clogged.
- Sediment shall be removed from the storage and/or treatment ponds as necessary. Typically, sediment removal is required once or twice during a wet season and at the decommissioning of the ponds.

4.3.12 BMP E3.65: Cleaning Inlets and Catch Basins

4.3.12.1 Definition

Removing debris from existing inlets, catch basins and connecting pipelines to protect and maintain private facilities and the public drainage system.

4.3.12.2 Purpose

The purpose of cleaning inlets and catch basins is to restore the function of the drainage collection system and reduce sediment transfer through the public drainage system.

4.3.12.3 Conditions Where Practice Applies

- Whenever other sediment control BMPs are not feasible or have failed
- Whenever the public drainage collection facilities immediately downstream are not functioning
- Whenever there is ponding in the travel lanes of the public roadway.

4.3.12.4 Planning Considerations

Large amounts of sediment can be conveyed through inlets, catch basins and the public storm drain system. Sediment can also plug these facilities, causing a flooding hazard or a hazard to traffic and pedestrians in the public roadway. Protection from sediment and debris is not always possible or effective; therefore, cleaning is the last action taken.

The best ways to prevent sediment from entering the storm drain are:

- To control the discharge points
- Stabilize the site to control pollution at its source
- Good housekeeping such as sweeping, vacuuming and cleaning (BMP E3.70)

It is important to identify which BMP is feasible at each point of drainage collection and discharge, and during each construction phase. Inlet and catch basin cleaning must be performed when other protection methods are not possible or fail.

4.3.12.5 Design Criteria

- Identify the drainage flow path(s) on-site and downstream for a minimum distance of 500 feet or 1 block, whichever is further in the public roadway.
- Identify the location of all existing inlets and catch basins within the project area that may be impacted and whether they will remain, be removed, or be abandoned during construction.

- When an inlet or catch basin is to be removed or abandoned, plug that path to the public drainage system prior to demolition of the immediate surroundings.
- Storm drain inlet protection (BMP E3.25) is required when feasible. When it is not feasible, or fails, plan for cleaning affected inlets, catch basins, and connecting pipe.
- Cleaning can be accomplished by vacuum truck or shovels with proper disposal. Jetting material downstream into the public drainage system is not allowed.
- New inlets and catch basins should be protected from on-site sediment and cleaned after site stabilization, as necessary.

4.3.12.6 Maintenance

Regularly inspect inlets and catch basins on-site and within 500 feet or 1 block, whichever is further, in the public roadway. Increase inspections as necessary, especially after street sweeping. Clean inlets when sediment and/or debris are visible. Clean catch basins whenever debris and/or sediment occupy more than one-half the capacity or is within 18 inches of the outlet pipe invert. Inlets and catch basins should always be cleaned after site stabilization.

4.3.13 BMP E3.70: Street Sweeping and Vacuuming

4.3.13.1 Definition

Street sweeping and vacuuming includes use of human-powered and/or mechanical equipment to collect sediment on paved surfaces to minimize sediment accumulation in private systems and the public drainage system. This BMP may also be used to clean paved surfaces in preparation for final paving.

4.3.13.2 Purpose

Sweeping and vacuuming minimizes project area sediment from entering the public drainage system. Targeted constituents include: sediment, nutrients, trash, metals, bacteria, oil and grease, and organics.

4.3.13.3 Conditions Where Practice Applies

Sweeping and vacuuming are suitable on any paved surface and, in particular, anywhere sediment is tracked from the project site onto public or private paved streets and roads, typically at the stabilized construction entrance (BMP E2.10) and other construction access points. Sweeping and vacuuming are also applicable during preparation of paved surfaces for final paving.

4.3.13.4 Planning Considerations

Sweeping and vacuuming may not be effective when sediment is wet or when tracked soil is caked (caked soil may need to be scraped loose). Washing is not an alternative to sweeping and vacuuming because of the risk of pollutant transport.

4.3.13.5 Design Criteria

Control the number of points where vehicles can leave the site to allow focused sweeping and vacuuming efforts.

Do not use kick brooms or sweeper attachments.

If not mixed with debris or trash, consider incorporating the removed sediment back into the project.

4.3.13.6 Maintenance

After initiating sweeping and/or vacuuming, the potential sediment tracking locations should be inspected daily to ensure it is being implemented effectively.

Visible sediment tracking should be swept or vacuumed on a daily basis.

Be careful not to sweep up any unknown substance or any object that may be potentially hazardous.

Adjust brooms frequently; maximize efficiency of sweeping operations.

After sweeping is finished, properly dispose of sweeper wastes at an approved dumpsite.

Chapter 5 - Standards and Specifications for Construction Pollutants Other than Sediment

5.1 Source Control Practices

The City of Seattle is committed to protecting the public drainage system, ponds, wetlands, lakes, streams, and coastal and estuarine water bodies from damage by sediment and other pollutants generated during construction activities. The focus of Chapter 4 was on erosion and sediment control; however, potential pollutants other than sediment are common at construction sites and may also impact stormwater quality when they come into direct contact with runoff.

Potential pollutants include non-hazardous materials such as wood, paper, demolition debris, concrete, and metal scraps. There are also potential pollutants from hazardous materials and their associated wastes such as pesticides (e.g., insecticides, fungicides, herbicides, rodenticides), petrochemicals (e.g., oils, gasoline, asphalt degreaser) and other construction chemicals such as concrete products, sealer, paints, and wash water associated with these products.

The most economical and effective controls for pollutants other than sediment are good “housekeeping” practices, and an awareness by construction workers, planners, engineers, and developers of the need for and purpose of compliance with federal, state, and local regulations.

> Please refer to the Stormwater Code and Volume 1, the *Source Control Technical Requirements Manual* for further information concerning controlling pollution at the source and preventing contamination of stormwater for all discharges. This manual should be reviewed to ensure that all Directors’ Rules requirements are being met for each construction project.

The standards for each individual BMP are divided into six sections:

1. Definition
2. Purpose
3. Conditions Where Practice Applies
4. Planning Considerations
5. Design Criteria
6. Maintenance.

Note that some BMPs were divided into different sections to reflect their individual needs. As with erosion and sediment control BMPs, source control BMPs include “Conditions Where Practice Applies,” which always refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance.

This chapter contains the standards and specifications for source control BMPs to properly manage construction pollutants other than sediment. They include:

- BMP C1.10: Certified Erosion and Sediment Control Lead (Section 5.1.1)
- BMP C1.15: Material Delivery, Storage, and Containment (Section 5.1.2)
- BMP C1.20: Use of Chemicals During Construction (Section 5.1.3)
- BMP C1.25: Demolition of Buildings (Section 5.1.4)
- BMP C1.30: Building Repair, Remodeling, and Construction (Section 5.1.5)
- BMP C1.35: Sawcutting and Paving Pollution Prevention (Section 5.1.6)
- BMP C1.40: Temporary Dewatering (Section 5.1.7)
- BMP C1.45: Solid Waste Handling and Disposal (Section 5.1.8)
- BMP C1.50: Disposal of Asbestos and Polychlorinatedbiphenols (PCBs) (Section 5.1.9)
- BMP C1.55: Airborne Debris Curtain (Section 5.1.10).

5.1.1 BMP C1.10: Certified Erosion and Sediment Control Lead

5.1.1.1 *Definition*

The Certified Erosion and Sediment Control Lead (CESCL) is responsible for ensuring compliance with all City of Seattle, county, state, and federal erosion and sediment control and water quality requirements.

5.1.1.2 *Purpose*

The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control, and water quality protection. The designated person shall be the CESCL.

5.1.1.3 *Conditions Where Practice Applies*

A CESCL shall be made available on Large Projects. The CESCL must perform all duties and take on all responsibilities listed in this BMP. The CESCL must also determine the site transport rating according to the Construction Site Sediment Damage Potential calculation (Section 5.1.1.6).

If the rating is high, the CESCL must arrange for a special inspection by the City (Section 2.1.2) or be a Certified Professional in Erosion and Sediment Control (CPESC). For more information about special inspections and the CPESC certification, visit (www.cpesc.net) and (http://www.seattle.gov/dpd/Site_Development/SiteInspections/default.asp#firstground).

