

Stormwater Management Manual for Western Washington

Volume I Minimum Technical Requirements and Site Planning

Prepared by:
Washington State Department of Ecology
Water Quality Program

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Chapter 1 - Introduction

1.1 Objective

The objective of this manual is to provide guidance on the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment such that they comply with water quality standards and contribute to the protection of beneficial uses of the receiving waters. ~~The water quality standards include: Chapter 173-200 WAC, Water Quality Standards for Ground Waters of the State of Washington; Chapter 173-201A, Water Quality Standards for Surface Waters of the State of Washington; and Chapter 173-204, Sediment Management Standards.~~ Application of appropriate minimum requirements and Best Management Practices (BMPs) identified in this manual are necessary but sometimes insufficient measures to achieve ~~these objectives. (See Section 1.7, Effects of Urbanization the objective. (See Section 1.7, Effects of Urbanization)).~~

Water quality standards include:

- Chapter 173-200 of the Washington Administrative Code (WAC), Water Quality Standards for Ground Waters of the State of Washington
- Chapter 173-201A WAC, Water Quality Standards for Surface Waters of the State of Washington
- Chapter 173-204 WAC, Sediment Management Standards

This manual ~~establishes~~identifies minimum requirements for development and redevelopment projects of all sizes and provides guidance concerning how to prepare and implement stormwater site plans. These requirements are, in turn, satisfied by the application of BMPs from Volumes II through V. Projects that follow this approach will apply reasonable, technology-based BMPs and water quality-based BMPs to reduce the adverse impacts of stormwater. This manual is applicable to all types of land development – including residential, commercial, industrial, and roads. Manuals with a more-specific focus, such as a Highway Runoff Manual, that have been determined to be equivalent to this manual, may provide more appropriate guidance to the intended audience.

Federal, state, and local permitting authorities with jurisdiction can require more stringent measures that are deemed necessary to meet locally established goals, state water quality standards, or other established natural resource or drainage objectives.

This manual can also ~~be helpful in~~help to identifying options for retrofitting BMPs ~~to~~in existing ~~development~~developments. Retrofitting stormwater BMPs into existing developed areas will be necessary in many

cases to meet federal Clean Water Act and state Water Pollution Control Act ([Chapter 90.48 RCW](#)~~(Chapter 90.48 RCW)~~) requirements.

The Department of Ecology (Ecology) does not have guidance specifically for retrofit situations (not including redevelopment situations). Application of BMPs from this manual is encouraged. However, there can be site constraints that make the strict application of these BMPs difficult.

1.2 **Expanded** Applicability to Western Washington

~~With this update of~~ This stormwater manual, ~~the applicability has been broadened applies to include~~ all of western Washington. This includes the area bounded on the south by the Columbia River, on the west by the Pacific Ocean, on the north by the Canadian border, and on the east by the Cascade Mountains crest. The manual also applies to those areas of Skamania and Cowlitz counties that lie east of the Cascade crest.

The Ecology stormwater manual was originally developed in response to a directive of the Puget Sound Water Quality Management Plan (PSWQA 1987 et seq.). The Puget Sound Water Quality Authority (since replaced by the Puget Sound ~~Action Team, PSAT~~Partnership, PSP) recognized the need for overall guidance for stormwater quality improvement. It incorporated requirements in its plan to implement a cohesive, integrated stormwater management approach through the development and implementation of programs by local jurisdictions, and the development of rules, permits and guidance by Ecology.

The Puget Sound Water Quality Management Plan included a stormwater element (SW-2.1) requiring Ecology to develop a stormwater technical manual for use by local jurisdictions. This manual was originally developed to meet this requirement. Ecology has found that the concepts developed for the Puget Sound Basin are applicable throughout western Washington.

~~Further~~ Information describing how this manual relates to the Puget Sound Water Quality Management Plan (now the Puget Sound Action Agenda) is included in [Section 1.6.4](#)~~Section 1.6, below.~~

1.3 Organization of this Manual

1.3.1 Overview of Manual Content

To accomplish the objective described in [Section 1.1](#)~~Section 1.1,~~ the manual includes the following:

- *Minimum Requirements* that cover a range of issues, such as preparation of Stormwater Site Plans, pollution prevention during the construction phase of a project, control of potential pollutant sources, treatment of runoff, control of stormwater flow volumes, protection of wetlands, and long-term operation and maintenance. The Minimum

Requirements applicable to a project vary depending on the type and size of the proposed project.

- *Best Management Practices (BMPs)* that can be used to meet the minimum requirements. BMPs are ~~defined as~~ schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce pollutants or other adverse impacts to waters of Washington State. BMPs are divided into those for short-term control of stormwater from construction sites, and those addressing long-term management of stormwater at developed sites. Long-term BMPs are further subdivided into those covering management of the volume and timing of stormwater flows, prevention of pollution from potential sources, and treatment of runoff to remove sediment and other pollutants.
- *Guidance on how to prepare and implement Stormwater Site Plans.* The Stormwater Site Plan is a comprehensive report that describes existing site conditions, explains development plans, examines potential ~~offsite/off-site~~ effects, identifies applicable Minimum Requirements, and proposes stormwater controls for both the construction phase and long-term stormwater management. The project proponent submits the Stormwater Site Plan to state and local permitting authorities with jurisdiction, who use the plan to evaluate a proposed project for compliance with stormwater requirements.

1.3.2 Organization of this Manual

Volume I of this manual serves as an introduction and covers several key elements of developing the Stormwater Site Plan. The remaining volumes of this manual cover BMPs for specific aspects of stormwater management. Volumes II through V are organized as follows:

- Volume II covers BMPs for short-term stormwater management at construction sites~~;~~.
- Volume III covers hydrologic analysis and BMPs to control flow volumes from developed sites~~;~~.
- Volume IV addresses BMPs to minimize pollution generated by potential pollution sources at developed sites~~;~~ ~~and~~.
- Volume V presents BMPs to treat runoff that contains sediment or other pollutants from developed sites.

1.3.3 Organization of Volume I

Following this introduction, Volume I contains three additional chapters.

[Chapter 2](#) ~~Chapter 2~~ identifies the Minimum Requirements for stormwater management at all new development and redevelopment projects. [Chapter 3](#) ~~In addition, Chapter 2 describes the relationship between the Minimum~~

~~Requirements and the Puget Sound Water Quality Management Plan.~~
~~Chapter 3~~ describes the Stormwater Site Plan, and provides step-by-step guidance on how to develop these plans. ~~Chapter 4~~ ~~Chapter 4~~ describes the process for selecting BMPs for long-term management of stormwater flows and quality. ~~Appendices~~ ~~Appendices~~ are included to support these topics. Volume I also includes the Glossary for all five volumes of the stormwater manual.

1.4 How to Use this Manual

This manual has applications for a variety of users. Project proponents should start by reading [Chapter 3](#) of Volume I. It explains how to complete stormwater site plans.

~~Local government officials may adopt and apply the requirements, thresholds, definitions, BMP selection processes, and BMP design criteria of this manual, or an equivalent manual.~~ Staff at all local governments and agencies with permitting jurisdiction may use this manual in reviewing Stormwater Site Plans, checking BMP designs, and providing technical advice to project proponents.

~~Other~~ Federal, State, and local permits may refer to this manual or the BMPs contained in this manual. For example, the Industrial Stormwater General Permit and the Construction Stormwater General Permit refer to this manual. In those cases, affected permit-holders or applicants should use this manual for specific guidance on how to comply with those permit conditions.

1.5 Development of Best Management Practices for Stormwater Management

1.5.1 Best Management Practices (BMPs)

The method by which the manual controls the adverse impacts of development and redevelopment is through the application of Best Management Practices.

Best Management Practices are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State. The types of BMPs are source control, treatment, and flow control. BMPs that involve construction of engineered structures are often referred to as facilities in this manual. For instance, the BMPs referenced in the menus of Chapter 3 in Volume V are called treatment facilities.

The primary purpose of using BMPs is to protect beneficial uses of water resources through the reduction of pollutant loads and concentrations, ~~and~~ through reduction of discharges (volumetric flow rates) causing stream channel erosion, and through reductions in deviations from natural hydrology. If it is found that, after the implementation of BMPs advocated in this manual, beneficial uses are still threatened or impaired, then additional controls may be required.

1.5.2 Source Control BMPs

Source control BMPs typically prevent pollution, or other adverse effects of stormwater, from occurring. Ecology further classifies source control BMPs as operational or structural. Examples of source control BMPs include methods as various as using mulches and covers on disturbed soil, putting roofs over outside storage areas, and berming areas to prevent stormwater run-on and pollutant runoff.

It is generally more cost effective to use source controls to **prevent** pollutants from entering runoff, than to treat runoff to remove pollutants. However, since source controls cannot prevent all impacts, some combination of measures will always be needed.

1.5.3 Treatment BMPs

Treatment BMPs include facilities that remove pollutants by simple gravity settling of particulate pollutants, centrifugal separation, filtration, biological uptake, and media or soil adsorption. Treatment BMPs can accomplish significant levels of pollutant load reductions if properly designed and maintained.

1.5.4 Flow Control BMPs

Flow control BMPs typically control the volume rate, frequency, and flow duration of stormwater surface runoff. The need to provide flow control BMPs depends on whether a development site discharges to a stream system or wetland, either directly or indirectly. Stream channel erosion control can be accomplished by BMPs that detain runoff flows and also by those which physically stabilize eroding streambanks. Both types of measures may be necessary in urban watersheds. Only the former is covered in this manual.

Construction of a detention pond is the most common means of meeting flow control requirements. Construction of an infiltration facility is the preferred option but is feasible only where more porous soils are available.

The concept of detention is to collect runoff from a developed area and release it at a slower rate than it enters the collection system. The reduced release rate requires temporary storage of the excess amounts in a pond with release occurring over a few hours or days. The volume of storage needed is dependent on ~~4~~:

1. The size of the drainage area; ~~2~~.
2. The extent of disturbance of the natural vegetation, topography, and soils and creation of effective impervious surfaces (surfaces that drain to a stormwater collection system) ~~; and 3~~.
- ~~3.~~ How rapidly the water is allowed to leave the detention pond, i.e., the target release rates.

The 1992 Ecology manual focused primarily on controlling the peak flow release rates for recurrence intervals of concern – the 2, 10, and 100-year rates. This level of control did not adequately address the increased duration at which those high flows occur because of the increased volume of water from the developed condition as compared to the pre-developed conditions.

To protect stream channels from increased erosion, it is necessary to control the durations over which a stream channel experiences geomorphically significant flows such that the energy imparted to the stream channel does not increase significantly. Geomorphically significant flows are those that are capable of moving sediments. This target will translate into lower release rates and significantly larger detention ponds than the previous Ecology standard. The size of such a facility can be reduced by changing the extent to which a site is disturbed.

In regard to wetlands, ~~the goal~~ is ~~necessary~~ to not alter the natural hydroperiod. This ~~means~~requires the control of input flows ~~from a development~~ such that the wetland is within certain elevations at different times of the year and short-term elevation changes are within the ~~prescribed~~desired limits. If the amount of surface water runoff draining to a wetland is increased because of land conversion from forested to impervious areas, it may be necessary to bypass some water around the wetland in the wet season. (Bypassed stormwater must still meet flow control and treatment requirements applicable to the receiving water.) If however, the wetland was fed by local ground water elevations during the dry season, the impervious surface additions and the bypassing practice may cause variations from the dry season elevations.

Because Ecology found it difficult to model water surface elevation changes, especially for riverine and slope wetlands, the new regulatory strategy is to simply try to match the pre-project surface and ground water inputs that drive the water surface elevations in wetlands. Estimates of what should be done to ~~maintain the natural hydroperiod~~require~~match~~ inputs requires the use of a continuous runoff model. It remains to be seen whether the available continuous runoff models are sufficiently accurate to determine successful flow management strategies. Even if the modeling approaches are sufficient, it will be a challenge to simulate pre-~~development~~project hydrology after significant development has occurred.

1.5.5 Construction Stormwater BMPs and On-site Stormwater Management BMPs

Construction stormwater BMPs can be source control, treatment, or flow control BMPs. Examples include stabilized construction entrances, silt fences, check dams, and sediment traps. Volume II contains construction stormwater BMPs.

On-site stormwater management BMPs can be either treatment or flow control BMPs. BMP's in this category serve to infiltrate, disperse, and retain stormwater runoff on-site. Examples include bioretention, rain gardens, and permeable pavements in Chapter 5, of Volume V. Other examples include downspout infiltration, downspout dispersion, and perforated sub-out connections in Chapter 3, of Volume III.

1.6 Relationship of this Manual to Federal, State, and Local Regulatory Requirements

1.6.1 The Manual's Role as Technical Guidance

The *Stormwater Management Manual for Western Washington* is not a regulation. The Manual does not have any independent regulatory authority and it does not establish new environmental regulatory requirements. Its "Requirements" and BMP's become required through:

- Ordinances and rules established by local governments; and
- Permits and other authorizations issued by local, state, and federal authorities.

Current law and regulations require the design, construction, operation and maintenance of stormwater systems that prevent pollution of State waters. The Manual is a guidance document which provides local governments, State and Federal agencies, developers and project proponents with a stormwater management strategy to apply at the project level. If this strategy is implemented correctly, in most cases it should result in compliance with existing regulatory requirements for stormwater – including compliance with the Federal Clean Water Act, Federal Safe Drinking Water Act and State Water Pollution Control Act.

The Manual provides generic, technical guidance on measures to control the quantity and quality of stormwater runoff from new development and redevelopment projects. These measures are considered to be necessary to achieve compliance with State water quality standards and to contribute to the protection of the beneficial uses of the receiving waters (both surface and ground waters). Stormwater management techniques applied in accordance with this Manual are presumed to meet the technology-based treatment requirement of State law to provide all known available and reasonable methods of treatment, prevention and control (AKART; [RCW 90.52.040](#) ~~RCW 90.52.040~~ and [RCW 90.48.010](#) ~~RCW 90.48.010~~).

This technology-based treatment requirement does not excuse any discharge from the obligation to apply additional stormwater management practices as necessary to comply with State water quality standards. The State water quality standards include: [Chapter 173-200 WAC](#) ~~Chapter 173-200 WAC~~, Water Quality Standards for Ground Waters of the State of Washington; [Chapter 173-201A WAC](#) ~~Chapter 173-201A~~, Water Quality

Standards for Surface Waters of the State of Washington; and [Chapter 173-204 WAC](#)~~Chapter 173-204,~~ Sediment Management Standards.

Following this Manual is not the only way to properly manage stormwater runoff. A municipality may adopt, or a project proponent may choose to implement other methods to protect water quality; but in those cases, they assume the responsibility of providing technical justification that the chosen methods will protect water quality (see [Section 1.6.3](#)~~Section 1.6.3,~~ Presumptive versus Demonstrative Approaches to Protecting Water Quality below).

1.6.2 More Stringent Measures and Retrofitting

Federal, State, and local government agencies with jurisdiction can require more stringent measures that are deemed necessary to meet locally established goals, State water quality standards, or other established natural resource or drainage objectives. Water cleanup plans or Total Maximum Daily Loads (TMDLs) may identify more stringent measures needed to restore water quality in an impaired water body.

This Manual is not a retrofit manual, but it can be helpful in identifying options for retrofitting BMPs to existing development. Retrofitting stormwater BMPs into existing developed areas may be necessary to meet federal Clean Water Act and state Water Pollution Control Act ([Chapter 90.48 RCW](#)) requirements. The Puget Sound Action Agenda, described in Section 1.6.4~~(Chapter 90.48 RCW) requirements,~~ also includes prioritizing and implementing stormwater retrofits as one objective. In retrofit situations there frequently are site constraints that make the strict application of these BMPs difficult. In these instances, the BMPs presented here can be modified using best professional judgment to provide reasonable improvements in stormwater management.

1.6.3 Presumptive versus Demonstrative Approaches to Protecting Water Quality

Wherever a discharge permit or other water-quality-based project approval is required, project proponents may be required to document the technical basis for the design criteria used to design their stormwater management BMPs. This includes: how stormwater BMPs were selected; the pollutant removal performance expected from the selected BMPs; the scientific basis, technical studies, and(or) modeling which supports the performance claims for the selected BMPs; and an assessment of how the selected BMP will comply with State water quality standards and satisfy State AKART requirements and Federal technology-based treatment requirements.