If the rating is low, the CESCL does not require the CPESC certification nor the special inspection, but must meet the requirements of this BMP.

5.1.1.4 *Certification Criteria*

The training and administrative requirements for a responsible person to be designated as the CESCL are listed below. The CESCL shall:

- Have a current certificate proving attendance in an erosion and sediment control training course that meets the minimum ESC training and certification requirements established by Ecology. Ecology maintains a list of ESC training and certification providers (www.ecy.wa.gov/programs/wq/stormwater).

  OR

  Be a Certified Professional in Erosion and Sediment Control (CPESC) or have a special inspection by the City (Section 2.1.2); for additional information on the CPESC certification, go to (www.cpesc.net).

- Certification shall remain valid for 3 years.

- The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, on call, 24 hours per day throughout the period of construction.
- The name, telephone number, fax number, and address of the designated CESCL shall be recorded in the:
  - TESC standard plan
  - Small Project Construction Stormwater Control Plan, or
  - Large Project Construction Stormwater Control Plan.
- A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region.

5.1.1.5 Duties and Responsibilities

The duties and responsibilities of the CESCL shall include, but are not limited to the following:

- Maintaining all applicable documentation, permits, and plans on site at all times.
- Directing BMP installation, inspection, maintenance, modification, and removal.
- Updating all project drawings and plans with changes made.
- Keeping daily logs, and inspection reports. Inspection reports should include:
  - Inspection date/time.
  - Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.
  - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:
    - Locations of BMPs inspected
    - Locations of BMPs that need maintenance
    - Locations of BMPs that failed to operate as designed or intended,
    - Locations of where additional or different BMPs are required.
  - Duties relating to temporary dewatering (BMP C1.40).
  - Visual monitoring results, including a description of discharged stormwater. The presence of suspended sediment, turbid water, discoloration, and oil sheen shall be noted, as applicable.

    - Any water quality monitoring performed during inspection.
    - General comments and notes, including a brief description of any BMP repairs, maintenance or installations made as a result of the inspection.
- Facilitate, participate in, and take corrective actions resulting from inspections performed by outside agencies or the owner.

5.1.1.6 Determining Construction Site Sediment Damage Potential

The following rating system allows an objective evaluation of a particular construction site's potential to discharge sediment. The Large Project CESCL must follow the steps outlined below to determine the site's rating.

Step 1 – Hydraulic Nearness Assessment

Sites are hydraulically near a feature if the pollutant load and peak quantity of runoff from the site will not be naturally attenuated before entering the feature. The conditions that render a site hydraulically near to a feature include, but are not limited to, the following:

- The feature or a buffer to protect the feature is within 200 feet downstream of the site.
- Runoff from the site is tight-lined to the feature or flows to the feature through a channel or ditch.

A site is not hydraulically near a feature if one of the following takes place to provide attenuation before runoff from the site enters the feature:

- Sheet flow through a vegetated area with dense ground cover
- Flow through a wetland not included as a sensitive feature
- Flow through a significant shallow or adverse slope, not in a conveyance channel, between the site and the sensitive feature.

If none of the sediment/erosion sensitive features are hydraulically near the site, go to Step 2.

Step 2 – ECA Feature Identification

ECAs are typically subject to significant degradation due to the effect of sediment deposition or erosion and special protections must be provided. ECA features include but are not limited to:

a) Wetlands

b) Areas important for fish and wildlife

c) Riparian corridors (such as creeks)

d) Geologic hazard areas (such as landslide-prone, steep-slope and liquefaction-prone areas)

e) Flood-prone areas

f) Abandoned landfills.

Identify any ECA features, and proceed to Step 3.

Step 3 – Construction Site Sediment Transport Potential

Using the attached worksheet, determine the total points for each location that meets the requirements of Steps 1 and 2. Assign points based on the most critical condition that affects 10 percent or more of the site. If soil testing has been performed on site, the results should be used to determine the predominant soil type on the site. Otherwise, soil information should be obtained from DPD to determine Hydrologic Soil Group (Table of Engineering Index Properties for Step 1.d) and Erosion Potential (Table of Water Features for Step 1.e).

When using published soil surveys, the dominant soil type may be in question, particularly when the site falls on a boundary between two soil types or when one of two soil types may be present on a site. In this case, the soil type resulting in the most points on the rating system will be assumed unless site soil tests indicate that another soil type dominates the site.

Use the point score from Step 3 to determine whether the development site has a high potential for sediment transport off of the site.

Total Score Transport Rating

<100 Low
≥100 High

A high transport rating indicates a higher risk that the site will generate sediment contaminated runoff.

Construction Site Sediment Transport Potential Worksheet

	Points
A. Existing slope of site (average, weighted by aerial extent):	
2% or less	0
>2 to 5%	5
>5 to 10%	15
>10 to 15%	30
>15%	50
B. Site Area to be cleared and/or graded:	
<5,000 square feet	0
5,000 square feet to 1 acre	30
>1 acres	50
C. Quantity of cut and/or fill on site:	
<500 cubic yards	0
500 to 5,000 cubic yards	5
>5,000 to 10,000 cubic yards	10
>10,000 to 20,000 cubic yards	25
>20,000 cubic yards	40
D. Runoff potential of predominant soils (Soil Conservation Service):	
Hydrologic soil group A	0
Hydrologic soil group B	10
Hydrologic soil group C	20
Hydrologic soil group D	40
E. Erosion Potential of predominant soils (Unified Classification System):	
GW, GP, SW, SP soils	0
Dual classifications (GW-GM, GP-GM, GW-GC, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC)	10
GM, GC, SM, SC soils	20
ML, CL, MH, CH soils	40
F. Surface or ground water entering site identified and intercepted:	
Yes	0
No	25
G. Depth of cut or height of fill >10 feet:	
Yes	25
No	0
H. Clearing and grading will occur in the wet season (October 1-May 1):	
Yes	50
No	0
TOTAL POINTS	____

5.1.2 BMP C1.15: Material Delivery, Storage, and Containment

5.1.2.1 Definition

For all deliveries, storage, and containment of materials, liquid and solid, on a construction site that may potentially pollute stormwater.

5.1.2.2 Purpose

The purpose of this BMP is to prevent, reduce, or eliminate the discharge of pollutants from material delivery and storage to the stormwater system or watercourses by minimizing the storage of hazardous materials onsite, storing materials in a designated area, and installing secondary containment.

5.1.2.3 Conditions Where Practice Applies

These procedures are suitable for use at all construction sites with delivery and storage of the following materials:

- Petroleum products such as fuel, oil and grease
- Soil stabilizers and binders (e.g., Polyacrylamide)
- Fertilizers, pesticides, and herbicides
- Detergents
- Asphalt and concrete compounds
- Hazardous chemicals such as acids, lime, adhesives, paints, solvents and curing compounds
- Any other material that may be detrimental if released to the environment.

5.1.2.4 Planning Considerations

Dangerous solid wastes must be stored and handled according to special guidelines and may require a permit. Follow the regulations and requirements outlined by the Washington State Department of Ecology and, in some cases, King County.

5.1.2.5 Design Criteria

The following steps must be taken to minimize risk:

- Temporary storage area should be located away from vehicular traffic, near the construction entrance(s), and away from waterways or storm drains.
- Material Safety Data Sheets (MSDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.

- Hazardous material storage on-site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (October 1 to April 30), consider storing materials in a covered area.
- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, in secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.
- Materials should be stored with secondary containment, such as a curbed paved area, pallets with built-in containment, 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.
- Maintenance, fueling, and repair of heavy equipment and vehicles shall be conducted using spill prevention and control measures. Contaminated surfaces shall be cleaned immediately following any spill incident.
- Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. On-site fueling tanks shall include secondary containment.

Secondary Containment Practices:

- All hazardous substances with a listed Reportable Quantity shall be stored in approved containers and drums and stored in secondary containment. The list of Reportable Quantities is available (http://www.epa.gov/superfund/programs/er/triggers/haztrigs/302final.xls).
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain precipitation from a 25-year, 24-hour storm event, plus 10 percent of the total enclosed container volume of all containers, or 110 percent of the capacity of the largest container within its boundary, whichever is greater.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (October 1 to April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.

- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.