The Manual is intended to provide project proponents, regulatory agencies and others with technically sound stormwater management practices which are *presumed* to protect water quality and instream habitat – and meet the stated environmental objectives of the regulations described in

this chapter. Project proponents always have the option of not following the stormwater management practices in this Manual. However, if a project proponent chooses not to follow the practices in the Manual then the project proponent may be required to individually *demonstrate* that the project will not adversely impact water quality by collecting and providing appropriate supporting data to show that the alternative approach is protective of water quality and satisfies State and federal water quality laws.

[Figure 1.6.1](#) ~~Figure 4.1~~ graphically depicts the relation between the *presumptive approach* (the use of this Manual) and the *demonstrative approach* for achieving the environmental objectives of the standards. Both the presumptive and demonstrative approaches are based on best available science and result from existing Federal and State laws that require stormwater treatment systems to be properly designed, constructed, maintained and operated to:

1. Prevent pollution of state waters and protect water quality, including compliance with state water quality standards~~;~~.
2. Satisfy state requirements for all known available and reasonable methods of prevention, control and treatment (AKART) of wastes prior to discharge to waters of the State~~;~~ ~~and~~.
3. Satisfy the federal technology based treatment requirements under 40 CFR part 125.3.

Relation between environmental science and standards in stormwater regulations. Both the presumptive and demonstrative approaches are based on using best available science to protect water quality. See the glossary for definitions.

Under the demonstration approach, the timeline and standards for

Water Pollution Control Act

(Chapter 90-48 RCW)
Discharges to state waters shall not cause pollution, which is defined as an alteration of the physical, chemical or biological properties of State waters which would impair beneficial uses. Requires the use of AKART and BMPs approved by Ecology.

Federal Clean Water Act

Restore and maintain the chemical, physical, and biological integrity of the Nation's waters.
• State water quality standards (water quality-based treatment requirements)
• Federal technology-based treatment requirements
• NPDES permits
• 303(d) impaired water body list and water clean-up plans

Others

Endangered Species Act
• Properly functioning conditions
Hydraulics Code (HPA)
Safe Drinking Water Act (SDWA)

approach may be more cost effective for large, complex or unusual types of projects.

Project proponents that choose to follow the stormwater management

approach are not required to meet the Minimum Technical Requirements (MTR) by Ecology.

(See Section 1.6.3). This approach will generally be more cost effective for typical development and redevelopment projects.

Presumptive Approach

The Stormwater Management Manual for Western Washington provides a default set of stormwater practices based on current science which satisfy State and Federal stormwater requirements.

Considerations:

- More predictable, practices are approved across jurisdictions
- Costly studies, etc. are not required as they may be under the demonstration approach

Demonstrative Approach

Project sponsor and approval agency individually review and condition proposed projects to meet federal and state stormwater standards based on current science.

Considerations:

- Lacks predictability and can be very time consuming
- For large, complex projects may reduce costs and/or improve environmental protection

Ecology lists approved equivalent stormwater management manuals this website:

<http://www.ecy.wa.gov/programs/wq/stormwater/municipal/PhaseIequivalents.htm>

Hydrology

- When native vegetation is removed and replaced with impervious surfaces (roads or buildings) there is an increase in stormwater runoff and other drastic alterations to the natural hydrology.
- Increased flows lead to increased flooding and stream bank and stream bed erosion.
- Unless mitigated, stormwater runoff impacts wetlands and riparian areas in urban development: 4% to 10% total impervious area.
- Transportation infrastructure (including parking areas) represents between 50% and 75% of the impervious surface area within any single watershed.

The following sub-sections will explain the relationship of the manual to various programs, permits, and planning efforts.

Water Quality

- More than a third of the State's urban streams, creeks and embayments are impaired due to stormwater runoff.
- Stormwater runoff from construction activities can contain large amounts of sediments and suspended solids which are harmful to fish and other aquatic life.
- Untreated stormwater from roads and urban areas can adversely impact water quality due to sediments, toxic metals, pesticides, herbicides, oils and greases, and possible human pathogens including fecal coliform bacteria.
- Untreated stormwater runoff from roads and urban areas can be toxic to aquatic life including fish.

SCIENCE

Both the presumptive and demonstrative approaches are based on using best available science to protect water quality. See the [glossary](#) for definitions.

STANDARDS

Water Pollution Control Act

(Chapter 90.48 RCW)

Discharges to state waters shall not cause pollution, which is defined as an alteration of the physical, chemical or biological properties of State waters which would impair beneficial uses. Requires the use of AKART and BMPs approved by Ecology.

Federal Clean Water Act

Restore and maintain the chemical, physical, and biological integrity of the Nation's waters.

- State water quality standards (water-quality based treatment requirements)
- Federal technology-based treatment requirements
- NPDES permits
- 303(d) impaired water body list and water clean-up plans

Others

Endangered Species Act

- Properly functioning conditions
- Hydraulics Code (HPA)
Safe Drinking Water Act (UIC)

Presumptive Approach

The Stormwater Management Manual for Western Washington provides a default set of stormwater practices based on current science which satisfy State and Federal stormwater requirements.

Considerations:

- More predictable, practices are approved across jurisdictions
- Costly studies, etc. are not required as they may be under the demonstration approach

Demonstrative Approach

Project sponsor and approval agency individually review and condition proposed projects to meet federal and state stormwater standards based on current science.

Considerations:

- Lacks predictability and can be very time consuming
- For large, complex projects may reduce costs and/or improve environmental protection

Hydrology

- When native vegetation is removed and replaced with impervious surfaces (roads or buildings) there is an increase in stormwater runoff and other drastic alterations to the natural hydrology.
- Increased flows lead to increased flooding and stream bank and stream bed erosion.
- Unless mitigated, adverse high flow impacts occur at even low levels of urban development: 4% to 10% total impervious area.
- Transportation infrastructure (including parking areas) represents between 50% and 75% of the impervious surface area within any single watershed.

Water Quality

- More than a third of the State's urban streams, creeks and embayments are impaired due to stormwater runoff.
- Stormwater runoff from construction activities can contain large amounts of sediments and suspended solids which are harmful to fish and other aquatic life.
- Untreated stormwater from roads and urban areas can adversely impact water quality due to sediments, toxic metals, pesticides, herbicides, oils and greases, and possible human pathogens including fecal coliform bacteria.
- Untreated stormwater runoff from roads and urban areas can be toxic to aquatic life including fish.

SCIENCE

Figure 1.6.1 - Relation between environmental science and standards in stormwater regulations.

1.6.4 The Puget Sound ~~Water Quality Management Plan~~ Action Agenda

~~Stormwater Comprehensive Programs~~

The Puget Sound ~~Water Quality Management Plan (the Plan)~~ directs every city and county in the Partnership's 2008 Action Agenda identifies a coordinated, regional approach to reducing the sources of water pollution in Puget Sound Basin to develop and implement that reflects six primary objectives. Urban stormwater is the focus of objective #2:

Use a comprehensive, integrated approach to managing urban stormwater and rural surface water runoff to reduce stormwater volumes and pollutant loadings.

The Actions that the Agenda identifies to achieve this objective are:

- Implement the municipal stormwater NPDES Phase I and II permits so that the discharges from municipal stormwater systems are reduced. Achieve overall water quality standards. Provide financial and technical assistance to permitted cities and counties.
- Implement other NPDES permits including those for industrial discharges and the Washington State Department of Transportation.
- Improve stormwater management program. The Plan recognizes that stormwater in communities not currently covered by NPDES permits by providing financial and technical assistance to local governments to create local comprehensive stormwater control programs will vary among.
- Investigate expansion of NPDES permit coverage to include additional jurisdictions, depending on the jurisdiction's population, density, threats posed by stormwater, and results of with municipal separated storm sewer systems (MS4). Initiate work in areas with documented stormwater-related problems and intact resources that are threatened by surface runoff.
- Provide cities and counties with comprehensive guidance and standards regarding LID practices to incorporate into stormwater codes for development and redevelopment. Assist local governments with revisions to regulations so that all jurisdictions in Puget Sound require the use of LID where feasible, as soon as possible.
- Advance the use of LID approaches to stormwater management. This includes, but is not limited to: a) resolve institutional barriers that limit use of LID for new development and redevelopment and road construction, including an update of stormwater flow control standards; b) implement, assess, and promote successful examples of LID techniques; c) develop incentives for using LID; d) develop focused training for contractors and developers and other stormwater

professionals; and e) develop focused training for local government staff on areas best suited for LID and assist them in revising their regulations to allow LID.

- Evaluate the technical and programmatic solutions for Combined Sewer Overflows (CSOs) in the context of improving water quality in fresh and marine water and preserving and recovering the health of Puget Sound. Continue efforts to eliminate discharge of raw sewage.
- Prioritize and implement stormwater retrofits in urbanized areas, including roads. In the near term, develop high-level prioritization criteria for the selection of new projects. Over the long term, link retrofit priorities to coordinated watershed planning efforts. Under the Plan, cities and counties are encouraged to form intergovernmental cooperative agreements in order to pool resources and carry out restoration and pollution prevention strategies.
- Improve future, new, and updated NPDES permits by requiring sub-basin planning to better identify specific actions for water bodies, improving collaboration of effort for shared water bodies, incorporating climate change projections related to stormwater runoff volumes, and meeting other requirements that will need to be identified.

In addition, the Action Agenda identifies a list of near term actions in regard to urban stormwater management.

- Establish a regional coordinated monitoring program for stormwater, working with the Monitoring Consortium of the Stormwater Work Group.
- Provide financial and technical assistance to cities and counties to implement NPDES Phase I and II permits, as well as Ecology for permit oversight and implementation.
- Assist cities and counties in incorporating LID requirements for development and redevelopment into all stormwater codes.
- Develop and implement LID incentives. Work with regional experts to develop and implement incentives and remove barriers to the use of low impact stormwater management techniques on development projects.
- Convene a group of regulating agencies, implementers with key funding responsibilities, and other stakeholders as appropriate to evaluate the technical and programmatic solutions for CSOs to meet overall program activities most efficiently—goals of improving water quality in fresh and marine water. The integration of CSO solutions into the larger range of solutions to stormwater and other water quality problems may improve cost effectiveness of both programs in urban areas, notably Seattle and King County. This will require flexibility in

implementation, timing, and scope of municipal wastewater NPDES program as applied to CSOs.

Comprehensive stormwater management programs under the Plan are to include:

- ◆ ~~**Stormwater Controls for New Development and Redevelopment**~~—Local governments are directed to adopt ordinances that require the use of best management practices (BMPs) to control stormwater flows, provide treatment, and prevent erosion and sedimentation from all new development and redevelopment projects. They are also directed to adopt and require the use of Ecology's stormwater technical manual (or an approved alternative manual) to meet these objectives. All new development in the basin, particularly new development sited outside of urban growth areas, are to seek to achieve no net detrimental change in natural surface runoff and infiltration.
- ◆ ~~**Stormwater Site Plan Review**~~—Local governments are directed to review new development and redevelopment projects to ensure that stormwater control measures are adequate and consistent with local requirements.
- ◆ ~~**Inspection of Construction Sites**~~—Local governments are directed to regularly inspect construction sites and to adopt ordinances to ensure clear authority to inspect construction sites, to require maintenance of BMPs, and to enforce violations. They are also directed to provide local inspectors with training on erosion and sediment control practices.
- ◆ ~~**Maintenance of Permanent Facilities**~~—Local governments are directed to adopt ordinances that require all permanent stormwater facilities to be regularly maintained to ensure performance. They are also directed to develop necessary provisions, such as agreements or maintenance contracts, to ensure that facilities on private land (e.g., residential subdivisions and commercial complexes) are maintained. The Plan directs local government to provide training for professionals who maintain stormwater facilities.
- ◆ ~~**Source Control**~~—Local governments are directed to develop and implement a program to control sources of pollutants from new development and redevelopment projects and from existing developed lands, using BMPs from Ecology's stormwater technical manual, or an equivalent manual. Source control activities are to include pollution from roadways and landscaping activities. Integrated pest management practices are to be used to manage roadside vegetation.
- ◆ ~~**Illicit Discharges and Water Quality Response**~~—Local governments are directed to adopt ordinances to prohibit dumping and illicit

discharges and to carry out activities to detect, eliminate and prevent illicit discharges, and respond to spills and water quality violations.

- ◆ **Identification and Ranking of Problems**—The Plan directs local government to identify and rank existing problems that degrade water quality, aquatic species and habitat, and natural hydrologic processes. Local governments may choose to achieve this through watershed or basin planning or another process. Local governments are directed to conduct a hydrologic analysis and map stormwater drainages, outfalls, and impervious surfaces by watershed and to develop plans and schedules and identify funding to fix the problems.
- ◆ **Public Education and Involvement**—The Plan directs local government to educate and involve citizens, businesses, elected officials, site designers, developers, builders and other members of the community to build awareness and understanding of stormwater and water quality issues. Local governments are to provide practical alternatives to actions that degrade water quality and biological resources.
- ◆ **Low Impact Development Practices**—Local governments are directed to adopt ordinances that allow and encourage low impact development practices. These are practices that infiltrate stormwater (using proper safeguards to protect ground water) on site rather than collecting, conveying and discharging stormwater off site. The goals of low impact development practices are to enhance overall habitat functions, reduce runoff, recharge aquifers, maintain historic in stream flows and reduce maintenance costs.
- ◆ **Watershed or Basin Planning**—The Plan directs local government to participate in watershed or basin planning processes, such as planning under Chapter 400-12 WAC or Chapter 90.82 RCW. The objective is to coordinate efforts, pool resources, ensure consistent methodologies and standards, maintain and restore watershed health, and protect and enhance natural hydrology and processes—including natural surface runoff, infiltration and evapotranspiration. Basin plans are to address water quality, aquatic habitat, ground water recharge and water re-use. Basin plans may prescribe stronger stormwater management measures to protect sensitive resources in a certain basin or sub-basin. Stormwater management measures in all basins are to at least meet the minimum requirements of Ecology's technical manual. Cities and counties are directed to incorporate recommendations from watershed or basin plans and specific requirements from Total Maximum Daily Load (TMDL) Water Cleanup Plan processes into their stormwater programs, land use comprehensive plans and site development ordinances.