5.1.2.6 Maintenance

- Secondary containment facilities shall be maintained free of accumulated rainwater and spills. In the event of spills or leaks, accumulated rainwater and spills shall be collected and placed into drums. These liquids shall be handled as hazardous waste unless testing determines them to be non-hazardous.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit). For spill prevention and cleanup requirements, including spill kit instructions, refer to Volume 1, the Source Control Technical Requirements Manual.

5.1.3 BMP C1.20: Use of Chemicals During Construction

5.1.3.1 Definition

For all chemical use at a construction site that may potentially pollute stormwater.

5.1.3.2 Purpose

A large percentage of potential pollutants from chemicals can be effectively controlled at construction sites through implementation of source control, and soil erosion and sedimentation control practices.

5.1.3.3 Conditions Where Practice Applies

Many types of chemicals may be used during construction activities. These chemical pollutants include paints, acids for cleaning masonry surfaces, cleaning solvents, asphalt products, soil additives used for stabilization and other purposes, concrete-curing compounds, and many others. These materials are carried by sediment and water runoff from construction sites.

5.1.3.4 Planning Considerations

Disposal of concrete products, additives, and curing compounds depends on the product. Some liquid wastes must be stored and handled according to special guidelines and may require a permit. Follow the regulations and requirements outlined by the Washington State Department of Ecology and, in some cases, King County.

5.1.3.5 Design Criteria

- As in the case of other pollutants, good housekeeping is the most important means of controlling pollution.
- Use only the recommended amounts of chemical materials and apply them in a proper manner can further reduce pollution.
- Concrete wash water from concrete mixers, acid and alkaline solutions from exposed soil or rock units high in acid, and alkaline-forming natural elements should be controlled using good site planning and pre-construction geological surveys. Neutralization of these pollutants often provides the best treatment.
- The City will require construction site operators to adjust the pH of stormwater if necessary to prevent violations of water quality standards.
- Chemicals used for temporary pH adjustment at construction sites (other than CO_2 or dry ice) must be approved in writing by the Department of Ecology prior to use. As such, formal approval from the Department of Planning and Development is based on Ecology's

protocols. For a list of treatment chemicals that have been evaluated and are currently approved for use by the Department of Ecology (http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html).

- For chemical disposal, the correct method of wastes varies with the material:
  - Wash-up waters from water-based paints may go into a sanitary sewer, which is regulated by the King County Industrial Waste Program (206) 263-3000.
  - Wastes from oil-based paints, cleaning solvents, thinners, and mineral spirits must be disposed of through a licensed waste management firm or treatment, storage, and disposal (TSD) facility.

5.1.3.6 Maintenance

- Seal fractures in the bedrock with grout and bentonite will reduce the amount of acid or alkaline seepage from excavations.
- Adequate treatment and disposal of concrete further reduces pollution.

5.1.4 BMP C1.25: Demolition of Buildings

5.1.4.1 Definition

This activity refers to the removal of existing buildings by means of controlled explosions, wrecking balls, or manual methods, and clearing of the rubble.

5.1.4.2 Purpose

The loose debris produced by building demolition activities can contain toxic organic compounds, metals, and suspended solids that may pollute stormwater.

5.1.4.3 Conditions Where Practice Applies

Complete or partial building demolition, structure demolition, or other activity that requires controlled explosions, wrecking balls, or manual methods to demolish a structure, and/or clearing of demolition rubble.

5.1.4.4 Planning Considerations

This BMP is intended to provide basic information to protect stormwater from being polluted by demolition debris. However, demolition of buildings is regulated in Washington by Ecology and the Puget Sound Clean Air Agency (PSCAA). Refer to Ecology's web page "Dangerous Waste Rules for Demolition, Construction, and Renovation" for additional requirements (http://www.ecy.wa.gov/programs/hwtr/demodebris/index.html) and PSCAA for other information and requirements (http://www.pscleanair.org/regulated/asbestos/contractors/demolitions.aspx).

5.1.4.5 Design Criteria

- Protect the stormwater drainage system from sediment-laden runoff and loose particles. To the extent possible, dikes, berms, or other methods must be used to protect overland discharge paths from runoff.
- Street gutters, sidewalks, driveways, and other paved surfaces in the immediate area of the demolition must be swept daily to collect and properly dispose of loose debris and garbage.
- Water should be sprayed to help control windblown fine materials such as soil, concrete dust, and paint chips. The amount of water should be controlled so that runoff from the site does not occur, yet dust control is achieved. Oils may never be used for dust control.
- Schedule demolition to take place during a dry time of the year.

5.1.4.6 Maintenance

Clean up debris on a regular basis to prevent stormwater contamination.

5.1.5 BMP C1.30: Building Repair, Remodeling, and Construction

5.1.5.1 Definition

Refers to activities associated with construction of buildings and other structures such as, but not limited to remodeling of existing buildings and houses, and general repair work on building exteriors.

5.1.5.2 Purpose

Pollutants of concern that may be generated during building repair, remodeling, and construction include petroleum hydrocarbons, organic compounds, suspended solids, metals, pH, and oils and greases.

5.1.5.3 Conditions Where Practice Applies

When buildings and/or structures are repaired, remodeled, and constructed.

5.1.5.4 Planning Considerations

Educating employees about the need to control site activities is one of the most effective methods to prevent stormwater pollution.

5.1.5.5 Design Criteria

- Use ground cloths or drop cloths underneath activities.
- Use drain covers or similarly effective devices if dust, grit, washwater, or other pollutants may impact onsite or downstream offsite catch basins. The accumulated sediment-laden runoff and solids must be collected and disposed of before the cover is removed.
- All tool cleaning must be done in an inside sink that drains to the sanitary sewer. If cleaning must be done outside, all wastewater must be collected and disposed of properly.
- Clean non-water-based finishes from tools in a manner that allows the collection of used solvents for recycling or proper disposal.
- Water can be sprayed to help control windblown fine materials such as soil, concrete dust, and paint chips. The amount of water should be controlled so that runoff from the site does not occur, yet dust control is achieved. Oils may never be used for dust control.

5.1.5.6 Maintenance

- Maintain the drain covers regularly (weekly or as needed) to prevent plugging.
- Recycle materials whenever possible.

5.1.6 BMP C1.35: Sawcutting and Paving Pollution Prevention

5.1.6.1 Definition

Sawcutting and paving operations include, but are not limited to, the following:

- Sawing
- Surfacing
- Coring
- Grinding
- Roughening
- Hydro-demolition
- Bridge and road surfacing.

5.1.6.2 Purpose

Sawcutting and paving operations generate slurry and wastewater that contain fine particles and high pH, both of which can violate the water quality standards in receiving waters.

5.1.6.3 Conditions Where Practice Applies

Any time sawcutting or paving operations take place.

5.1.6.4 Planning Considerations

This BMP is intended to minimize and eliminate wastewater and slurry from entering the public drainage control system and waters of the state. Wastewater may go into a sanitary sewer, which is regulated by the King County Industrial Waste Program (206) 263-3000.

5.1.6.5 Design Criteria

- Slurry and cuttings shall be vacuumed during the activity to prevent migration offsite and must not remain on permanent concrete or asphalt paving overnight.
- Collected slurry and cuttings shall be disposed of in a manner that does not violate ground water or surface water quality standards.
- Wastewater that is generated during hydro-demolition, surface roughening, or similar operations shall not drain to any natural or constructed drainage conveyance and shall be disposed of in a manner that does not violate ground water or surface water quality standards.

- Cleaning waste material and demolition debris shall be handled and disposed of in a manner that does not cause contamination of water. If the area is swept with a pick-up sweeper, the material must be hauled out of the area to an appropriate disposal site.

5.1.6.6 Maintenance

Continually monitor operations to determine whether slurry, cuttings, or wastewater could enter waters of the state. If inspections show that a violation of water quality standards could occur, stop operations and immediately implement preventative measures such as berms, barriers, secondary containment, and vacuum trucks.

5.1.7 BMP C1.40: Temporary Dewatering

5.1.7.1 Definition

Dewatering is a necessary activity on most construction sites in the Pacific Northwest and typically is temporary while construction occurs. Excavations that do not result in a daylight drain, or have insufficient slope onsite to easily provide daylight drains, trap surface and/or ground water, whether it's a simple trench or a large excavation.