- ~~**Funding**—The Plan directs local government to create local funding capacity, such as a utility, to ensure adequate, ongoing funding for program activities and to provide funding to contribute to regional stormwater projects.~~
- ~~**Monitoring**—The Plan directs local government to monitor program implementation and environmental conditions and trends over time to measure the effectiveness of program activities. Local governments are directed to periodically share monitoring results with local and state agencies, citizens and others.~~

Stormwater Technical Manual

~~The Plan states that “A single technical stormwater manual for the region provides uniform standards and a central repository for BMPs”. The Plan directs Ecology to maintain the region’s technical stormwater manual for new development and redevelopment. Publication of this manual partially fulfills Ecology’s responsibilities under the Puget Sound Water Quality Management Plan.~~

Alternative Technical Manuals

- ~~Cities and counties that choose to develop an alternative technical manual are directed to submit their manual to Retrofit existing stormwater systems by: a) developing high-level criteria that can be used in 2009 to determine the highest priority areas around the Sound for stormwater retrofits; and b) implementing stormwater retrofit projects in the highest priority areas based upon these criteria to bring areas into compliance with current stormwater regulations. Retrofits should include low impact stormwater management techniques to the greatest extent feasible. Monitor effectiveness of the techniques.~~

~~Implement NPDES industrial permits and Washington State Department of Transportation permits, including Ecology. The submittal is to include an outline of significant differences between the manuals and demonstrate how the alternative manual is substantively equivalent to Ecology’s. The Plan directs Ecology to work with jurisdictions to ensure that all alternative manuals meet or exceed the standards in Ecology’s technical manual. Jurisdictions choosing to develop an alternative manual are directed to use Ecology’s technical manual in the interim.~~

~~Ecology published guidance for equivalency reviews (“Guidance for Local Governments When Submitting Manuals and Associated Ordinances for Equivalency Review,” 3/94, Publication #94-45). The criteria in that guidance are replaced with the following criteria:~~

- ~~1. The Minimum Requirements (Chapter 2) for new development and redevelopment, or their equivalents, must be included in ordinance or enforceable rules adopted by the local government. More stringent requirements may be used, and/or the Minimum Requirements may be tailored to local circumstances through the use of basin plans or other similar water quality and quantity planning efforts.~~
- ~~2. The thresholds for and definitions of new development, redevelopment, land disturbing activities, impervious surfaces, maintenance, and pollution generating surfaces should provide equivalent protection of receiving waters or equivalent levels of pollution treatment as those provided by Ecology's criteria.~~
- ~~3. The substantially equivalent manual must include BMP selection and site planning processes that have outcomes that provide equivalent or greater protection to those in Ecology's manual.~~
- ~~4. The types of BMPs and design criteria for those BMPs specified by local governments must provide equivalent or greater protection than those contained in Volumes II through V of Ecology's manual.~~
- ~~5. Adjustment and Variance criteria similar to those in Volume I must be included.~~

~~Where Ecology is uncertain that a local government requirement provides equivalent or better protection, it may provisionally approve the local requirement. The provisions would require the local government to implement an approved monitoring effort to assess the performance of the local requirement.~~

- ~~• Ecology has used bold highlighting of statements in Chapter 2 of Volume I for which local governments must have equivalent statements if they are to comply with criteria 1, 2, and 5 above for permit oversight and implementation.~~

1.6.5 Phase I - NPDES and State Waste Discharge Stormwater Permits for Municipalities

Certain municipalities and other entities are subject to permitting under the U.S. Environmental Protection Agency (EPA) Phase I Stormwater Regulations (40 CFR Part 122). In Western Washington, Ecology has issued joint NPDES and State Waste Discharge permits to regulate the discharges of stormwater from the municipal separate storm sewer systems operated by the following cities and counties:

- Clark County;
- King County;
- Pierce County;

- Snohomish County;
- ~~City of Seattle, and~~
- ~~City of Tacoma.~~

The Washington Department of Transportation is also a Phase I municipal stormwater permittee for its stormwater discharges within the jurisdictions of the above cities and counties.

~~—These Phase I Municipal Stormwater Permittees must refer to Appendix 1 of their permit rather than relying on Chapter 2. As a condition (Special Condition S7.b.8.a.) of the permits issued in July 1995, these entities are required to implement stormwater programs that must include:~~

~~“... ordinances (except WSDOT’s program), minimum requirements and best management practices (BMPs) equivalent to those found in Volumes I-IV of Ecology’s Stormwater Management Manual for the Puget Sound Basin (1992 edition, and as amended by its replacement)....”~~

~~—These entities had until the end of the permit terms, July 2000 to comply with this requirement.~~

~~—Ecology has administratively extended these municipal permits until it can reissue updated permits. In the development of those permits, Ecology will consider incorporating the minimum requirements and thresholds and referencing the BMP’s within this manual. Ecology will also add a deadline or deadlines within the term of the permit for compliance with the condition.~~

of this volume to find the minimum requirements, thresholds, and definitions that their jurisdiction either must implement, or must adopt equivalent measures as determined by Ecology. The permits also direct these permittees to require site planning processes and BMP selection and design criteria from this manual, or an Ecology approved equivalent manual. Municipal permittees which want to deviate from the site planning process and BMP selection and design criteria in this manual must demonstrate that their alternative will protect water quality, meet the federal statutory requirement to reduce pollutants to the maximum extent practicable (MEP), and satisfy the state requirement to apply all known, available, and reasonable methods of pollution control.

1.6.6 Phase II - NPDES and State Waste Discharge Stormwater Permits for Municipalities

The EPA adopted Phase II stormwater regulations in December 1999. Those rules identify additional municipalities as subject to NPDES municipal stormwater permitting requirements. ~~Over 100 municipalities in Washington are subject to the requirements. Federal regulations~~

~~required issuance of Phase II permits by December 2002, and required the Phase II communities to submit their stormwater programs to comply with permit requirements by March 2003. Ecology made a standard permit application format available to municipalities and encouraged all to apply by March 2003. Ecology anticipates issuing the Phase II permit for Western Washington in 2005. Over 100 municipalities in Washington are subject to the requirements.~~

~~Ecology first issued a Western Washington Phase II Municipal Stormwater Permit in 2007. These Phase II Municipal Stormwater Permittees must refer to Appendix 1 of their permit rather than relying on Chapter 2. The USEPA regulations specify minimum measures for the stormwater programs developed to comply with the Phase II permits. One of these measures is the adoption of a program for “post-construction stormwater management in new development and redevelopment.” Another is a program for “construction site stormwater runoff control.” To at least partially fulfill these requirements, portions of this manual that apply will be used as the starting point for permit requirements. Ecology will propose using the federal phase II thresholds for the phase II municipal stormwater permits rather than the lower thresholds in this manual. A schedule (or schedules) for compliance will be necessary. Municipalities within the Puget Sound Basin should have already completed these tasks as required by the Puget Sound Water Quality Management Plan, and as encouraged by the State’s strategy for salmon recovery.~~

~~of this volume to find the minimum requirements, thresholds, and definitions that their jurisdiction either must implement, or must adopt equivalent measures approved by Ecology for a Phase II permittee. The permits also directs these permittees to require site planning processes and BMP selection and design criteria from this manual, or an Ecology approved equivalent manual. Municipal permittees which want to deviate from the site planning process and BMP selection and design criteria in this manual must demonstrate that their alternative will protect water quality, meet the federal statutory requirement to reduce pollutants to the maximum extent practicable (MEP), and satisfy the state requirement to apply all known, available, and reasonable methods of pollution control.~~

1.6.7 Municipalities Not Subject to the ~~Puget Sound Water Quality Management Plan~~ nor NPDES Stormwater Municipal Permits for Municipalities

Municipalities not subject to ~~the Puget Sound Plan~~ nor NPDES stormwater permits for municipalities are encouraged to adopt stormwater programs ~~at least equivalent to the Puget Sound Basic Stormwater Program.~~ This would include adoption of ordinances, minimum requirements ~~described in the 1994 Puget Sound Plan~~, and BMPs equivalent to those in

~~Ecology's this~~ manual. Any municipalities in areas where urban stormwater has been identified as a limiting factor to salmon recovery ~~are expected to should~~ have an equivalent stormwater manual ~~as part of a Comprehensive Stormwater Program as defined by The Salmon Habitat Limiting Factors Reports~~ available at the [Washington State Conservation Commission's website](http://www.scc.wa.gov/index.php/174-Salmon-Habitat-Limiting-Factors-Reports/View-category/Page-6.html) provide information on these areas: <http://www.scc.wa.gov/index.php/174-Salmon-Habitat-Limiting-Factors-Reports/View-category/Page-6.html> ~~Puget Sound Water Quality Management Plan.~~

1.6.8 Industrial Stormwater General Permit (i.e. NPDES and State Waste Discharge Baseline)

Facilities covered under Ecology's Industrial Stormwater General Permit (i.e. NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated With Industrial Activities) must manage stormwater in accordance with specific terms and conditions including: the development and implementation of an Industrial Stormwater Pollution Prevention Plan (Industrial SWPPP), monitoring, reporting, and ongoing adaptive management based on sampling and inspections.

The Industrial Stormwater General Permit (ISGP) requires Industrial SWPPPs to include certain mandatory Best Management Practices (BMPs), including those BMPs identified as "applicable" to specific industrial activities in Volume IV and V of the this manual. Facilities with new development or redevelopment must evaluate whether flow control BMPs are necessary. BMPs must be consistent with this manual, or other stormwater management guidance documents that are approved by Ecology and incorporated into the ISGP. Facilities may also use alternative BMPs if their Industrial SWPPP includes documentation that the BMPs selected are demonstrably equivalent to practices contained in stormwater technical manuals approved by Ecology, including the proper selection, implementation, and maintenance of all applicable and appropriate best management practices for on-site pollution control.

Ecology's Industrial Stormwater Webpage has a fill-in-the-blank Industrial SWPPP template for use by industrial facilities.

ISGP facilities are required to update their Industrial SWPPPs and perform corrective actions if stormwater monitoring results exceed "benchmark" or indicator values. Facilities that trigger corrective actions under the ISGP, or otherwise need to update their SWPPP, should consider:

- 1) "Recommended" operational and structural source control BMPs listed in Volume IV.
- 2) Treatment BMPs listed in Volume V.
- 3) Erosion and sediment control BMPs listed in Volume II (e.g., if turbidity, sediment, or associated pollutants need to be addressed).

Treatment BMPs that have been evaluated through Ecology's TAPE or C-TAPE Businesses subject to the Baseline General Permit for Stormwater Discharges Associated With Industrial Activities have to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) in accordance with the terms of that permit. The current permit was issued in August 2002, and modified in December 2004. The modified permit allows permittees to follow a presumptive approach or a demonstration approach (see section 1.6.3 for a detailed explanation) to compliance with the permit. Permittees who choose the presumptive approach select BMP's from an approved stormwater manual. The permit identifies the Stormwater Management Manual for Western Washington and the Regional Road Maintenance ESA Program Guidelines as the applicable stormwater manuals for all facilities in western Washington.

4) Under the presumptive approach, new facilities are to apply the minimum technical requirements and BMP's appropriate for their facility as found in the most recent version of the Western Washington manual or an equivalent manual. Existing facilities are to use the most recent version of this manual when updating their SWPPP to accommodate changes at their facility or when additional BMPs are required to maintain compliance with permit conditions. Facilities undergoing new development or re-development are to apply the applicable minimum requirements of the most recent edition of this manual when beginning final design of the project to the development site program.

5) BMPs that are "demonstrably equivalent", as defined by the ISGP.

1.6.9 Construction Stormwater Permit (i.e. NPDES and State Waste Discharge General Permit for Stormwater Discharges Associated With Construction Activity)

Construction sites that will disturb five acres or more and will have a discharge of stormwater from Coverage under the CSWGP is generally required for any clearing, grading, or excavating if the project site to discharges:

- Stormwater from the site into surface water must apply for Ecology's(s) State, or
- Into storm drainage systems that discharge to a surface water(s) of the State.

And

- Disturbs one or more acres of land area, or
- Disturb less than one acre of land area, if the project or activity is part of a larger common plan of development or sale.

Any construction ~~stormwater permit~~ activity discharging stormwater that Ecology and/or the local permitting authority determines to be a significant contributor of pollutants to waters of the State may also require permit coverage, regardless of project size, at the discretion of the agency.

The permit requires application of stabilization and structural practices to reduce the potential for erosion and the discharge of sediments from the site. The stabilization and structural practices cited in the permit are similar to the minimum requirements for sedimentation and erosion control in Volume I of the SWMM.

The permit also requires construction sites within the Puget Sound basin/Western Washington to “select from implement stormwater BMPs described contained in stormwater management manuals published or approved by Ecology, or BMPs that are demonstrably equivalent. Volume II of the most recent edition of Ecology’s Stormwater Management Manual (SWMM) that has been available at least 120 days prior to the BMP selection.” Sites outside the basin are required to select BMPs from the this manual, from further describes the Erosion requirements and Sediment Control Handbook, by Goldman et al., or to select other BMPs appropriate BMPs. The permit also states that where Ecology has determined that the local government requirements for managing construction sites are at least as stringent as Ecology’s, Ecology will accept compliance with the local requirements.

The existing construction stormwater general permit expires in November 2005. However, that permit was appealed. The parties to the case have entered into a settlement agreement (stipulation and order for dismissal) that stipulates that the construction stormwater general permit must be revised and reissued according to specified dates. Ecology expects the permit will be available by September 2005.

This revised permit will incorporate identified changes and implement applicable USEPA Phase II regulations. According to those regulations, coverage under the Construction General Permit is required for any clearing, grading, or excavating that will disturb one or more acres of land area, and that will discharge site stormwater from the site into surface water(s), or into storm drainage systems that discharge to a surface water.

In developing the revised permit, Ecology anticipates drawing upon Minimum Requirement #2 and the BMP’s in this volume.

1.6.10 Endangered Species Act

With the listing of multiple species of salmon as threatened or endangered across much of Washington State, and the probability of more listings in the future, implementation of the requirements of the Endangered Species Act will have a dramatic effect on impacts urban stormwater management. The manner in which that will occur is still evolving. Provisions of the

Endangered Species Act ~~that may can~~ apply ~~directly~~ to stormwater management include the Section 4(d) rules, Section 7 consultations, and Section 10 Habitat Conservation Plans (HCP).

Under Section 4(d) of the statute, the federal government issues regulations to provide for the conservation of the species. A 4(d) rule may require new development and redevelopment to comply with specific requirements. ~~It remains to be seen whether the federal government will cite the requirements of this manual in a 4(d) rule.~~

Under Section 7 of the statute, all federal agencies must insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species (or a species proposed for listing), nor result in the destruction or adverse modification of designated critical habitat. The responsibility for initially determining whether jeopardy is likely to occur rests with the "action" agency. If an action "may affect" a listed species, the "action" agency must consult with ~~the National Marine~~ NMFS ~~Oceanic and Atmospheric Administration~~ NOAA Fisheries Service (NMFSNOAA Fisheries), or the U.S. Fish and Wildlife Service (USFWS) depending on the species involved, to determine whether jeopardy is likely to occur.

Where NMFSNOAA Fisheries or USFWS believes that jeopardy would result, it must specify reasonable and prudent alternatives to the action that would avoid jeopardy if any such alternatives are available. If the "action" agency rejects these, the action cannot proceed. ~~This manual may play a role in these jeopardy decisions and the alternatives cited to avoid jeopardy.~~

Under Section 10 of the ESA, through voluntary agreements with the federal government that provide protections to an endangered species, a non-federal applicant may commit an "incidental take" of individuals of that species as long as it is incidental to an otherwise lawful activity (such as developing land or building a road). This provision of the ESA may help resolve conflicts between development pressures and endangered species protection. A "Habitat Conservation Plan" (HCP) is an example of this type of agreement. Under an HCP, the applicant's plan must:

- Outline the impact that will likely result from the taking;
- List steps the applicant will take to minimize and mitigate such impacts, and funding available to implement such steps; and
- Include alternative actions the applicant considered and reasons alternative acts are not being used.

The federal government may grant a permit if it finds that the taking will be incidental; the applicant will minimize and mitigate impacts of taking; and the applicant will ensure that adequate funding for the conservation plan will be provided. The USFWS and NMFSNOAA Fisheries may require additional measures as necessary or appropriate for purposes of the

plan. ~~This manual may play a key role in any proposed Habitat Conservation Plans.~~

1.6.11 Section 401 Water Quality Certifications

For projects that require a fill or dredge permit under Section 404 of the Clean Water Act, Ecology must certify to the permitting agency, the U.S. Army Corps of Engineers, that the proposed project will not violate water quality standards. In order to make such a determination, Ecology may do a more specific review of the potential impacts of a stormwater discharge from the construction phase of the project and from the completed project. As a result of that review, Ecology may condition its certification to require:

- Application of the minimum requirements and BMPs in this manual; or
- Application of more stringent requirements.

1.6.12 Hydraulic Project Approvals (HPAs)

Under [Chapter 77.55 RCW](#) ~~Chapter 77.55 RCW~~, the Hydraulics Act, the Washington State Department of Fish and Wildlife has the authority to require actions when stormwater discharges related to a project would change the natural flow or bed of state waters. The implementing mechanism is the issuance of a Hydraulics Project Approval (HPA) permit. In exercising this authority, Fish and Wildlife may require:

- Compliance with the provisions of this manual; or
- Application of more stringent requirements that they determine are necessary to meet their statutory obligations to protect fish and wildlife.

1.6.13 Aquatic Lands Use Authorizations

The Department of Natural Resources (DNR), as the steward of public aquatic lands, may require a stormwater outfall to have a valid use authorization, and to avoid or mitigate resource impacts. Through its use authorizations, which are issued under authority of [Chapter 79.105-79.140 RCW](#) ~~Chapter 79.90 through 96~~, and in accordance with [Chapter 332-30 WAC](#) ~~Chapter 332-30 WAC~~, DNR may require:

- Compliance with the provisions of this manual; or
- Application of more stringent requirements that they determine are necessary to meet their statutory obligations to protect the quality of the state's aquatic lands.

1.6.14 Requirements Identified through Watershed/Basin Planning or Total Maximum Daily Loads

A number of the requirements of this manual can be superseded by the adoption of ordinances and rules to implement the recommendations of watershed plans or basin plans. Local governments may initiate their own watershed ~~or~~ basin planning processes to identify more stringent or alternative requirements. They may also choose to develop a watershed plan in accordance with the Watershed Management Act ([Chapter 90.82 RCW](#) ~~(Chapter 90.82 RCW)~~) that includes the optional elements of water quality and habitat. ~~They may also choose to develop a basin plan in accordance with Chapter 400-12 WAC.~~ As long as the actions or requirements identified in those plans and implemented through local or state ordinances or rules comply with applicable state and federal statutes (e.g., the federal Clean Water Act and the Endangered Species Act), they can supersede the requirements in this manual. The decisions concerning whether such locally derived requirements comply with federal and state statutes rest with the regulatory agencies responsible for implementing those statutes.

A requirement of this manual can also be superseded or added to through the adoption of actions and requirements identified in a Total Maximum Daily Load (TMDL) that is approved by the EPA. However, it is likely that at least some TMDLs will require use of the BMPs in this manual.

1.6.15 Underground Injection Control Authorizations

To implement provisions of the federal Safe Drinking Water Act ([see Federal UIC regulations, 40 CFR, Part 144](#)), Ecology has adopted rules ([Chapter 173-218 WAC](#) ~~(Chapter 173-218 WAC)~~) for an underground injection control (UIC) program. [For more information visit Ecology's home page for the UIC program at <http://www.ecy.wa.gov/programs/wq/grndwtr/uic/> and "Guidance for UIC Wells that Manage Stormwater" at <http://www.ecy.wa.gov/pubs/0510067.pdf>.](#)

[According to WAC 173-218-030 UIC well is defined as "a well that is used to discharge fluids into the subsurface. A UIC well is one of the following: \(1\) A bored, drilled or driven shaft, or dug hole whose depth is greater than the largest surface dimension; \(2\) An improved sinkhole; or \(3\) A subsurface fluid distribution system \(contains perforated pipe or similar structure\)."](#)

Depending upon the manner in which it is accomplished, the discharge of stormwater into the ground can be classified as a Class V injection well. [For more information and for a listing on potential stormwater facilities that may have Class V classification refer to the memorandum available at <http://www.ecy.wa.gov/programs/wq/stormwater/municipal/resources/EPAmemoInfiltrationClassVwells.pdf>](#) ~~Federal UIC regulations, 40 CFR Part 144, were revised in 2000 to include subsurface distribution systems, drywells, catch basins, and similar devices that discharge to the ground.~~

~~To date, Ecology's activity under this program has been primarily in regard to registering all UIC wells.~~

1.6.16 Other Local Government Requirements

Local governments have the option of applying more stringent requirements than those in this manual. They are not required to base those more stringent requirements on a watershed/basin plan or their obligations under a TMDL. Project proponents should always check with the local governmental agency with jurisdiction to determine the stormwater requirements that apply to their project.

1.7 Effects of Urbanization

1.7.1 Background Conditions

Prior to the Euro-American settlement, western Washington primarily was forested in alder, maple, fir, hemlock and cedar. The area's bountiful rainfall supported the forest and the many creeks, springs, ponds, lakes and wetlands. The forest system provided protection by intercepting rainfall in the canopy, reducing the possibility of erosion and the deposition of sediment in waterways. The trees and other vegetative cover evapotranspired at least 40% of the rainfall. The forest duff layer absorbed large amounts of runoff releasing it slowly to the streams through shallow ground water flow.

1.7.2 Hydrologic Changes

As settlement occurs and the population grows, trees are logged and land is cleared for the addition of impervious surfaces such as rooftops, roads, parking lots, and sidewalks. Maintained landscapes that have much higher runoff characteristics typically replace the natural vegetation. The natural soil structure is also lost due to grading and compaction during construction. Roads are cut through slopes and low spots are filled. Drainage patterns are irrevocably altered. All of this results in drastic changes in the natural hydrology, including:

- Increased volumetric flow rates of runoff;
- Increased volume of runoff;
- Decreased time for runoff to reach a natural receiving water;
- Reduced ground water recharge;
- Increased frequency and duration of high stream flows and wetlands inundation during and after wet weather;
- Reduced stream flows and wetlands water levels during the dry season; and

- Greater stream velocities-

~~Figure 1.1~~ [Figure 1.7.1](#) illustrates some of these hydrologic changes. As a consequence of these hydrology changes, stream channels are eroded by high flows and can lose summertime base flows. Increased flooding occurs. Streams lose their hydraulic complexity. Habitat is degraded and receiving water species composition is altered as explained below.

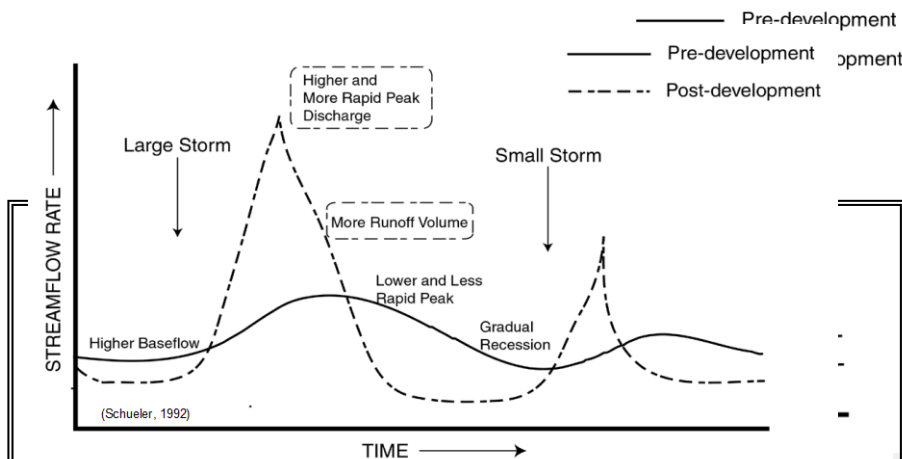
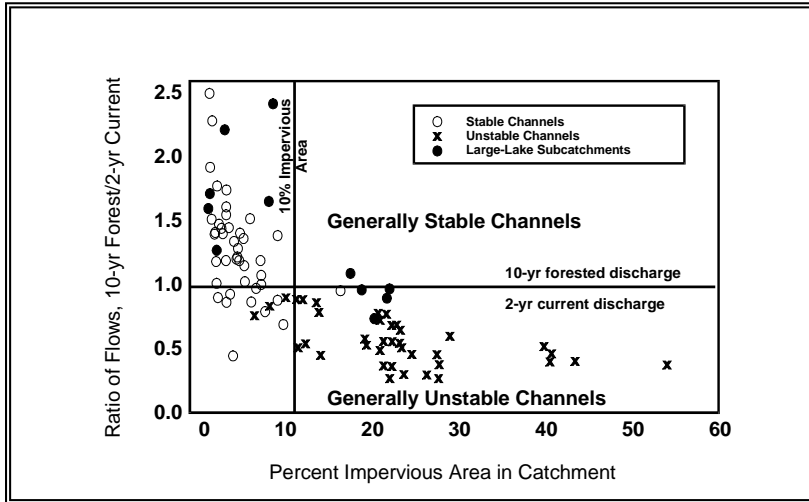


Figure 1.1 – Changes in Hydrology After Development

Figure 1.7.1 – Changes in Hydrology after Development

~~Figure 1.2~~ [Figure 1.7.2](#) (Booth and Jackson, 1997) illustrates one observed relationship between the level of development in a basin (as measured by effective, not total, impervious area), the changes in the recurrence of modeled stream flows, and the resultant streambank instability and channel erosion. These data show that even a crude measure of stream degradation, “channel instability,” shows significant changes at relatively low levels of urban development. More sensitive measures, such as biological indicators (see [Section 1.7.4](#) ~~section 1.7.4~~), document degradation at even lower levels of human activity.



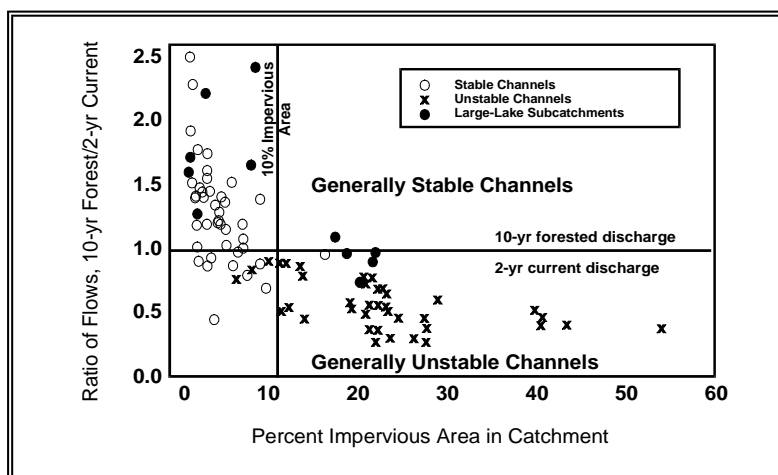


Figure 1.7.2 - Channel Stability and Land Use: Hylebos, East Lake Sammamish, Issaquah Basins

1.7.3 Water Quality Changes

Urbanization also causes an increase in the types and quantities of pollutants in surface and ground waters. Runoff from urban areas has been shown to contain many different types of pollutants, depending on the nature of the activities in those areas. [Table 1.7.1](#) ~~Table 1.1.~~, from an analysis of Oregon urban runoff water quality monitoring data collected from 1990 to 1996, shows mean concentrations for a limited number of pollutants from different land uses. (Strecker et al, 1997)

Table 1.7.1 Mean Concentrations of Selected Pollutants in Runoff from Different Land Uses

Land Use	TSS mg/l	Total Cu mg/l	Total Zn mg/l	Dissolved Cu mg/l	Total P mg/l
In-pipe Industry	194	0.053	0.629	0.009	0.633
Instream Industry	102	0.024	0.274	0.007	0.509
Transportation	169	0.035	0.236	0.008	0.376
Commercial	92	0.032	0.168	0.009	0.391
Residential	64	0.014	0.108	0.006	0.365
Open	58	0.004	0.025	0.004	0.166

Note: In-pipe industry means the samples were taken in stormwater pipes. Instream industry means the samples were taken in streams flowing through industrial areas. Samples for all other categories were taken within stormwater pipes.

The runoff from roads and highways is contaminated with pollutants from vehicles. Oil and grease, polynuclear aromatic hydrocarbons (PAH's), lead, zinc, copper, cadmium, as well as sediments (soil particles) and road salts are typical pollutants in road runoff. Runoff from industrial areas typically contains even more types of heavy metals, sediments, and a

broad range of man-made organic pollutants, including phthalates, PAH's, and other petroleum hydrocarbons. Residential areas contribute the same road-based pollutants to runoff, as well as herbicides, pesticides, nutrients (from fertilizers), bacteria and viruses (from animal waste). All of these contaminants can seriously impair beneficial uses of receiving waters.

Regardless of the eventual land use conversion, the sediment load produced by a construction site can turn the receiving waters turbid and be deposited over the natural sediments of the receiving water.

The pollutants added by urbanization can be dissolved in the water column or can be attached to particulates that settle in streambeds, lakes, wetlands, or marine estuaries. A number of urban bays in Puget Sound have contaminated sediments due to pollutants associated with particulates in stormwater runoff.

Urbanization also tends to cause changes in water temperature. Heated stormwater from impervious surfaces and exposed treatment and detention ponds discharges to streams with less riparian vegetation for shade. Urbanization also reduces ground water recharge, which reduces sources of cool ground water inputs to streams. In winter, stream temperatures may lower due to loss of riparian cover. There is also concern that the replacement of warmer ground water inputs with colder surface runoff during colder periods may have biological impacts.

1.7.4 Biological Changes

The hydrologic and water quality changes result in changes to the biological systems that were supported by the natural hydrologic system. In particular, aquatic life is greatly affected by urbanization. Habitats are drastically altered when a stream changes its physical configuration and substrate due to increased flows. Natural riffles, pools, gravel bars and other areas are altered or destroyed. These and other alterations produce a habitat structure that is very different from the one in which the resident aquatic life evolved. For example, spawning areas, particularly those of salmonids, are lost. Fine sediments imbed stream gravels and suffocate salmon redds. The complex food web is destroyed and is replaced by a biological system that can tolerate the changes. However, that biological community is typically not as complex, is less desirable, and is unstable due to the ongoing rapid changes in the new hydrologic regime.

Significant and detectable changes in the biological community of Puget Sound lowland streams begin early in the urbanization process. May *et al* (1997) reported changes in the 5-10% total impervious area range of a watershed. [Figure 1.7.3](#) ~~Figure 1.3~~ from May *et al* (1997) shows the relationship observed between the Benthic Index of Biotic Integrity (B-IBI) developed by Kleindl (1995) and Karr (1991), and the extent of watershed urbanization as estimated by the percentage of total impervious area (% TIA). Also shown in the figure is the correlation between the

abundance ratio of juvenile coho salmon to cutthroat trout (Lucchetti and Fuerstenberg 1993) and the extent of urbanization.

The biological communities in wetlands are also severely impacted and altered by the hydrological changes. Relatively small changes in the natural water elevation fluctuations can cause dramatic shifts in vegetative and animal species composition.

In addition, the toxic pollutants in the water column such as pesticides, soaps, and metals can have immediate and long-term lethal impacts. Toxic pollutants in sediments can yield similar impacts with the lesions and cancers in bottom fish of urban bays serving as a prime example.

A rise in water temperature can have direct lethal effects. It reduces the maximum available dissolved oxygen and may cause algae blooms that further reduce the amount of dissolved oxygen in the water.

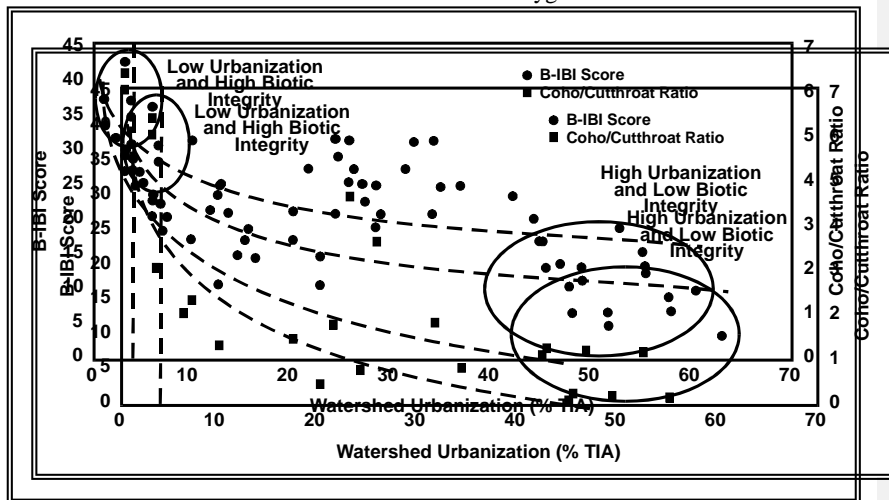


Figure 1.7.3 – Relationship Between Basin Development and Biotic Integrity in Puget Sound Lowland Streams

1.7.5 The Role of Land Use and Lifestyles

The manual's scope is limited to managing the surface runoff generated by a new development or redevelopment project. The manual does not intend to delve deeply into site development standards or where development should be allowed. Those are land use decisions that should not be directed by this stormwater manual. The manual applies after the decision to develop a site has been made. The manual can provide site development

strategies to reduce the pollutants generated and the hydrologic disruptions caused by development.

The engineered stormwater conveyance, treatment, and detention systems advocated by this and other stormwater manuals can reduce the impacts of development to water quality and hydrology. But they cannot replicate the natural hydrologic functions of the natural watershed that existed before development, nor can they remove sufficient pollutants to replicate the water quality of pre-development conditions. Ecology understands that despite the application of appropriate practices and technologies identified in this manual, some degradation of urban and suburban receiving waters will continue, and some beneficial uses will continue to be impaired or lost due to new development. This is because land development, as practiced today, is incompatible with the achievement of sustainable ecosystems. Unless development methods are adopted that cause significantly less disruption of the hydrologic cycle, the cycle of new development followed by beneficial use impairments will continue.