5.1.7.2 Purpose

Temporary dewatering is used when surface and/or ground water needs to be removed before certain operations can be performed, or to keep work conditions safe. It is typical for contractors to use ditch pumps to dewater, but it is very important to identify and use the appropriate locations for discharge. Often, discharged water flows to downgradient receiving waters, stormwater drains, or other natural resources that are sensitive and require protection. Also, temporary dewatering requires a temporary structure for settling and/or filtering sediment-laden water. A temporary sediment pond or other equivalent facility is used to settle and/or filter the water. Properly designed and implemented temporary dewatering will:

- Prevent the discharged water from eroding soil on the site
- Remove sediment from the collected water
- Choose the best location for discharge
- Preserve downgradient natural resources and real property.

5.1.7.3 Conditions Where Practice Applies

Public or private properties with the following:

- Foundation work excavations
- Utilities and infrastructure installation and repair projects, including installation, repair and maintenance of:
    - Electrical conduits
    - Vaults/tanks
    - Sewer and storm drain systems
    - Phone and cable lines
    - Gas or other fuel lines
    - Other excavations or graded areas requiring dewatering.

Clean, non-turbid dewatering water, such as well-point ground water, can be discharged to systems tributary to, or directly into surface waters of the state provided the dewatering flow is discharged to a stabilized system and does not cause erosion or flooding of receiving waters. Clean de-watering water should not be routed through stormwater sediment ponds

If dewatering must occur, a Side Sewer Permit for Temporary Dewatering (SSPTD) may be required prior to commencing dewatering at the site. The permit includes a separate Temporary Dewatering Plan, water quality and treatment requirements, and compliance monitoring.

For a copy of the SSPTD CAM, go to the DPD Public Resources Center on the 20th floor of the Seattle Municipal Tower, 700 Fifth Avenue, Seattle, Washington 98124 (same location as above), or visit DPD's CAM website (http://web1.seattle.gov/DPD/CAMs/CamList.aspx).

5.1.7.4 Planning Considerations

Prior to implementing temporary dewatering, minimize the amount of water that will be collected and the potential amount of sediment that may enter the water. Implement the following prior to temporary dewatering:

- For trench excavation, limit the trench length to 150 feet and place the excavated material on the up gradient side of the trench.
- Install diversion ditches or berms to minimize the amount of clean stormwater runoff allowed into the excavated area.
- Dewatering in periods of intense, heavy rain, when the infiltrative capacity of the soil is exceeded, should be avoided.
- Never discharge to bare or newly vegetated areas.

Once the site has been prepared as described above, it should also be assessed for the issues listed below to assist DPD in determining which discharge option to approve:

- Water clarity. If the water is turbid (cloudy), there are dissolved and/or settable solids in the water that should be filtered or settled out prior to discharge. Determine if contaminants are present in impounded water. Check for odors, discoloration, or oily sheen. Check any soils and/or ground water testing results.
- If contamination may be or is present, the City reserves the right to require sampling and analysis to prove that water quality is being protected. Contact DPD to get assistance in identifying the required parameters of concern and any specific sampling requirements. Highly turbid or contaminated dewatering water shall be handled separately from stormwater.

Any permanent dewatering that is not part of temporary dewatering, as described in this BMP, should be identified in the Construction Stormwater Control Plan narrative and on the plan sheets.

5.1.7.5 Design Criteria

One of several types of dewatering facilities may be constructed, depending upon site conditions and the type of activities.

Water Removal

The removal of water from the excavated area can be accomplished by numerous methods. The most common of these are:

- Gravity drain through a daylight channel
- Mechanical pumping
- Siphoning
- Using the bucket of construction equipment to scoop and dump water from the excavation.

Channels or any conveyance feature dug for discharging water from the excavated area must be stable. If flow velocities cause erosion within the channel, then a ditch lining, such as geotextile or heavy plastic sheeting, should be used.

Discharge Structure

Water conveyed by channels, ditches, pumps, hose, or equipment buckets should be discharged in a regulated manner to a stable discharge structure. The structure must be:

- Appropriate to filter sediment
- Able to withstand the velocity of the discharged water to prevent erosion
- Sized and operated such that pumped water will flow through a sediment removal device
- Not overtop the structure.

Typical constructed areas are:

- Vegetated buffers
- Sediment ponds (refer to BMP E3.45)
- Portable sediment tanks (refer to BMP E3.50)
- Enclosure of hay bales, filter fabric (BMP E3.10), or both
- Sediment Filter Bag.

Sediment Removal – General

Sediment should be settled prior to discharge. All settling systems should be engineered and adequately sized for site conditions. In general settling and filtering options include the following:

- Containment in a pond structure for a minimum of 4 hours or until water is clear. Place pump in a gravel bed at bottom of pond.
- Discharge to a manufactured / pre-made structure specifically designed for sediment removal, like a Silt Sak, Silt Bag, or other similar product. Pumping to a settling tank with sampling ports.
- Transport offsite in vehicle, such as a vacuum flush truck, for legal disposal.
- Filtering through a sieve or other filter media (swimming pool filter). Simple on-site filter systems can be constructed including: wrapping the ends of the suction and discharge pipes with filter fabric; discharging through a series of drums filled with successively finer gravel and sand; and other filtering techniques like those described in the inlet protection section.
- Manufactured bags, polymers, or other systems. These systems do not always work on fine clay soils, and will only be allowed for use where approved. Chemical treatments should have state approval before they are used (refer to BMP C1.20 and Appendix B).
- The flow path should be lined or protected in some way to prevent mobilization of additional sediment.
- Filtered material should be either dried and reused on site in a mixture with other site soils or should be appropriately disposed of based on nature and levels of any contaminants present.

In addition to sediment, if the collected water is contaminated with oil, grease, or other petroleum products, an oil/water separator or a filtration mechanism may be necessary prior to the discharge. Another disposal method may be using a vendor for collection, transport, and offsite disposal.

Vegetated Buffer

A well stabilized, onsite, vegetated area may serve as a dewatering facility if the area is appropriate to filter sediment and at the same time withstand the velocity of the discharged water without erosion. The discharge of sediment-laden water onto a vegetated area should not pose a threat to the survival of the existing vegetative stand through smothering by sedimentation.

Direct discharge of lightly sediment bearing water may be able to go directly into well-buffered areas with 0 2 percent slope as long as a method of spreading flow into sheet flow is available.

Straw Bale/Filter Fabric Pit

An excavated or bermed sedimentation pond or structure can also be created using straw bale and filter fabric (see and BMP E3.10 Filter Fence) to create a pit. Flow to the structure may not exceed the sediment removal structure's capacity to settle and filter flow or the structure's volume capacity. The structure should also discharge wherever possible to a well-vegetated buffer (see above) through sheet flow and should maximize the distance to the nearest water resources and minimizing the slope of the buffer area. Also, the excavated portion may need to be lined with geotextile to help reduce scour and to prevent the inclusion of soil from within the structure.

For details, refer to the BMP E3.40 Sediment Trap.

Sediment Filter Bag

The filter bag should be constructed of non-woven geotextile material that will provide adequate filtering ability to capture the larger soil particles from the pumped water. The bag should be constructed so that there is an inlet neck that may be clamped around the dewatering pump discharge hose so that all of the pumped water passes through the bag.

The filter bag should be used in combination with a straw bale/silt fence pit when located within 50 feet of a receiving water. When the distance is greater than 50 feet, the bag may be placed on well-established vegetation, or on an aggregate pad constructed of crushed rock at a minimum depth of 6 inches. The bag should never be placed on bare soil.

The capacity of the sediment filter bag should be adequate to handle the dewatering pump discharge, and should be based on the bag manufacturer's recommendation.

When used in conjunction with a straw bale/silt fence pit, a filter bag may be operated until the water in the pit reaches the crest of the emergency overflow. The pump must be shut off at this point. When placed on either a stone pad or well-established vegetation, the pad may be operated until such time the discharge from the bag reaches a receiving water. Unless the discharge is at least as clear as the receiving water, the pump must be shut off at this point.

When the bag has been completely filled with sediment, it should be cut open, regraded in place, and immediately stabilized with either sod or erosion control mat.