In recent years, researchers (May et al, 1997) and regulators (e.g., Issaquah Creek Basin and Nonpoint Action Plan, 1996) have speculated on the amount of natural land cover and soils that should be preserved in a watershed to retain sufficient hydrologic conditions to prevent stream channel degradation, maintain base flows, and contribute to achieving properly functioning conditions for salmonids. There is some agreement that preserving a high percentage (possibly 65 to 75%) of the land cover and soils in an undisturbed state is necessary. To achieve these high percentages in urban, urbanizing, and suburban watersheds, a dramatic reduction is necessary in the amount of impervious surfaces and artificially landscaped areas to accommodate our preferred housing, play, and work environments, and most significantly, our transportation choices.

Surfaces created to provide “car habitat” comprise the greatest portion of impervious areas in land development. Therefore, to make appreciable progress in reducing impervious surfaces in a watershed, we must reduce the density of our road systems, alter our road construction standards, reduce surface parking, and rely more on transportation systems that do not require such extensive impervious surfaces (rail, bicycles, walking).

Reducing the extent of impervious surfaces and increasing natural land cover in watersheds are also necessary to solve the water quality problems of sediment, temperature, toxicants, and bacteria. Changing public attitudes toward chemical use and preferred housing are also necessary to achieve healthy water ecosystems.

Until we are successful in applying land development techniques that result in matching the natural hydrologic functions and cycles of watersheds, management of the increased surface runoff is necessary to reduce the impact of the changes. [Figure 1.7.3](#) ~~Figure 1.3~~ illustrates that significant biological impacts in streams can occur at even low levels of

development associated with rural areas where stormwater runoff has not been properly managed. Improving our stormwater detention, treatment, and source control management practices should help reduce the impacts of land development in urban and rural areas. We must also improve the operation and maintenance of our engineered systems so that they function as well as possible. This manual is Ecology's latest effort to apply updated knowledge in these areas.

The question yet to be answered is whether better management – including improved treatment and detention techniques – of the increased surface runoff from developed areas can work in combination with preservation of high percentages of natural vegetation and soils on a watershed scale to yield a minimally altered hydrologic and water quality regime that protects the water-related natural resources.

In summary, implementing improved engineering techniques and drastic changes in where and how land is developed and how people live and move across the land are necessary to achieve the goals in the federal Clean Water Act - to preserve, maintain, and restore the beneficial uses of our nation's waters.

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Chapter 2 - Minimum Requirements for New Development and Redevelopment

This chapter identifies the ~~ten~~^{nine} Minimum Requirements for stormwater management applicable to new development and redevelopment sites. The Minimum Requirements are:

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems and Outfalls
5. On-site Stormwater Management
6. Runoff Treatment
7. Flow Control
8. Wetlands Protection

~~9. Basin/Watershed Planning~~

~~10.9.~~ Operation and Maintenance

Depending on the type and size of the proposed project, different combinations of these minimum requirements apply. In general, small sites are required to control erosion and sedimentation from construction activities and to apply simpler approaches to treatment and flow control of stormwater runoff from the developed site. Controlling flows from small sites is important because the cumulative effect of uncontrolled flows from many small sites can be as damaging as those from a single large site.

Large sites must provide erosion and sedimentation control during construction, permanent control of stormwater runoff from the developed site through selection of appropriate BMPs and facilities, and other measures to reduce and control the ~~onsite~~^{on-site} and ~~offsite~~^{off-site} impacts of the project. Sites being redeveloped must generally meet the same minimum requirements as new development for the new ~~impervious~~^{hard} surfaces and pervious surfaces converted ~~from natural vegetation~~. Redevelopment sites must also provide erosion control, source control, and on-site stormwater management for the portion of the site being redeveloped. In addition, if the redevelopment meets certain cost or space (as applied to roads) thresholds, updated stormwater management for the redeveloped pervious and ~~impervious~~^{hard} surfaces must be provided. There may also be situations in which additional controls are required for sites, regardless of type or size, as a result of basin plans or special water quality concerns.

Development sites are to demonstrate compliance with these requirements through the preparation of Stormwater Site Plans (SSP). The plans are

described in detail in ~~Chapter 3~~[Chapter 3](#). Two major components of these plans are a Construction Stormwater Pollution Prevention Plan (SWPPP) and a Permanent Stormwater Control Plan (PSCP). The Construction SWPPP shall identify how the project intends to control pollution generated during the construction phase only, primarily erosion and sediment. The PSCP shall identify how the project intends to provide permanent BMPs for the control of pollution from stormwater runoff after construction has been completed. Sites must submit these plans for review by the local government if they add or replace 2,000 square feet or more of ~~impervious~~[hard](#) surface, or disturb 7,000 square feet or more of land.

[Section 2.4](#)~~Section 2.4~~ provides additional information on applicability of the Minimum Requirements to different types of sites.

2.1 Relationship to ~~Puget Sound Water Quality Management Plan~~[Municipal Stormwater Permits](#)

~~— This manual, now expanded to be applicable throughout western Washington, was originally developed to comply with the 1991 Puget Sound Water Quality Management Plan. That plan (as amended in 2000) requires all counties and cities within the Puget Sound drainage basin to adopt stormwater programs which include minimum requirements for new development and redevelopment set by the Plan and in guidance developed by the Department of Ecology (Ecology). The programs are to include ordinances that address:~~

~~*"... at a minimum: (1) the control of off-site water quality and quantity effects; (2) the use of best management practices for source control and treatment; (3) the effective treatment, using best management practices, of the storm size and frequency (design storm) as specified in the manual for proposed development; (4) the use of infiltration, with appropriate precautions, as the first consideration in stormwater management; (5) the protection of stream channels, fish, shellfish habitat, other aquatic habitat, and wetlands; (6) erosion and sedimentation control for new construction and redevelopment projects; and (7) local enforcement of these stormwater controls."*~~

~~— Ecology considers the above description to be generic to proper stormwater management in any region within the state of Washington.~~

~~— Throughout this Chapter, guidance to meet the requirements of the Puget Sound Water Quality Management Plan is written in bold and supplemental guidelines that serve as advice and other materials are not in bold. To have an equivalent manual, local governments must adopt into ordinance and/or enforceable rules, the definitions, thresholds, minimum requirements, and adjustment and variance criteria that are displayed in bold. Alternative definitions,~~

~~thresholds, minimum requirements, and adjustment and variance criteria are acceptable if they provide equivalent protection of receiving waters and equivalent levels of treatment and control.~~

Municipalities covered under the Phase I or Western Washington Phase II NPDES and State Waste Discharge Municipal Stormwater Permits should use Appendix 1 of those permits rather than the bold font statements of this chapter for determining their compliance requirements.

The State recommends that local governments not covered under the Phase I or Western Washington Phase II Municipal Stormwater Permits should adopt and use the bold font statements of the thresholds, definitions, minimum requirements, adjustment, and variance sections in this chapter. Use of the two optional guidance statements is also advisable. The statements in the supplemental guidance sections are for background, clarification, and implementation guidance.

2.2 Exemptions

Unless otherwise indicated in this Section, the practices described in this section are exempt from the Minimum Requirements, even if such practices meet the definition of new development or redevelopment.

Forest practices:

Forest practices regulated under ~~Title 222 WAC~~^{Title 222 WAC}, except for Class IV General forest practices that are conversions from timber land to other uses, are exempt from the provisions of the minimum requirements.

Commercial agriculture:

Commercial agriculture practices involving working the land for production are generally exempt. However, the conversion from timberland to agriculture, and the construction of impervious surfaces are not exempt.

RoadPavement Maintenance:

The following ~~roadpavement~~ maintenance practices are exempt: pothole and square cut patching, overlaying existing asphalt or concrete pavement with asphalt or concrete without expanding the area of coverage, shoulder grading, reshaping/regrading drainage systems, crack sealing, resurfacing with in-kind material without expanding the road prism, pavement preservation activities that do not expand the road prism, and vegetation maintenance.

The following ~~roadpavement~~ maintenance practices are ~~considered redevelopment, and therefore are~~ not categorically exempt. They are considered redevelopment. The extent to which the manual applies is explained for each circumstance.

- ~~Removing and replacing a paved surface to base course or lower, or repairing the roadway pavement base: If impervious surfaces are not expanded, Minimum Requirements #1 - #5 apply. ~~However, in most cases, only Minimum Requirement #2, Construction Stormwater Pollution Prevention, will be germane. Where appropriate, project proponents are encouraged to look for opportunities to use permeable and porous pavements.~~~~
- Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders: These are considered new impervious surfaces and are subject to the minimum requirements that are triggered when the thresholds identified for new or redevelopment projects are met.
- Resurfacing by upgrading from dirt to gravel, asphalt, or concrete; upgrading from gravel to asphalt, or concrete; or upgrading from a bituminous surface treatment (“chip seal”) to asphalt or concrete: These are considered new impervious surfaces and are subject to the minimum requirements that are triggered when the thresholds identified for new or redevelopment projects are met.

Underground utility projects:

Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics are only subject to Minimum Requirement #2, Construction Stormwater Pollution Prevention.

~~All other new development is subject to one or more of the Minimum Requirements (see Section 2.4).~~

2.3 Definitions Related to Minimum Requirements

A full listing and definition of stormwater-related words and phrases that are used in this manual is given in the glossary. A few of the key definitions are listed here for ease in understanding the requirements that follow.

- **Arterial** - A road or street primarily for through traffic. ~~A major arterial connects an Interstate Highway to cities and counties. A minor arterial connects major arterials to~~ The term generally includes roads or streets considered collectors. A collector connects an arterial to a neighborhood. A collector is ~~It does not an arterial. A include~~ local access roads which are generally limited to providing access to abutting property. See also RCW 35.78.010, RCW 36.86.070, and RCW 47.05.021 ~~road connects.~~
- **Bioretention** – Engineered facilities that treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for flow attenuation. Refer to Chapter 7 of Volume V for Bioretention BMP types and design specifications.

- **Certified Erosion and Sediment Control Lead (CESCL)** - means 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 Department of Ecology (Ecology) (see BMP C160 in Volume II). A CESCL is knowledgeable in the principles and practices of erosion and sediment control. The CESCL must have the skills to assess site conditions and construction activities that could impact the quality of stormwater and the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. Certification is obtained through an Ecology approved erosion and sediment control course. Course listings are provided online at Ecology's web site.
- **Commercial Agriculture** means those activities conducted on lands defined in RCW 84.34.020(2) ~~homes~~ and activities involved in the production of crops or livestock for ~~wholesale~~ commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a ~~collector~~ nonagricultural use or has lain idle for more than five years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.
- **Converted vegetation (areas)** – The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation (e.g., Himalayan blackberry scotch broom) are converted to lawn or landscaped areas, or where native vegetation is converted to pasture.
- **Effective Impervious surface** - Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces ~~on residential development sites~~ are considered ineffective if: 1) the runoff is dispersed through at least one hundred feet of native vegetation in accordance with BMP T5.30 – “Full Dispersion,” as described in Chapter 5 of Volume V; 2) residential roof runoff is infiltrated in accordance with Downspout Full Infiltration Systems in BMP T5.10A in Volume III; or 3) approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.
- **Erodible or leachable materials** – Wastes, chemicals, or other substances that measurably alter the physical or chemical characteristics of runoff when exposed to rainfall. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage.

- **Hard Surface** – An impervious surface, a permeable pavement, or a vegetated roof.
- **Highway** – A main public road connecting towns and cities
- **Impervious surface** - A ~~hard~~non-vegetated surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A ~~hard~~non-vegetated surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, 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 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 runoff modeling.
- **Land disturbing activity** - Any activity that results in ~~movement of earth, or~~ a change in the existing soil cover (both vegetative and non-vegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices, including landscape maintenance and gardening, are not considered land - disturbing activity. Stormwater facility maintenance is not considered land disturbing activity if conducted according to established standards and procedures.
- **Low Impact Development (LID)** – A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation, and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.
- **LID Best management Practices** - Distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to, bioretention/rain gardens, permeable pavements, roof downspout controls, dispersion, soil quality and depth, minimal excavation foundations, vegetated roofs, and water re-use.
- **LID Principles** – Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to

minimize impervious surfaces, native vegetation loss, and stormwater runoff.

- **Maintenance** - Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and results in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include ~~and~~ replacement of dysfunctioning facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. One example is the replacement of a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway. In regard to stormwater facilities, maintenance includes assessment to ensure ongoing proper operation, removal of built up pollutants (i.e.sediments), replacement of failed or failing treatment media, and other actions taken to correct defects as identified in the maintenance standards of Chapter 4, Volume V. See also Pavement Maintenance exemptions in Section 2.2. ~~For further details on the application of this manual to various road management functions, please see Section 2.2.~~
- **Native vegetation** – Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas Fir, western hemlock, western red cedar, alder, big-leaf maple, and vine maple; shrubs such as willow, elderberry, salmonberry, and salal; and herbaceous plants such as sword fern, foam flower, and fireweed.
- **New development** - Land disturbing activities, including Class IV - general forest practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of ~~impervioushard~~ surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in ~~Chapter 58.17 RCW~~ Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.
- **On-site Stormwater Management BMPs** - As used in this chapter, a synonym for Low Impact Development BMPs.
- **Permeable pavement** – Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water through the pavement section. It often includes an aggregate base that provides structural support and acts as a stormwater reservoir.

- **Pervious Surface** – Any surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.
- **Pollution-generating hard surface (PGHS)** – Those hard surfaces considered to be a significant source of pollutants in stormwater runoff. See the listing of surfaces under pollution-generating impervious surface.
- **Pollution-generating impervious surface (PGIS)** - Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use; industrial activities (as further defined in the glossary); storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall; metal roofs unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating); or roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.
- **Pollution-generating pervious surfaces (PGPS)** - Any non-impervious surface subject to vehicular use, industrial activities (as further defined in the glossary); 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 rainfall runoff. 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).~~ that receive direct rainfall or run-on or blow-in of rainfall, use of pesticides and fertilizers or loss of soil. Typical PGPS include permeable pavement subject to vehicular use, lawns and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf).
 - 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, 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 surfaces (PGPS)** – Any non-impervious surface subject to use of pesticides and fertilizers or loss of soil. Typical PGPS include lawns, landscaped areas, golf courses, parks, cemeteries, and sports fields.~~
- **Pre-developed condition** – The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.
- **Project site** - That portion of a property, properties, or right of way subject to land disturbing activities, new ~~impervious~~**hard** surfaces, or replaced ~~impervious~~**hard** surfaces.
- **Rain Garden** – A non-engineered, shallow, landscaped depression, with compost-amended native soils or imported soils, and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. Refer to the Rain Garden Handbook for Western Washington Homeowners (WSU, 2007 or as revised) for rain garden specifications and construction guidance.
- **Receiving waters** - Bodies of water or surface water systems to which surface runoff is discharged via a point source of stormwater or via sheet flow. Ground water to which surface runoff is directed by infiltration.
- **Redevelopment** - On a site that is already substantially developed (i.e., has 35% or more of existing ~~impervious~~**hard** surface coverage), the creation or addition of ~~impervious~~**hard** surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure;; replacement of ~~impervious~~**hard** surface that is not part of a routine maintenance activity; and land disturbing activities.
- **Replaced hard surface** – For structures, the removal and replacement of hard surfaces down to the foundation. For other hard surfaces, the removal down to bare soil or base course and replacement.
- **Replaced impervious surface** - For structures, the removal and replacement of ~~any exterior~~ impervious surfaces down to or including the foundation. For other impervious surfaces, the removal down to bare soil or base course, and replacement.
- **Site** – The area defined by the legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.

- **Source control BMP** - A structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This manual separates source control BMPs into two types. *Structural Source Control BMPs* are physical, structural, or mechanical devices, or facilities that are intended to prevent pollutants from entering stormwater. *Operational BMPs* are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV for details.
- **Threshold Discharge Area** - An ~~onsite~~^{on-site} area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). The examples in [Figure 2.3.1](#) ~~Figure 2.1~~ below illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.