5.1.7.6 Maintenance

- Remember to check filtering devices frequently to make sure they are unclogged and operating correctly. Special attention should be paid to the buffer area for any sign of erosion and concentration of flow that may compromise the buffer area. Observe where possible the visual quality of the effluent and determine if additional treatment can be provided.

- Adjustments may be needed depending on the amount of sediment in the water being pumped.
- Repair and/or replace any equipment that does not function as designed.
- The accumulated sediment which is removed during maintenance must be spread on-site and stabilized or disposed of at an approved disposal site.
- Systems should be filled-in or otherwise removed when permanent dewatering controls are in place and connected to an approved treatment and receiving system.

5.1.8 BMP C1.45: Solid Waste Handling and Disposal

5.1.8.1 Definition

For all solid waste management, including handling and disposal, which takes place on a construction site which may potentially pollute stormwater.

5.1.8.2 Purpose

Solid waste is one of the major pollutants caused by construction and can have direct impacts to stormwater as a potential pollutant if not managed and disposed of properly. Solid waste is generated many ways, including:

- From trees and shrubs removed during land clearing
- From wood and paper used in packaging and building materials
- Scrap metals and metal shavings
- Sanitary wastes
- Rubber, plastic and glass pieces
- Masonry products
- Leftover food, food containers, beverage cans, coffee cups, lunch wrapping paper, aluminum foil, and plastic
- Cigarette packages and butts.

5.1.8.3 Conditions Where Practice Applies

All construction sites.

5.1.8.4 Planning Considerations

The major control mechanism for these pollutants is to provide adequate disposal facilities.

5.1.8.5 Design Criteria

- Frequent garbage removal helps maintain construction sites in a clean and attractive manner; however, accumulated solid waste should ultimately be removed and disposed of at authorized disposal areas.
- Waste containers should be labeled and located in a covered area. Lids should be kept closed at all times.
- Any useful materials should be salvaged and recycled. For example:
    - Masonry waste can be used for filling borrow pits

    - Trees and brush from land-clearing operations can be converted into woodchips through mechanical chippers and then used as mulch in graded areas.

- Selective (rather than wholesale) removal of trees is helpful in conservation of soil and reduction of wood wastes. Indiscriminate removal of trees and other beneficial vegetation should be avoided.

5.1.8.6 Maintenance

- Soil erosion and sediment control structures capture much of the solid waste from construction sites. Constant removal of litter from these structures will reduce the amount of solid waste despoiling the landscape.

5.1.9 BMP C1.50: Disposal of Asbestos and Polychlorinatedbiphenols (PCBs)

Use and disposal of these potential pollutants are regulated by both state and federal agencies. For further information, contact:

- For asbestos:
  - Puget Sound Air Pollution Control Agency (www.pscleanair.org/) (206) 343-8800 or toll free (800) 552-3565
  - U.S. EPA (www.epa.gov/asbestos/) (206) 553-1200 or toll free (800) 424-4EPA
- For wastes containing PCBs:
  - Washington Department of Ecology, Hazardous Waste Section: (206) 449-6687
  - U.S. EPA (http://www.epa.gov/ebtpages/pollchemicalspolychlorinatedbiphenylspcbs.html) (206) 553-1200 or toll free (800) 424-4EPA.

5.1.10 BMP C1.55: Airborne Debris Curtain

5.1.10.1 Definition

Using plastic or other material to create a vertical barrier, or curtain, around a building or other structure undergoing exposed construction or cleaning activities to minimize the spread of airborne debris.

5.1.10.2 Purpose

Activities related to exposed building construction, repair, or cleaning include spraying, pressure washing, surface preparation, sand blasting, paint removal, sanding, and painting. If conducted outdoors, all of these activities are associated with a high risk for contaminating water resources.

Potential pollutants include spent fire retardants, abrasive grits, solvents, oils, washwater, paint overspray, cleaners and detergents, paint chips, glass fibers, and dust. Pollutant constituents include suspended solids, oils and greases, organic compounds, copper, lead, tin, and zinc.

5.1.10.3 Conditions Where Practice Applies

This BMP should be implemented when spraying, blasting, sanding, or washing outdoors.

5.1.10.4 Planning Considerations

- For maintenance and repair activities that can be moved indoors, relocate them to reduce the potential for direct pollution of stormwater.
- Properly dispose of spent abrasives, cleaners, etc.
- Consider using no soaps or detergents. Brush the exterior surface with water only.

> Despite what is on the label, the term biodegradable does not mean that the product is safe or environmentally friendly. Some cleaning products may degrade eventually, but is still harmful to the environment.

5.1.10.5 Design Criteria

- Use fixed platforms with appropriate plastic or tarpaulin barriers as work surfaces and for containment when work is performed near a receiving water to prevent material or overspray from contacting stormwater or the receiving water.
- Use sanders that have dust-containment bags and avoid sanding in windy conditions.

- Store materials such as paints, tools, and ground cloths indoors or in a covered area when not in use.
- Contain blasting and spraying activities by hanging tarpaulins to block the wind and prevent dust and overspray from escaping. Do not perform uncontained spray painting, blasting, or sanding activities over open water without proper protection (e.g., overspray collection, drop clothes, booms).
- Use plywood and/or plastic sheeting to cover open areas when sandblasting.
- Use ground cloths to collect drips and spills during painting and finishing operations, and paint chips, and used blasting sand during sand blasting.
- Avoid collecting debris in areas subject to foot or vehicular traffic to control tracking.

5.1.10.6 Maintenance

- Collect spent abrasives and other waste materials regularly and contain and store them under cover until they can be disposed of properly.
- At least once each week or more often as needed, sweep and clean ground surface areas. Do not hose them down and properly dispose of the collected materials.
- Use one of the following treatment BMPs when paint chips or blasting grit are present in the work area:
  - Cleaning inlets and catch basins (BMP E3.65)
  - Street sweeping and vacuuming (BMP E3.70)
  - Storm drain inlet protection (BMP E3.25). Use filtration with media designed for the pollutants present.

Catch basin filters only remove solids and do not provide treatment for other pollutants associated with some building cleaning activities.

Appendix A –

Definitions

Appendix A - Definitions

The following definitions are provided for reference and use with this manual. **All projects must also refer to the definitions section of the Stormwater Code (SMC Chapter 22.801). Where any inconsistencies exist between this appendix and SMC Chapter 22.801, the SMC definitions shall be used.**

Aquatic	In or of water. The term can be either a noun or an adjective; the implication is that of fresh water. The term marine (ocean) is typically substituted where reference to salt water is intended.
Bacteria	Bacteria are a major group of micro-organisms that live in soil, water, plants, organic matter, or the bodies of animals or people. They are microscopic and mostly unicellular, with a relatively simple cell structure. Stormwater can contain disease-causing bacteria and viruses.
Baffle	A device to check, deflect, or regulate flow.
Basic treatment facility	A drainage control facility designed to reduce concentrations of total suspended solids in drainage water.
Best management practice (BMP)	A schedule of activities, prohibitions of practices, operational and maintenance procedures, structural facilities, or managerial practice or device that, when used singly or in combination, prevents, reduces, or treats contamination of drainage water, prevents or reduces soil erosion, or prevents or reduces other adverse effects of drainage water on receiving waters. When the Directors develop rules and/or manuals prescribing best management practices for particular purposes, whether or not those rules and/or manuals are adopted by ordinance, BMPs prescribed in the rules and/or manuals shall be the BMPs required for compliance with SMC 22.800 – 22.808.
Biochemical oxygen demand (BOD)	A water quality parameter that indicates the amount of free oxygen utilized by aerobic organisms. Also refer to Chemical Oxygen Demand (COD).
Biodegradable	Capable of being readily broken down by biological means, especially by microbial action. Degradation can be rapid or may take many years depending upon such factors as the nature of the substance and available oxygen and moisture.
Biofilter	Biofilter means a designed treatment facility using a combined soil and vegetation system for filtration, infiltration, adsorption, and biological uptake of pollutants in stormwater when runoff flows over and through. Vegetation growing in these facilities acts as both a physical filter which causes gravity settling of particulates by regulating velocity of flow, and also as a biological sink when direct uptake of dissolved pollutants occurs.

Biofiltration	Biofiltration means the process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.
Capacity-constrained system	A drainage system that the Director of SPU has determined to have inadequate capacity to carry drainage water.
Cause or contribute to a violation	Acts or omissions that create a violation, that increase the duration, extent or severity of a violation, or that aid or abet a violation.
Certified Erosion and Sediment Control Lead (CESCL)	An individual who has current certification through an approved erosion and sediment control training program that meets the minimum training standards established by the Washington State Department of Ecology.
Chemical oxygen demand (COD)	A water quality parameter that represents organic, nitrogenous and other materials that are consumed by bacteria present in receiving waters. Oxygen may be depleted in the process, threatening higher organisms such as fish. The COD test is used to determine the degree of pollution in water. Also refer to Biochemical Oxygen Demand (BOD).
Civil engineer, licensed	A person who is licensed by the State of Washington to practice civil engineering.
Clearing	Clearing means the removal of vegetation, and removal of roots or stumps that include ground disturbance.
Containment area	The area designated for conducting pollution-generating activities for the purposes of implementing source controls or designing and installing source controls or treatment facilities.
Compaction	The densification of earth material by mechanical means.
Construction Stormwater Control Plan	A document that explains and illustrates the measures to be taken on the construction site to control pollutants on a construction project.
Contaminate	The addition of sediment, any other pollutant or waste, or any illicit or prohibited discharge.
Creek	A Type 2-5 water as defined in WAC 222-16-031 and is used synonymously with “stream.”
Designated receiving water	Designated receiving waters include the Duwamish River, Puget Sound, Lake Washington, Lake Union, Elliott Bay, Portage Bay, Union Bay, the Lake Washington Ship Canal, and other receiving waters determined by the Director of SPU and approved by Ecology as having sufficient capacity to receive discharges of drainage water such that a site discharging to the designated receiving water is not required to implement flow control.

Detention	Temporary storage of drainage water for the purpose of controlling the drainage discharge rate.
Development	Land disturbing activity or the addition or replacement of impervious surface.
Director	The Director of the Department authorized to take a particular action, and the Director's designees, who may be employees of that department or another City department.
Discharge point	The location from which drainage water from a site is released.
Drainage basin	The tributary area or subunit of a watershed through which drainage water is collected, regulated, transported, and discharged to receiving waters.
Drainage control	The management of drainage water. Drainage control is accomplished through one or more of the following: collecting, conveying, and discharging drainage water; controlling the discharge rate from a site; controlling the flow duration from a site; and separating, treating or preventing the introduction of pollutants.
Drainage control facility	Any facility, including best management practices, installed or constructed for the purpose of controlling the discharge rate, flow duration, quantity, and/or quality of drainage water.
Drainage control plan	A plan for collecting, controlling, transporting and disposing of drainage water falling upon, entering, flowing within, and exiting the site, including designs for drainage control facilities.
Drainage system	A system intended to collect, convey and control release of only drainage water. The system may be either publicly or privately owned or operated, and the system may serve public or private property. It includes constructed and/or natural components such as pipes, ditches, culverts, streams, creeks, or drainage control facilities.
Drainage water	Stormwater and all other discharges that are permissible per subsection 22.802.030 A.
Enhanced treatment facility	A drainage control facility designed to reduce concentrations of dissolved metals in drainage water.
Erosion	The wearing away of the ground surface as a result of mass wasting or of the movement of wind, water, ice, or other geological agents, including such processes as gravitational creep. Erosion also means the detachment and movement of soil or rock fragments by water, wind, ice, or gravity.
Excavation	The mechanical removal of earth material.

Existing grade	Existing grade means the current surface contour of a site, including minor adjustments to the surface of the site in preparation for construction, or the surface contour that existed immediately prior to grading done without a permit.
Fill	Fill means a deposit of earth material placed by artificial means.
Flow control	Controlling the discharge rate, flow duration, or both of drainage water from the site through means such as infiltration or detention.
Flow control facility	A drainage control facility for controlling the discharge rate, flow duration, or both of drainage water from a site.
Flow-critical receiving water	A surface water that is not a “designated receiving water” as defined in SMC 22.800 – 22.808.
Flow duration	The aggregate time that peak flows are at or above a particular flow rate of interest.
Geotechnical engineer	A professional civil engineer licensed by the State of Washington who has at least four (4) years of professional experience as a geotechnical engineer, including experience with landslide evaluation.
Grading	Excavation, filling, in-place ground modification, removal of roots or stumps that includes ground disturbance, stockpiling of earth materials, or any combination thereof, including the establishment of a grade following demolition of a structure.
Green stormwater infrastructure	A drainage control facility that uses infiltration, evapotranspiration, or stormwater reuse. Examples of green stormwater infrastructure include permeable pavement, bioretention facilities, and green roofs.
Groundwater	Water in a saturated zone or stratum beneath the land surface or a surface waterbody.
Impervious Surface	Any surface exposed to rainwater from which most water runs off. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, formal planters, parking lots or storage areas, concrete or asphalt paving, permeable paving, gravel surfaces subjected to vehicular traffic, compact gravel, packed earthen materials, and oiled macadam or other surfaces which similarly impede the natural infiltration of stormwater. Open, uncovered retention/detention facilities shall not be considered as impervious surfaces for the purposes of determining whether the thresholds for application of minimum requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of stormwater modeling.

Industrial activities	Activities such as material handling, transportation, or storage; manufacturing; maintenance; treatment; or disposal. Areas with industrial activities include plant yards, access roads and rail lines used by carriers of raw materials, manufactured products, waste material, or by-products; material handling sites; refuse sites; sites used for the application or disposal of process waste waters; sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater.
Infiltration	The downward movement of water from the surface to the subsoil.
Infiltration facility	A drainage control facility that temporarily stores, and then percolates drainage water into the underlying soil.
Inspector	A City inspector, their designee, or licensed civil engineer performing the inspection work required by SMC 22.800 – 22.808.
Land disturbing activity	Any activity that results in a movement of earth, or a change in the existing soil cover, both vegetative and nonvegetative, or the existing topography. Land disturbing activities include, but are not limited to, clearing, grading, filling, excavation, or addition of new or the replacement of impervious surface. Compaction, excluding hot asphalt mix, which is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices are not considered land disturbing activities.
Listed creek basins	Listed creek basins include Blue Ridge Creek, Broadview Creek, Discovery Park Creek, Durham Creek, Frink Creek, Golden Gardens Creek, Kiwanis Ravine/Wolfe Creek, Licton Springs Creek, Madrona Park Creek, Mee-Kwa-Mooks Creek, Mount Baker Park Creek, Puget Creek, Riverview Creek, Schmitz Creek, Taylor Creek, or Washington Park Creek.
Maximum extent feasible	Maximum extent feasible means that the requirement is to be fully implemented, constrained only by the physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts.
Metals	Metallic elements that can be beneficial or hazardous to the environment, depending on the type and concentration. Typical metals include copper, zinc, mercury, chromium, cadmium, arsenic, and lead.

Monitoring	The collection of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures imposed as conditions of development.
Municipal stormwater NPDES permit	The permit issued to the City under the federal Clean Water Act for public drainage systems within the City limits.
NPDES	National Pollutant Discharge Elimination System, the national program for controlling discharges under the federal Clean Water Act.
NPDES permit	An authorization, license or equivalent control document issued by the United States Environmental Protection Agency or the Washington State Department of Ecology to implement the requirements of the NPDES program.
Nutrients	Essential chemicals, such as phosphorus and nitrogen, needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and algal blooms. Some nutrients can be toxic at high concentrations.
Oil control treatment facility	A drainage control facility designed to reduce concentrations of oil in drainage water.
Outlet Trap	A tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze.
Pervious surface	A surface that is not impervious. See also “impervious surface.”
Petroleum Hydrocarbons	This is a term used to refer to a broad range of petroleum products such as mineral oil, gasoline, diesel, heating oil, lubricant oil, and hydraulic fluid.
pH	The "pH" value is a measure of the alkalinity or acidity of a substance which is conducted by measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acidic.
Plan	A graphic or schematic representation, with accompanying notes, schedules, specifications and other related documents, or a document consisting of checklists, steps, actions, schedules, or other contents that has been prepared pursuant to SMC 22.800 – 22.808, such as a drainage control plan, construction stormwater control plan, stormwater pollution prevention plan, and integrated drainage plan.