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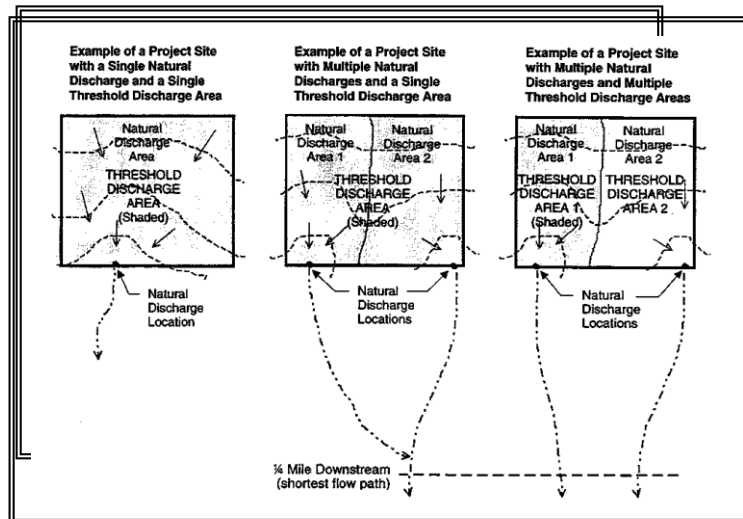


Figure 2.3.1 = Threshold Discharge Areas

2.4 Applicability of the Minimum Requirements

~~Not all of the Minimum Requirements apply to every development or redevelopment project.~~

- **Vehicular Use** – Regular use of an impervious or pervious surface by motor vehicles. The following are subject to regular vehicle use: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unrestricted access fire lanes, vehicular equipment storage yards, and airport runways.

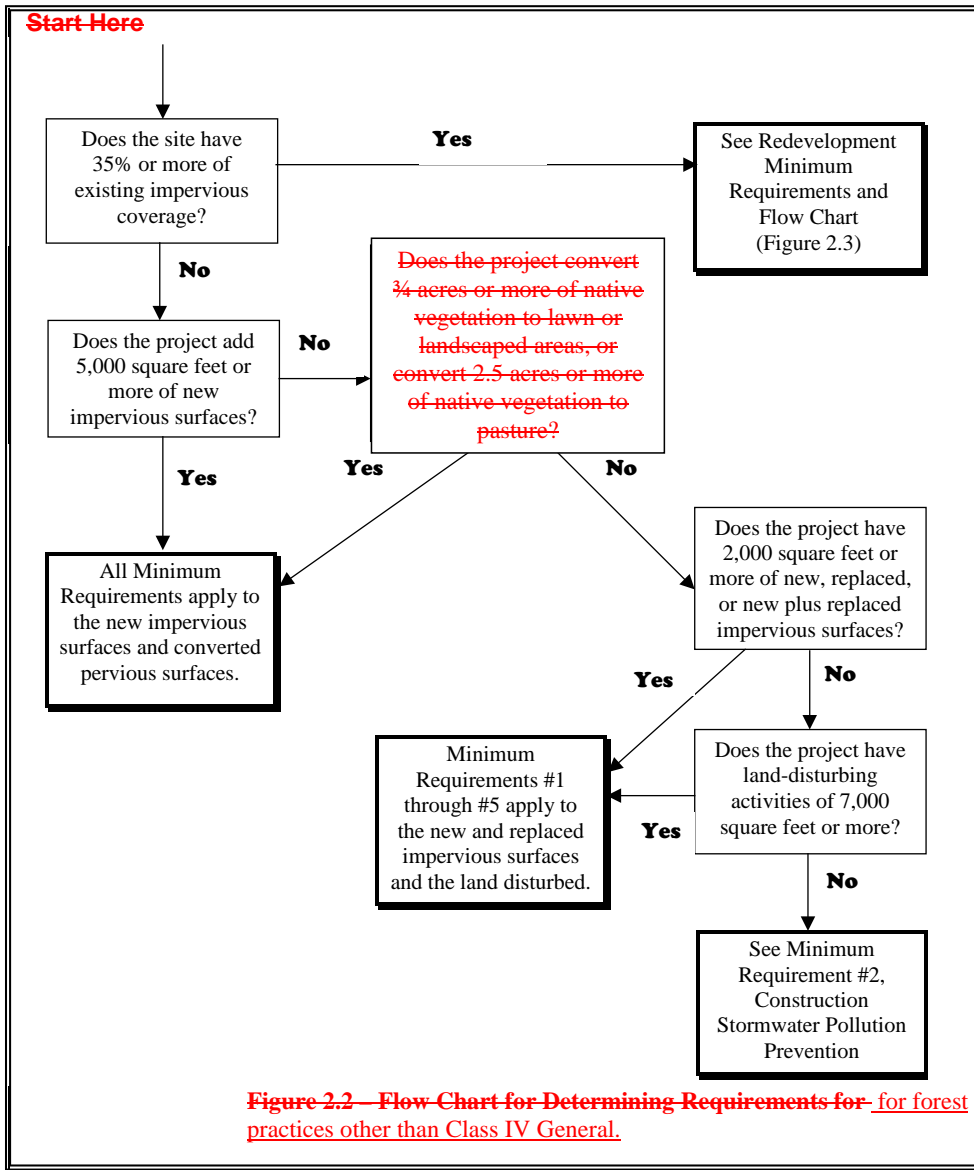
The following are not considered subject to regular vehicle use: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, restricted access fire lanes, and infrequently used maintenance access roads.

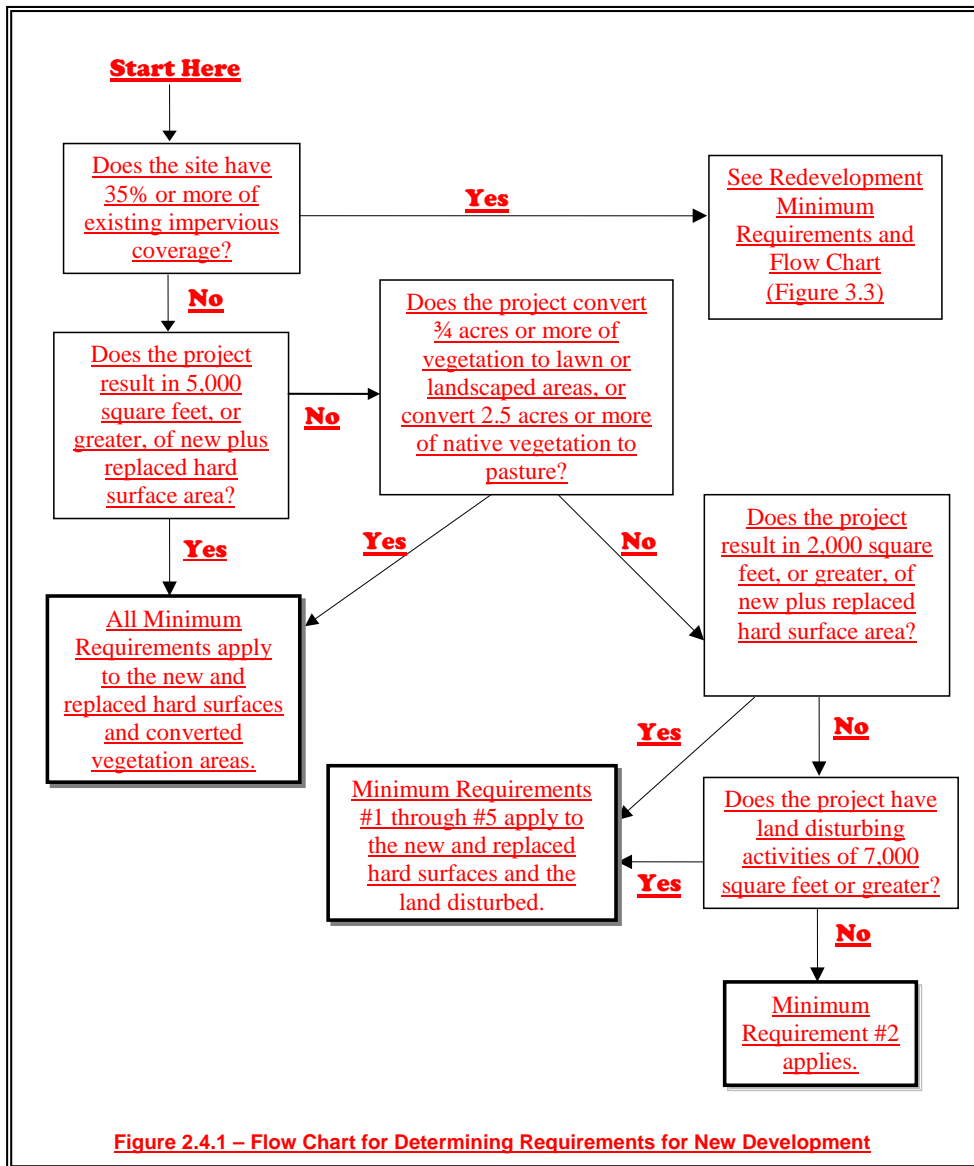
- **Wetland** – Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands.

2.4 Applicability of the Minimum Requirements

Not all of the Minimum Requirements apply to every development or redevelopment project. The applicability varies depending on the project type and size. This section identifies thresholds that determine the applicability of the Minimum Requirements to different projects. ~~of the project. This section identifies thresholds that determine the applicability of the Minimum Requirements to different projects.~~ Use the flow charts in Figures 2.4.1, Figures 2.2 and 2.4.2.3 can be used to determine which of the Minimum Requirements apply. The Minimum Requirements themselves are presented in Section 2.5.

Use the thresholds in Figures 2.4.1 and 2.4.2 at the time of application for a subdivision, plat, short plat, building permit, or other construction permit. The plat or short plat approval shall identify all stormwater BMPs that are required for each lot. For projects involving only land disturbing activities, (e.g., clearing or grading), the thresholds apply at the time of application for the permit allowing or authorizing that activity. Note the exemption in Section 2.2





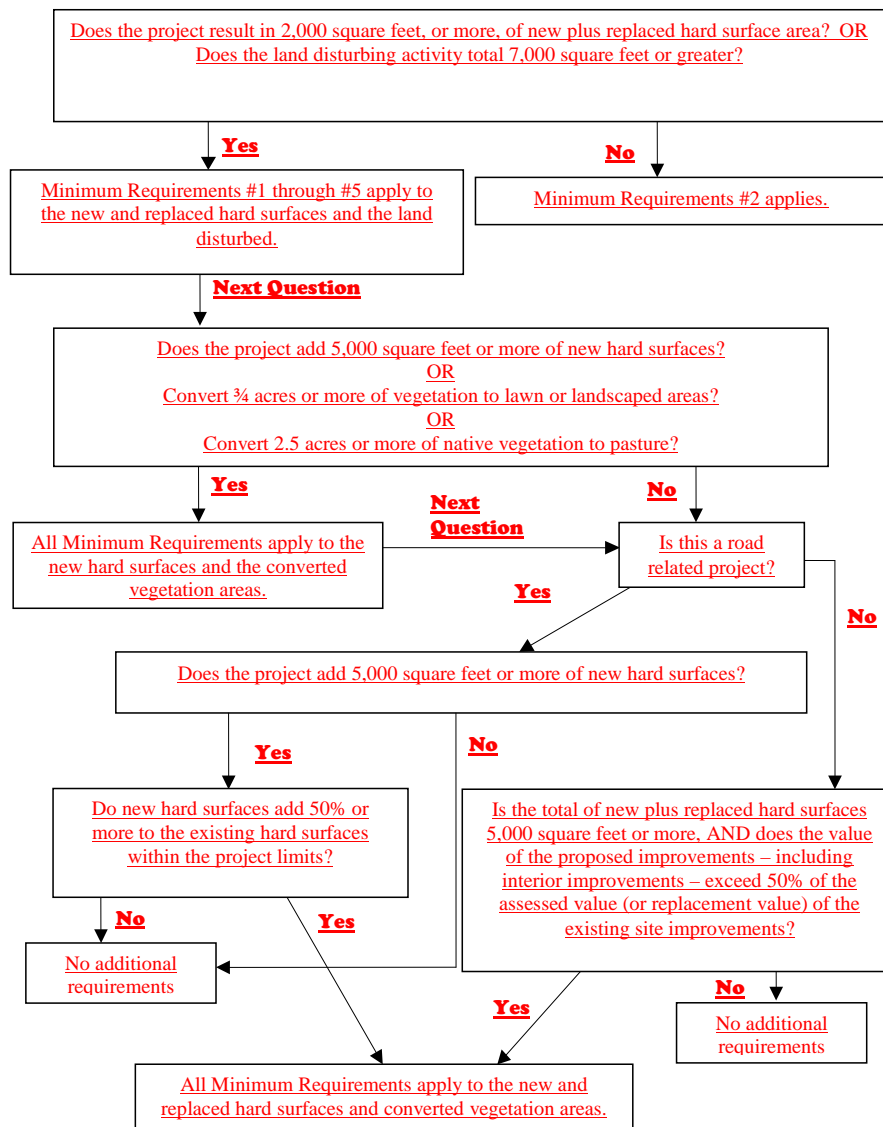


Figure 2.4.2 – Flow Chart for Determining Requirements for Redevelopment

2.4.1 New Development

All new development shall be required to comply with Minimum Requirement #2.

The following new development shall comply with Minimum Requirements #1 through #5 for the new and replaced

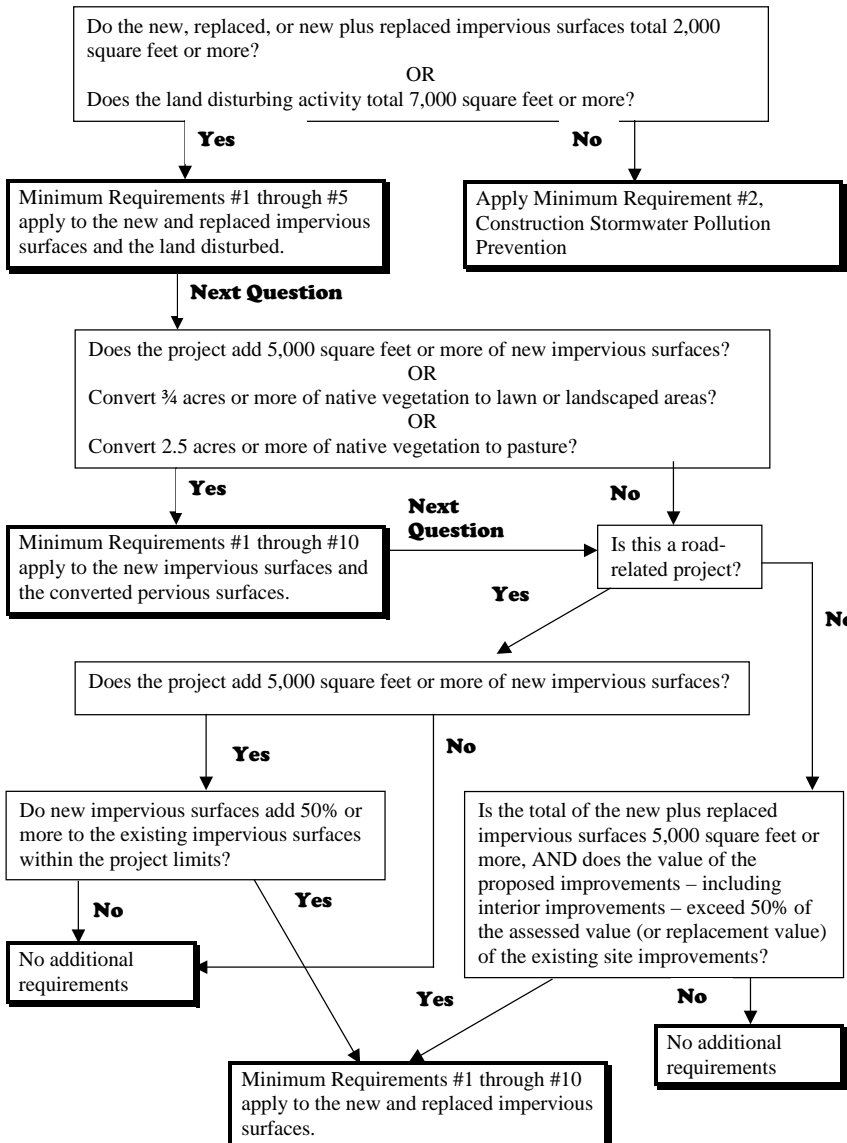


Figure 2.3 – Flow Chart for Determining Requirements for Redevelopment

2.4.1 New Development

~~All new development shall be required to comply with Minimum Requirement #2.~~

~~The following new development shall comply with Minimum Requirements #1 through #5 for the new and replaced~~
~~impervioushard~~ surfaces and the land disturbed:

- ~~Creates or adds~~Results in 2,000 square feet, or greater, of new, replaced, or new plus replaced ~~impervioushard~~ surface area, or
- Has land disturbing activity of 7,000 square feet or greater.

The following new development shall comply with Minimum Requirements #1 through ~~#109~~ for the new ~~imperviousand replaced~~
~~hard~~ surfaces and the converted ~~pervious surfaces~~vegetation areas:

- ~~Creates or adds~~Results in 5,000 square feet, or ~~moregreater~~, of new ~~imperviousplus replaced hard~~ surface area, or
- Converts $\frac{3}{4}$ acres, or more, of ~~native~~ vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or more, of native vegetation to pasture.

Supplemental Guidelines

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- ~~Converts 2.5 acres, or more, of native vegetation to pasture.~~

Supplemental Guidelines

For purposes of applying the above thresholds to a proposed single family residential subdivision (i.e., a plat or short plat project) assume 4,000 sq. ft. of hard surface (8,000 sq. ft. on lots of 5 acres or more) for each newly created lot, unless the project proponent has otherwise formally declared other values for each lot in the corresponding complete land division application. Where local land use regulations restrict maximum hard (or impervious) surfaces to smaller amounts, those maxima may be used.

Regional stormwater facilities may be used as an alternative method of meeting Minimum Requirements 6, 7, and 8, through documented engineering reports detailing how the proposed facilities meet these requirements for the sites that drain to them. Such facilities must be operational prior to and must have capacity for new development.

Basin planning is encouraged and may be used to tailor ~~certain of the~~
~~Minimum Requirements to a specific basin (Minimum Requirement #9).~~
~~#5 On-site Stormwater Management, #6 Runoff Treatment and, #7 Flow Control, and / or #8 Wetlands Protection.~~ Basin planning may be used to support alternative treatment, flow control ~~requirements may be achieved,~~
~~and/or wetland protection~~ through construction of regional stormwater

facilities. Such facilities must be operational prior to and must have capacity for new ~~development.~~

~~Appendix C of Volume III directs users to model various low impact development techniques as landscaped area, 50% landscaped area, or pasture. Those same modeling credits may be used when summing project areas to determine whether the thresholds in Figures 2.2 and 2.3 are exceeded.~~

Where new development projects require improvements (e.g., frontage improvements) that are not within the same threshold discharge area, the local government may allow the Minimum Requirements to be met for an equivalent (flow and pollution characteristics) area that drains to the same receiving water.

2.4.2 Redevelopment

All redevelopment shall be required to comply with Minimum Requirement #2. ~~In addition, all redevelopment that exceeds certain thresholds shall be required to comply with additional Minimum Requirements as follows.~~

The following redevelopment shall comply with Minimum Requirements #1 through #5 for the new and replaced ~~impervioushard~~ surfaces and the land disturbed:

- ~~The new, replaced, or total of new plus replaced impervious surfaces is~~Results in 2,000 square feet or more, ~~or of new plus replaced hard surface area, or~~
- ~~Has land disturbing activity of~~ 7,000 square feet or ~~more of land disturbing activities~~greater.

The following redevelopment shall comply with Minimum Requirements #1 through #~~109~~ for the new ~~impervioushard~~ surfaces and converted pervious areas:

- Adds 5,000 square feet or more of new ~~impervioushard~~ surfaces or,
- Converts $\frac{3}{4}$ acres, or more, of ~~native~~ vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or more, of native vegetation to pasture.

~~If the runoff from the new impervious surfaces and converted pervious surfaces is not separated from runoff from other surfaces on the project site, the stormwater treatment facilities must be sized for the entire flow that is directed to them.~~

The local government may allow the Minimum Requirements to be met for an equivalent (flow and pollution characteristics) area within

the same site. For public ~~roads'~~roads projects, the equivalent area does not have to be within the project limits, but must drain to the same receiving water.

Additional Requirements for the Project Site

For road-related projects, runoff from the replaced and new ~~impervioushard~~ surfaces (including pavement, shoulders, curbs, and sidewalks) and the converted vegetated areas shall meet all the Minimum Requirements if the new ~~impervioushard~~ surfaces total 5,000 square feet or more and total 50% or more of the existing ~~impervioushard~~ surfaces within the project limits. The project limits shall be defined by the length of the project and the width of the right-of-way.

Other types of redevelopment projects shall comply with ~~all the~~ Minimum Requirements #1 through #9 for the new and replaced ~~impervioushard~~ surfaces and the converted vegetated areas if the total of new plus replaced ~~impervioushard~~ surfaces is 5,000 square feet or more, and the valuation of proposed improvements – including interior improvements – exceeds 50% of the assessed value of the existing site improvements.

A local government may exempt or institute a stop-loss provision for redevelopment projects from compliance with Minimum Requirements ~~for treatment,~~#5 On-site Stormwater Management, Minimum Requirement #6 Runoff Treatment, Minimum Requirement #7 Flow Control, and/or Minimum Requirement #8 Wetlands Protection as applied to the replaced ~~impervioushard~~ surfaces if the local government has adopted a plan and a schedule that fulfills those requirements in regional facilities.

A local government may grant a variance/exception to the application of the flow control requirements to replaced impervious surfaces if such application imposes a severe economic hardship. See [Section 2.8 of this chapter](#).

Objective

Redevelopment projects have the same requirements as new development projects in order to minimize the impacts from new surfaces. To not discourage redevelopment projects, replaced surfaces aren't required to be brought up to new stormwater standards unless the noted cost or space thresholds are exceeded. As long as the replaced surfaces have similar pollution-generating potential, the amount of pollutants discharged shouldn't be significantly different. However, if the redevelopment project scope is sufficiently large that the cost or space criteria noted above are exceeded, it is reasonable to require the replaced surfaces to be brought up to current stormwater standards. This is consistent with other utility standards. When a structure or a property undergoes significant

remodeling, local governments often require the site to be brought up to new building code requirements (e.g., onsite/on-site sewage disposal systems, fire systems).

Supplemental Guidelines

If runoff from new impervioushard surfaces, converted pervious surfaces/vegetation areas, and replaced impervioushard surfaces (if the applicable cost or space threshold has been exceeded) is not separated from runoff from other existing surfaces within the project site or the site, the guidance in Appendix III-B of Volume III for offsite/off-site inflow shall be used to size the detention facilities.

Local governments can select from various bases for identifying projects that must retrofit the replaced impervioushard surfaces on the project site. Those can include:

- Exceeding 50% of the assessed value of the existing improvements;
- Exceeding 50% of the replacement value of the existing site improvements as determined by the Marshall Value System, or a similar valuation system; and
- Exceeding a certain dollar value of improvements; and
- Exceeding a certain ratio of the new impervioushard surfaces to the total of replaced plus new impervioushard surfaces.

A local government's thresholds for the application of stormwater controls to replaced impervioushard surfaces must be at least as stringent as Ecology's thresholds. Local governments should be prepared to demonstrate that by comparing the number and types of historical projects that would have been regulated using the Ecology thresholds versus the local government's thresholds.

Local governments are allowed to institute a stop-loss provision on the application of stormwater requirements to replaced impervioushard surfaces. A stop-loss provision is an upper limit on the extent to which a requirement is applied. For instance, there could be a maximum percentage of the estimated total project costs that are dedicated to meeting stormwater requirements. A project would not have to incur additional stormwater costs above that maximum though the standard redevelopment requirements will not be fully achieved. The allowance for a stop-loss provision pertains to the extent that treatment, flow control and wetlands protection requirements are imposed on replaced impervioushard surfaces. It does not apply to meeting stormwater requirements for new impervioushard surfaces.

Local governments can also establish criteria for allowing redevelopment projects to pay a fee in lieu of constructing water quality or flow control facilities on a redeveloped site. At a minimum, the fee should be the equivalent of an engineering estimate of the cost of meeting all applicable

stormwater requirements for the project. The local government should use such funds for the implementation of stormwater control projects that would have similar benefits to the same receiving water as if the project had constructed its required improvements. Expenditure of such funds is subject to other state statutory requirements.

Ecology cautions local governments about the potential long-term consequences of allowing a fee-in-lieu of stormwater facilities. Sites that are allowed to pay a fee continue without stormwater controls. If it is determined, through future basin planning for instance, that controls on such sites are necessary to achieve water quality goals or legal requirements, the public may bear the costs for providing those controls.

Underground utility projects that replace the ground surface with in-kind material or materials with similar runoff characteristics should not be subject to redevelopment requirements except construction site erosion control.

Local governments are also encouraged to review all road projects for changes in elevations or drainage flowpath that could cause flooding, upland or stream erosion, or changes to discharges to wetlands. For example, adding curbs will result in redirecting flows and possibly causing new downstream impacts. The local government should set project-specific requirements to avoid or mitigate those impacts.

2.5 Minimum Requirements

This section describes the minimum requirements for stormwater management at development and redevelopment sites. ~~Section 2.4~~ Section 2.4 should be consulted to determine which requirements apply to any given project. Figures 2.4.1 and 2.4.2 should be consulted to determine whether the minimum requirements apply to new surfaces, replaced surfaces, or new and replaced surfaces. Volumes II through V of this manual present Best Management Practices (BMPs) for use in meeting the Minimum Requirements.

Throughout this chapter, ~~guidance to meet the requirements of the Puget Sound Water Quality Management Plan is~~ are written in bold and supplemental guidelines that serve as advice and other materials are not in bold.

2.5.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

All projects meeting the thresholds in ~~Section 2.4~~ Section 2.4 shall prepare a Stormwater Site Plan for local government review. Stormwater Site Plans shall use site-appropriate development principles, as required and encouraged by local development codes, to retain native vegetation and minimize impervious surfaces to the extent feasible. Stormwater Site Plans shall be prepared in accordance with ~~Chapter 3~~ Chapter 3 of this volume.

Objective

The 2,000 square feet threshold for ~~impervious~~ hard surfaces and 7,000 square foot threshold for land disturbance are chosen to capture most single family home construction and their equivalent. Note that the scope of the stormwater site plan only covers compliance with Minimum Requirements #2 through #5 if the thresholds of 5,000 square feet of ~~impervious~~ hard surface or conversion of ¾ acre of ~~native~~ vegetation to lawn or landscape, or conversion of 2.5 acres of ~~native~~ vegetation to pasture are not exceeded.

Supplemental guidelines

Projects proposed by departments and agencies within the local government with jurisdiction must comply with this requirement. The local government shall determine the process for ensuring proper project review, inspection, and compliance by its own departments and agencies.

2.5.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention (SWPP)

Thresholds

All new development and redevelopment ~~shall comply with Construction SWPP Elements #1 through #12 below.~~ projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters.

Projects ~~in which the new, replaced, or new plus replaced impervious surfaces total result in 2,000 square feet or more, or of new plus replaced hard surface area, or which~~ disturb 7,000 square feet or more of land must prepare a Construction SWPP Plan (SWPPP) as part of the Stormwater Site Plan (see [Section 2.5.12.5.1](#)). ~~Each of the twelve elements must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.~~

Projects that ~~add or replace~~ result in less than 2,000 square feet of ~~impervious~~ new plus replaced hard surface ~~area~~, or disturb less than 7,000 square feet of land are not required to prepare a Construction SWPPP, but must consider all of the ~~twelve~~ 13 Elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site.

Element 1: Mark Clearing Limits

~~Prior to beginning land-disturbing activities, including clearing and grading, all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts.~~

- ~~Plastic, metal, or stake wire fence may be used to mark the clearing limits.~~

~~The duff layer, native top soil, and natural vegetation shall be retained in an undisturbed state to the maximum extent practicable. If it is not practicable to retain the duff layer in place, it should be stockpiled on-site, covered to prevent erosion, and replaced immediately upon completion of the ground-disturbing activities.~~

Element 2: Establish Construction Access

- ~~Construction vehicle access and exit shall be limited to one route, if possible, or two for linear projects such as roadways where more than one access is necessary for large equipment maneuvering.~~
- ~~Access points shall be stabilized with a pad of quarry spalls or crushed rock prior to traffic leaving the construction site to minimize the tracking of sediment onto public roads.~~
- ~~Wheel wash or tire baths should be located on-site, if applicable.~~
- ~~If sediment is tracked off site, public roads shall be cleaned thoroughly at the end of each day, or more frequently during wet weather, if necessary to prevent sediment from entering waters of the state. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area. Street washing will be allowed only after sediment is removed in this manner.~~
- ~~Street wash wastewater shall be controlled by pumping back on-site, or otherwise be prevented from discharging into systems tributary to state surface waters.~~

Element 3: Control Flow Rates

- ~~Properties and waterways downstream from development sites shall be protected from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site, as required by local plan approval authority.~~
- ~~Downstream analysis is necessary if changes in flows could impair or alter conveyance systems, stream banks, bed sediment or aquatic habitat. See Chapter 3 for offsite analysis guidance.~~
- ~~Where necessary to comply with Minimum Requirement #7, stormwater retention/detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional prior to construction of site improvements (e.g. impervious surfaces).~~
- ~~The local permitting agency may require pond designs that provide additional or different stormwater flow control if necessary to address local conditions or to protect properties and~~
- ~~waterways downstream from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.~~
- ~~If permanent infiltration ponds are used for flow control during construction, these facilities should be protected from siltation during the construction phase.~~

Element 4: Install Sediment Controls

- ~~Prior to leaving a construction site, or prior to discharge to an infiltration facility, stormwater runoff from disturbed areas shall pass through a sediment pond or other appropriate sediment removal BMP. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard of Element #3, bullet #1. Full stabilization means concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion. The Local Permitting Authority shall inspect and approve areas stabilized by means other than pavement or quarry spalls.~~
- ~~Sediment ponds, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment on site shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.~~
- ~~Earthen structures such as dams, dikes, and diversions shall be seeded and mulched according to the timing indicated in Element #5.~~
- ~~BMPs intended to trap sediment on site must be located in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages, often during non-storm events, in response to rain event changes in stream elevation or wetted area.~~

Element 5: Stabilize Soils

- ~~All exposed and unworked soils shall be stabilized by application of effective BMPs that protect the soil from the erosive forces of raindrop impact and flowing water, and wind erosion.~~
- ~~From October 1 through 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. This condition applies to all soils on site, whether at final grade or not. These time limits may be adjusted by the local permitting authority if it can be shown that the average time between storm events justifies a different standard.~~
- ~~Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast.~~
- ~~Applicable practices include, but are not limited to, temporary and permanent seeding, sodding, mulching, plastic covering, soil~~

~~application of polyacrylamide (PAM), the early application of gravel base on areas to be paved, and dust control.~~

- ~~• Soil stabilization measures selected should be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization agents may have on downstream waters or ground water.~~
- ~~• Soil stockpiles must be stabilized from erosion, protected with sediment trapping measures, and when possible, be located away from storm drain inlets, waterways and drainage channels.~~
- ~~• Linear construction activities, including right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall be conducted to meet the soil stabilization requirement. Contractors shall install the bedding materials, roadbeds, structures, pipelines, or utilities and re-stabilize the disturbed soils so that:~~
 - ~~• from October 1 through April 30 no soils shall remain exposed and unworked for more than 2 days; and~~
 - ~~• from May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.~~

Element 6: Protect Slopes

- ~~• Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion.~~
- ~~• Consider soil type and its potential for erosion.~~
- ~~• Reduce slope runoff velocities by reducing the continuous length of slope with terracing and diversions, reduce slope steepness, and roughen slope surface.~~

~~Off-site stormwater (run-on) shall be diverted away from slopes and disturbed areas with interceptor dikes and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.~~ *General Requirements*

The SWPPP shall include a narrative and drawings. All BMPs shall be clearly referenced in the narrative and marked on the drawings. The SWPPP narrative shall include documentation to explain and justify the pollution prevention decisions made for the project. Each of the 13 elements must be considered and included in the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP.