Pollution-generating activity

Any activity that is regulated by the joint SPU/DPD Directors' Rule titled "Source Control Technical Requirements Manual" or activities with similar impacts on drainage water. These activities include, but are not limited to: cleaning and washing activities; transfer of liquid or solid material; production and application activities; dust, soil, and sediment control; commercial animal care and handling; log sorting and handling; boat building, mooring, maintenance, and repair; logging and tree removal; mining and quarrying of sand, gravel, rock, peat, clay, and other materials; cleaning and maintenance of swimming pool and spas; deicing and anti-icing operations for airports and streets; maintenance and management of roof and building drains at manufacturing and commercial buildings; maintenance and operation of railroad yards; maintenance of public and utility corridors and facilities; and maintenance of roadside ditches.

Pollution-generating impervious surface

Those impervious surfaces considered to be a significant source of pollutants in drainage water. Such surfaces include those that are subject to: vehicular use; certain industrial activities; or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Erodible or leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the drainage water. Examples include: erodible soils that are stockpiled; uncovered process wastes; manure; fertilizers; oily substances; ashes; kiln dust; and garbage dumpster leakage. Metal roofs are also considered to be PGIS unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating).

A surface, whether paved or not, shall be considered subject to vehicular use if it is regularly used by motor vehicles. The following are considered regularly-used surfaces: roads; unvegetated road shoulders; permeable pavement; bike lanes within the traveled lane of a roadway; driveways; parking lots; unfenced fire lanes; vehicular equipment storage yards; and airport runways.

The following are not considered regularly-used surfaces: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles; fenced fire lanes; and infrequently used maintenance access roads.

Pollution-generating pervious surface

Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil, and typically includes lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.

Pre-developed condition	The vegetation and soil conditions that are used to determine the allowable post-development discharge peak flow rates and flow durations, such as pasture or forest.
Project	The addition or replacement of impervious surface or the undertaking of land disturbing activity on a site.
Public combined sewer	A publicly owned and maintained system which carries drainage water and wastewater and flows to a publicly owned treatment works.
Public drainage system	A drainage system owned or used by the City of Seattle.
Public sanitary sewer	The sanitary sewer that is owned or operated by a City agency.
Public storm drain	The part of a public drainage system that is wholly or partially piped, owned or operated by a City agency, and designed to carry only drainage water.
Receiving water	The surface water or wetland receiving drainage water.
Recommended BMPs	Recommended BMPs are those source control BMPs that are not mandatory for activities or at new development and redevelopment sites. However, they may improve pollutant control efficiency, and may provide a more comprehensive and environmentally effective stormwater management program.
Replaced impervious surface	For structures, the removal and replacement of impervious surface down to the foundation. For other impervious surface, the impervious surface that is removed down to earth material and a new impervious surface is installed.
Required BMPs	Required BMPs are those BMPs that are required by the City of Seattle for applicable activities, in accordance with the City of Seattle Stormwater Code.
Secondary containment	Secondary containment provides a barrier between a container (e.g., fuel tank, drum, paint cans) and the environment. The barrier holds the leaked material until the leak is detected and fixed. The barrier also prevents stormwater from being polluted in the event of a spill or leak. Examples include an impervious dike, berm, or retaining wall; a temporary pan, tub, or absorptive pad can be used to contain incidental leaks.
Single-family residential project	A project, that constructs one Single-family Dwelling Unit per SMC 23.44.006.A located in land classified as being Single-family Residential 9,600 (SF 9600), Single-family Residential 7,200 (SF 7200), or Single-family Residential 5,000 (SF 5000) per SMC 23.30.010, and the total new plus replaced impervious surface is less than 10,000 square feet and the total new plus replaced pollution-generating impervious surface is less than 5,000 square feet.

Site	The lot or parcel, or portion of street, highway or other right-of-way, or contiguous combination thereof, where a permit for the addition or replacement of impervious surface or the undertaking of land disturbing activity has been issued or where any such work is proposed or performed. For roadway projects, the length of the project site and the right-of-way boundaries define the site.
Sludge	A generic term for solids separated from suspension in a liquid by a variety of processes.
Source controls	Structures or operations that prevent contaminants from coming in contact with drainage water through physical separation or careful management of activities that are known sources of pollution.
Stormwater	That portion of precipitation and snowmelt that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a drainage system into a receiving water or a constructed infiltration facility.
Sump	A sump, commonly found in the home basement, is simply a hole to collect water that has entered because of rain or because of natural groundwater. Some businesses use sumps to collect liquids from their operations (e.g., oil change operation). A sump pump is commonly used to move the liquid to a disposal point or the liquid is pumped out and disposed separately.
Total suspended solids (TSS)	That portion of the solids carried by stormwater that can be captured on a standard glass filter.
Treatment Facility	A drainage control facility designed to remove pollutants from drainage water.
Turbidity	A measure of water clarity. Color or cloudiness in a liquid caused by the dispersion or scattering of light, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.
Water quality	A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Quality Standards	Surface Water Quality Standards, Chapter 173-201A WAC, Ground Water Quality Standards, Chapter 173-200 WAC, and Sediment Management Standards, Chapter 173-204 WAC.
Watershed	A geographic region within which water drains into a particular river, stream, or other body of water.

Wetland function The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. Wetland functions can be grouped into three categories: functions that improve water quality; functions that change the water regime in a watershed, such as flood storage; and functions that provide habitat for plants and animals.

Appendix B –

Background Information on Chemical Treatment

Appendix B - Background Information on Chemical Treatment

This information was obtained from the 2005 Stormwater Management Manual for Western Washington, including updates.

D.1 Coagulation and Flocculation

Coagulation and flocculation have been used for over a century to treat water. It is used less frequently for the treatment of wastewater. The use of coagulation and flocculation for treating stormwater is a very recent application. Experience with the treatment of water and wastewater has resulted in a basic understanding of the process, in particular factors that affect performance. This experience can provide insights as to how to most effectively design and operate similar systems in the treatment of stormwater.

Fine particles suspended in water give it a milky appearance, measured as turbidity. Their small size, often much less than 1 µm in diameter, give them a very large surface area relative to their volume. These fine particles typically carry a negative surface charge. Largely because of these two factors, small size and negative charge, these particles tend to stay in suspension for extended periods of time. Thus, removal is not practical by gravity settling. These are called stable suspensions. Polymers, as well as inorganic chemicals such as alum, speed the process of clarification. The added chemical destabilizes the suspension and causes the smaller particles to agglomerate. The process consists of three steps: coagulation, flocculation, and settling or clarification. Each step is explained below as well as the factors that affect the efficiency of the process.

Coagulation is the first step. It is the process by which negative charges on the fine particles that prevent their agglomeration are disrupted. Chemical addition is one method of destabilizing the suspension, and polymers are one class of chemicals that are generally effective. Chemicals that are used for this purpose are called coagulants. Coagulation is complete when the suspension is destabilized by the neutralization of the negative charges. Coagulants perform best when they are thoroughly and evenly dispersed under relatively intense mixing. This rapid mixing involves adding the coagulant in a manner that promotes rapid dispersion, followed by a short time period for destabilization of the particle suspension. The particles are still very small and are not readily separated by clarification until flocculation occurs.

Flocculation is the process by which fine particles that have been destabilized bind together to form larger particles that settle rapidly. Flocculation begins naturally following coagulation, but is enhanced by gentle mixing of the destabilized suspension. Gentle mixing helps to bring particles in contact with one another such that they bind and continually grow to form "flocs." As the size of the flocs increases they become heavier and tend to settle more rapidly.

Clarification is the final step, settling of the particles. Particle density, size and shape are important during settling. Dense, compact flocs settle more readily than less dense, fluffy flocs. Because of this, flocculation to form dense, compact flocs is particularly important during water treatment. Water temperature is important during settling. Both the density and viscosity of water are affected by temperature; these in turn affect settling. Cold temperatures increase viscosity and density, thus slowing down the rate at which the particles settle.

The conditions under which clarification is achieved can affect performance. Currents can affect settling. Currents can be produced by wind, by differences between the temperature of the incoming water and the water in the clarifier, and by flow conditions near the inlets and outlets. Quiescent water such as that which occurs during batch clarification provides a good environment for effective performance as many of these factors become less important in comparison to typical sedimentation basins. One source of currents that is likely important in batch systems is movement of the water leaving the clarifier unit. Given that flocs are relatively small and light the exit velocity of the water must be as low as possible. Sediment on the bottom of the basin can be resuspended and removed by fairly modest velocities.

Coagulants, such as polymers, are large organic molecules that are made up of subunits linked together in a chain-like structure. Attached to these chain-like structures are other groups that carry positive or negative charges, or have no charge. Polymers that carry groups with positive charges are called cationic, those with negative charges are called anionic, and those with no charge (neutral) are called nonionic.

Cationic polymers can be used as coagulants to destabilize negatively charged turbidity particles present in natural waters, wastewater and stormwater. Aluminum sulfate (alum) can also be used as this chemical becomes positively charged when dispersed in water. In practice, the only way to determine whether a polymer is effective for a specific application is to perform preliminary or on-site testing.

Polymers are available as powders, concentrated liquids, and emulsions (which appear as milky liquids). The latter are petroleum based, which are not allowed for construction stormwater treatment. Polymer effectiveness can degrade with time and also from other influences. Thus, manufacturers' recommendations for storage should be followed. Manufacturer’s recommendations usually do not provide assurance of water quality protection or safety to aquatic organisms. Consideration of water quality protection is necessary in the selection and use of all polymers.

D.1.1 Application Considerations

Application of coagulants at the appropriate concentration or dosage rate for optimum turbidity removal is important for management of chemical cost, for effective performance, and to avoid aquatic toxicity. The optimum dose in a given application depends on several site-specific features. Turbidity of untreated water can be important with turbidities greater than 5,000 NTU. The surface charge of particles to be removed is also important. Environmental factors that can influence dosage rate are water temperature, pH, and the presence of constituents that consume or otherwise affect polymer effectiveness. Laboratory experiments indicate that mixing previously settled sediment (floc sludge) with the untreated stormwater significantly improves clarification, therefore reducing the effective dosage rate. Preparation of working solutions and thorough dispersal of polymers in water to be treated is also important to establish the appropriate dosage rate.

For a given water sample, there is generally an optimum dosage rate that yields the lowest residual turbidity after settling. When dosage rates below this optimum value (under dosing) are applied, there is an insufficient quantity of coagulant to react with, and therefore destabilize, all of the turbidity present. The result is residual turbidity (after flocculation and settling) that is higher than with the optimum dose. Overdosing, application of dosage rates greater than the optimum value, can also negatively impact performance. Again, the result is higher residual turbidity than that with the optimum dose.

For mixing in coagulation/flocculation, the G-value, or just "G", is often used as a measure of the mixing intensity applied during coagulation and flocculation. The symbol G stands for “velocity gradient”, which is related in part to the degree of turbulence generated during mixing. High G-values mean high turbulence, and vice versa. High G-values provide the best conditions for coagulant addition. With high G's, turbulence is high and coagulants are rapidly dispersed to their appropriate concentrations for effective destabilization of particle suspensions.

Low G-values provide the best conditions for flocculation. Here, the goal is to promote formation of dense, compact flocs that will settle readily. Low G's provide low turbulence to promote particle collisions so that flocs can form. Low G's generate sufficient turbulence such that collisions are effective in floc formation, but do not break up flocs that have already formed.

Design engineers wishing to review more detailed presentations on this subject are referred to the following textbooks:

Fair, G., J. Geyer and D. Okun, Water and Wastewater Engineering, Wiley and Sons, NY, 1968.

American Water Works Association, Water Quality and Treatment, McGraw-Hill, NY, 1990.

Weber, W.J., Physiochemical Processes for Water Quality Control, Wiley and Sons, NY, 1972.

D.1.2 Polymer Batch Treatment Process Description

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to a storage pond or other holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

The first step in the treatment sequence is to check the pH of the stormwater in the storage pond. The pH is adjusted by the application of acid or base until the stormwater in the storage pond is within the desired pH range. When used, acid is added immediately downstream of the transfer pump. Typically sodium bicarbonate (baking soda) is used as a base, although other bases may be used. When needed, base is added directly to the storage pond. The stormwater is recirculated with the treatment pump to provide mixing in the storage pond. Initial pH adjustments should be based on daily bench tests. Further pH adjustments can be made at any point in the process.

Once the stormwater is within the desired pH range, the stormwater is pumped from the storage pond to a treatment cell as polymer is added. The polymer is added upstream of the pump to facilitate rapid mixing.

After polymer addition, the water is kept in a lined treatment cell for clarification of the sediment-floc. In a batch mode process, clarification typically takes from 30 minutes to several hours. Prior to discharge samples are withdrawn for analysis of pH and turbidity. If both are acceptable, the treated water is discharged.

Several configurations have been developed to withdraw treated water from the treatment cell. The original configuration is a device that withdraws the treated water from just beneath the water surface using a float with adjustable struts that prevent the float from settling on the cell bottom. This reduces the possibility of picking up sediment-floc from the bottom of the pond. The struts are usually set at a minimum clearance of about 12 inches; that is, the float will come within 12 inches of the bottom of the cell. Other systems have used vertical guides or cables which constrain the float, allowing it to drift up and down with the water level. More recent designs have an H-shaped array of pipes, set on the horizontal.

This scheme provides for withdrawal from four points rather than one. This configuration reduces the likelihood of sucking settled solids from the bottom. It also reduces the tendency for a vortex to form. Inlet diffusers, a long floating or fixed pipe with many small holes in it, are also an option.

Safety is a primary concern. Design should consider the hazards associated with operations, such as sampling. Facilities should be designed to reduce slip hazards and drowning. Tanks and ponds should have life rings, ladders, or steps extending from the bottom to the top.

D.2 Adjustment of pH and Alkalinity

The pH must be in the proper range for the polymers to be effective, which is 6.5 to 8.5 for Calgon CatFloc 2953, the most commonly used polymer. As polymers tend to lower the pH, it is important that the stormwater have sufficient buffering capacity. Buffering capacity is a function of alkalinity. Without sufficient alkalinity, the application of the polymer may lower the pH to below 6.5. A pH below 6.5 not only reduces the effectiveness of the polymer, it may create a toxic condition for aquatic organisms. Stormwater may not be discharged without readjustment of the pH to above 6.5. The target pH should be within 0.2 standard units of the receiving water pH.

Experience gained at several projects in the City of Redmond has shown that the alkalinity needs to be at least 50 mg/L to prevent a drop in pH to below 6.5 when the polymer is added. Baking soda has been used to raise both the alkalinity and the pH. Although lime is less expensive than baking soda, if overdosed lime can raise the pH above 8.5 requiring downward adjustment for the polymer to be effective. Baking soda has the advantage of not raising the pH above 8.3 regardless of the amount that is added. Experience indicates that the amount of baking soda sufficient to raise the alkalinity to above 50 mg/L produces a pH near neutral or 7.

Alkalinity cannot be easily measured in the field. Therefore, conductivity, which can be measured directly with a hand-held probe, has been used to ascertain the buffering condition. It has been found through local experience that when the conductivity is above about 100 µS/cm the alkalinity is above 50 mg/L. This relationship may not be constant and therefore care must be taken to define the relationship for each site.

Experience has shown that the placement of concrete has a significant effect on the pH of construction stormwater. If the area of fresh exposed concrete surface is significant, the pH of the untreated stormwater may be considerably above 8.5. Concrete equipment washwater shall be controlled to prevent contact with stormwater. Acid may be added to lower the pH to the background level pH of the receiving water. The amount of acid needed to adjust the pH to the desired level is not constant but depends upon the polymer dosage, and the pH, turbidity, and alkalinity of the untreated stormwater. The acid commonly used is sulfuric although muriatic and ascorbic acids have been used. Pelletized dry ice has also been used and reduces the safety concerns associated with handling acid.

Note: The Stormwater Management Manual for Western Washington has recently added BMPs for chemical treatment and sand filtration, pH neutralization (carbon dioxide), and ph control.