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- ~~At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion. Temporary pipe slope drains shall handle the peak flow from a 10-year, 24-hour event assuming a Type 1A rainfall distribution. Alternatively, the 10-year and 25-year, 1-hour flow rates indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. Consult the local drainage requirements for sizing permanent pipe slope drains.~~
- ~~Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.~~
- ~~Excavated material shall be placed on the uphill side of trenches, consistent with safety and space considerations.~~
- ~~Check dams shall be placed at regular intervals within channels that are cut down a slope.~~
- ~~Stabilize soils on slopes, as specified in Element #5.~~

Element 7: Protect Drain Inlets

- ~~All storm drain inlets made operable during construction shall be protected so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment.~~
- ~~All approach roads shall be kept clean. All sediment and street wash water shall not be allowed to enter storm drains without prior and adequate treatment unless treatment is provided before the storm drain discharges to waters of the State.~~
- ~~Inlets should be inspected weekly at a minimum and daily during storm events. Inlet protection devices should 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).~~

Element 8: Stabilize Channels and Outlets

- ~~All temporary on-site conveyance channels shall be designed, constructed and stabilized to prevent erosion from the expected peak 10-minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used.~~
- ~~Stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent stream banks, slopes and downstream reaches shall be provided at the outlets of all conveyance systems.~~

Element 9: Control Pollutants

- ~~All pollutants, including waste materials and demolition debris, that occur on-site shall be handled and disposed of in a manner~~

that does not cause contamination of stormwater. Woody debris may be chopped and spread on site.

- ~~Cover, containment, and protection from vandalism shall be provided for all chemicals, liquid products, petroleum products, and non-inert wastes present on the site (see Chapter 173-304 WAC for the definition of inert waste). On-site fueling tanks shall include secondary containment.~~
- ~~Maintenance and repair of heavy equipment and vehicles involving oil changes, hydraulic system drain-down, solvent and de-greasing cleaning operations, fuel tank drain-down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff must be conducted using spill prevention measures, such as drip pans. Contaminated surfaces shall be cleaned immediately following any discharge or spill incident. Emergency repairs may be performed on-site using temporary plastic placed beneath and, if raining, over the vehicle.~~
- ~~Wheel wash or tire bath wastewater, shall be discharged to a separate on-site treatment system or to the sanitary sewer.~~
- ~~Application of agricultural chemicals, including fertilizers and pesticides, shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations for application rates and procedures shall be followed.~~
- ~~BMPs shall be used to prevent or treat contamination of stormwater runoff by pH modifying sources. These sources include, but are not limited to, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, and concrete pumping and mixer washout waters. Stormwater discharges shall not cause or contribute to a violation of the water quality standard for pH in the receiving water.~~
- ~~Construction sites with significant concrete work shall adjust the pH of stormwater if necessary to prevent violations of water quality standards.~~

Element 10: Control De-Watering

- ~~Foundation, vault, and trench de-watering water, which has similar characteristics to stormwater runoff at the site, shall be discharged into a controlled conveyance system prior to discharge to a sediment trap or sediment pond. Channels must be stabilized, as specified in Element #8.~~
- ~~Clean, non-turbid de-watering water, such as well-point ground water, can be discharged to systems tributary to state surface~~

waters, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters. These clean waters should not be routed through a stormwater sediment pond.

- ~~Highly turbid or otherwise contaminated dewatering water, such as from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, shall be handled separately from stormwater.~~

Other disposal options, depending on site constraints, may include: 1) infiltration, 2) transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters, 3) Ecology-approved on-site chemical treatment or other suitable treatment technologies, 4) sanitary sewer discharge with local sewer district approval, if there is no other option, or 5) ~~Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.~~ **Element 11: Maintain BMPs**

- ~~All temporary and permanent erosion and sediment control BMPs shall be maintained and repaired as needed to assure continued performance of their intended function. All maintenance and repair shall be conducted in accordance with BMP specifications.~~
- ~~All temporary erosion and sediment control BMPs shall be removed within 30 days after final site stabilization is achieved or after the temporary BMPs are no longer needed. Trapped sediment shall be removed or stabilized on site. Disturbed soil areas resulting from removal of BMPs or vegetation shall be permanently stabilized.~~

~~Element 12: Manage The Project~~

- ~~Phasing of Construction – Development projects shall be phased where feasible in order to prevent soil erosion and, to the maximum extent practicable, the transport of sediment from the site during construction. Revegetation of exposed areas and maintenance of that vegetation shall be an integral part of the clearing activities for any phase.~~

Clearing and grading activities for developments shall be permitted only if conducted pursuant to an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. ~~When establishing these permitted clearing and grading areas, consideration should be given to minimizing removal of existing trees and minimizing disturbance/compaction of native soils except as needed for building purposes.~~ These permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention areas ~~as may be~~

~~required by local jurisdictions,~~ shall be delineated on the site plans and the development site.

The SWPPP shall be implemented beginning with initial land disturbance and until final stabilization. Sediment and Erosion control BMPs shall be consistent with the BMPs contained in chapters 3 and 4 of Volume II.

Seasonal Work Limitations - From October 1 through April 30, clearing, grading, and other soil disturbing activities shall only be permitted if shown to the satisfaction of the local permitting authority that silt-laden runoff will be prevented from leaving the site through a combination of the following:

1. Site conditions including existing vegetative coverage, slope, soil type and proximity to receiving waters; ~~and,~~
2. Limitations on activities and the extent of disturbed areas; ~~and,~~
3. Proposed erosion and sediment control measures.

~~Based on the information provided and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. The local permitting authority shall take enforcement action—such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:~~

- ~~If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or~~
- ~~If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.~~

The following activities are exempt from the seasonal clearing and grading limitations:

1. Routine maintenance and necessary repair of erosion and sediment control BMPs; ~~and,~~
2. Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; ~~and,~~
3. Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

- ~~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 Construction SWPPP.~~

Inspection and Monitoring—All Project Requirements -
Construction SWPPP Elements

Element 1: Preserve Vegetation/Mark Clearing Limits

- Before beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area.
- Retain the duff layer, native top soil, and natural vegetation in an undisturbed state to the maximum degree practicable.

Element 2: Establish Construction Access

- Limit construction vehicle access and exit to one route, if possible.
- Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent BMPs, to minimize tracking of sediment onto public roads.
- Locate wheel wash or tire baths on site, if the stabilized construction entrance is not effective in preventing tracking sediment onto roads.
- If sediment is tracked off site, clean the affected roadway thoroughly at the end of each day, or more frequently as necessary (for example, during wet weather). Remove sediment from roads by shoveling, sweeping, or pick up and transport the sediment to a controlled sediment disposal area.
- Conduct street washing only after sediment is removed in accordance with the above bullet.
- Control street wash wastewater by pumping back on-site, or otherwise prevent it from discharging into systems tributary to waters of the State.

Element 3: Control Flow Rates

- Protect properties and waterways downstream of development sites from erosion and the associated discharge of turbid waters due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site.
- Where necessary to comply with the bullet above, construct stormwater retention or detention facilities as one of the first steps in grading. Assure that detention facilities function properly before constructing site improvements (e.g. impervious surfaces).

- If permanent infiltration ponds are used for flow control during construction, protect these facilities from siltation during the construction phase.

Element 4: Install Sediment Controls

- Design, install, and maintain effective erosion controls and sediment controls to minimize the discharge of pollutants.
- Construct sediment control BMPs (sediment ponds, traps, filters, etc.) as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.
- Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.
- Direct stormwater runoff from disturbed areas through a sediment pond or other appropriate sediment removal BMP, before the runoff leaves a construction site or before discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard in Element #3, bullet #1.
- Locate BMPs intended to trap sediment on-site in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.
- Where feasible, design outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column.

Element 5: Stabilize Soils

- Stabilize exposed and unworked soils by application of effective BMPs that prevent erosion. Applicable BMPs include, but are not limited to: temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base early on areas to be paved, and dust control.
- Control stormwater volume and velocity within the site to minimize soil erosion.
- Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.

- Soils must not remain exposed and unworked for more than the time periods set forth below to prevent erosion:
 - During the dry season (May 1 - Sept. 30): 7 days
 - During the wet season (October 1 - April 30): 2 days
- Stabilize soils at the end of the shift before a holiday or weekend if needed based on the weather forecast.
- Stabilize soil stockpiles from erosion, protected with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways and drainage channels.
- Minimize the amount of soil exposed during construction activity.
- Minimize the disturbance of steep slopes.
- Minimize soil compaction and, unless infeasible, preserve topsoil.

Element 6: Protect Slopes

- Design and construct cut-and-fill slopes in a manner to minimize erosion. Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, reducing slope steepness, and roughening slope surfaces (for example, track walking).
- Divert off-site stormwater (run-on) or ground water away from slopes and disturbed areas with interceptor dikes, pipes and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.
- At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion.
 - Temporary pipe slope drains must handle the peak 10-minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year and 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must 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 must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.
- Place excavated material on the uphill side of trenches, consistent with safety and space considerations.

- Place check dams at regular intervals within constructed channels that are cut down a slope.

Element 7: Protect Drain Inlets

- Protect all storm drain inlets made operable during construction so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment.
- Clean or remove and replace inlet protection devices when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

Element 8: Stabilize Channels and Outlets

- Design, construct, and stabilize all on-site conveyance channels to prevent erosion from the following expected peak flows:
 - Channels must handle the peak 10-minute velocity of flow from a Type 1A, 10- year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must 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 must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped area.
- Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent stream banks, slopes and downstream reaches at the outlets of all conveyance systems.

Element 9: Control Pollutants

- Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants.
- Handle and dispose of all pollutants, including waste materials and demolition debris that occur on-site in a manner that does not cause contamination of stormwater.
- Provide cover, containment, and protection from vandalism 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 must include secondary containment. Secondary containment means placing tanks or containers within an impervious structure capable of containing

110% of the volume contained in the largest tank within the containment structure. Double-walled tanks do not require additional secondary containment.

- Conduct maintenance, fueling, and repair of heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as closed-loop recirculation or upland application, or to the sanitary sewer, with local sewer district approval.
- Apply fertilizers and pesticides in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Follow manufacturers' label requirements for application rates and procedures.
- Use BMPs to prevent contamination of stormwater runoff by pH modifying sources. The sources for this contamination include, but are not limited to: bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, concrete pumping and mixer washout waters.
- Adjust the pH of stormwater if necessary to prevent violations of water quality standards.
- Assure that washout of concrete trucks is performed off-site or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams. Do not dump excess concrete on-site, except in designated concrete washout areas. Concrete spillage or concrete discharge to surface waters of the State is prohibited.
- Obtain written approval from Ecology before using chemical treatment other than CO₂ or dry ice to adjust pH.

Element 10: Control De-Watering

- Discharge foundation, vault, and trench de-watering water, which has similar characteristics to stormwater runoff at the site, into a controlled conveyance system before discharge to a sediment trap or sediment pond.
- Discharge clean, non-turbid de-watering water, such as well-point ground water, to systems tributary to, or directly into surface waters of the State, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters. Do not route clean dewatering water through stormwater

sediment ponds. Note that “surface waters of the State” may exist on a construction site as well as off site; for example, a creek running through a site.

- Handle highly turbid or otherwise contaminated dewatering water separately from stormwater.
- Other treatment or disposal options may include:
 1. Infiltration.
 2. Transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.
 3. Ecology-approved on-site chemical treatment or other suitable treatment technologies.
 4. Sanitary or combined sewer discharge with local sewer district approval, if there is no other option.
 - 4-5. Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Element 11: Maintain BMPs ~~be inspected, maintained, and repaired~~

- Maintain and repair all temporary and permanent erosion and sediment control BMPs as needed to assure continued performance of their intended function, in accordance with BMP specifications.
- Remove all temporary erosion and sediment control BMPs within 30 days after achieving final site stabilization or after the temporary BMPs are no longer needed.

Element 12: Manage The Project

- Phase development projects to the maximum degree practicable and take into account seasonal work limitations.
 - Inspection and monitoring – Inspect, maintain and repair all BMPs as needed to assure continued performance of their intended function. Projects regulated under the Construction Stormwater General Permit must conduct site inspections ~~shall be~~ and monitoring in accordance with Special Condition S4 of the Construction Stormwater General Permit.
 - Maintaining an updated construction SWPPP – Maintain, update, and implement the SWPPP.
 - Projects that disturb one or more acres must have site inspections conducted by a Certified Erosion and Sediment Control Lead (CESCL). Project sites disturbing less than one acre may have a CESCL or a person without CESCL certification conduct inspections. By the initiation of construction, the SWPPP must identify the CESCL or inspector, who is knowledgeable in the principles and practices of erosion and sediment control. ~~The person must be present on-site or on-call at all times.~~
 - The CESCL or inspector (project sites less than one acre) must have the skills to ~~1)~~ assess the:
 - Site conditions and construction activities that could impact the quality of stormwater, ~~and 2) assess.~~
 - Effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.
 - The CESCL or inspector must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen. They must evaluate the effectiveness of ~~erosion and sediment control measures used to control~~ BMPs and determine if it is necessary to install, maintain, or repair BMPs to improve the quality of stormwater discharges.
- ~~For~~ Based on the results of the inspection, construction site operators must correct the problems identified by:
- Reviewing the SWPPP for compliance with the 13 construction SWPPP elements and making appropriate revisions within 7 days of the inspection.
 - Immediately beginning the process of fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible, addressing the problems not later than within 10 days of the inspection. If installation of necessary treatment BMPs

is not feasible within 10 days, the construction site operator may request an extension within the initial 10-day response period.

- Documenting BMP implementation and maintenance in the site log book (sites ~~one acre or larger~~ **that discharge** than 1 acre).
- The CESCL or inspector must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at least once every calendar week and within 24 hours of any discharge from the site. (For purposes of this condition, individual discharge events that last more than one day do not require daily inspections. For example, if a stormwater pond discharges continuously over the course of a week, only one inspection is required that week.) The CESCL or inspector may reduce the inspection frequency for temporary stabilized, inactive sites to **surface waters of the state, a Certified Erosion and Sediment Control Specialist shall be identified in the Construction SWPPP and shall be on-site or on-call at all times. Certification may be obtained** once every calendar month.

Element 13: Protect Low Impact Development BMPs

- **Protect all Bioretention and Rain Garden BMPs from sedimentation through an approved training program that meets the installation and maintenance of erosion and sediment control training standards established by Ecology. BMPs on portions of the site that drain into the Bioretention and/or Rain Garden BMPs. Restore the BMPs to their fully functioning condition if they accumulate sediment during construction. Restoring the BMP must include removal of sediment and any sediment-laden Bioretention/rain garden soils, and replacing the removed soils with soils meeting the design specification.**
—Whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of or potential to discharge a significant amount of any pollutant, appropriate BMPs or design changes shall be implemented as soon as possible.
- **Maintaining an Updated Construction SWPPP—The Construction SWPPP shall be retained on-site or within reasonable access to the site.**
—The SWPPP shall be modified whenever there is a significant change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.
—The SWPPP shall be modified, if during inspections or investigations conducted by the owner/operator, or the applicable

~~local or state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. The SWPPP shall be modified as necessary to include additional or modified BMPs designed to correct problems identified. Revisions to the SWPPP shall be completed within seven (7) calendar days following the inspection.~~

- Prevent compacting Bioretention and rain garden BMPs by excluding construction equipment and foot traffic. Protect completed lawn and landscaped areas from compaction due to construction equipment.
- Control erosion and avoid introducing sediment from surrounding land uses onto permeable pavements. Do not allow muddy construction equipment on the base material or pavement. Do not allow sediment-laden runoff onto permeable pavements or base materials.
- Pavement fouled with sediments or no longer passing an initial infiltration test must be cleaned using procedures in accordance with this manual or the manufacturer's procedures.
- Keep all heavy equipment off existing soils under LID facilities that have been excavated to final grade to retain the infiltration rate of the soils.

Objective

To control erosion and prevent sediment and other pollutants from leaving the site during the construction phase of a project. To have fully functional stormwater facilities and BMP's for the developed site upon completion of construction.

Supplemental Guidelines

If a Construction SWPPP is found to be inadequate (with respect to erosion and sediment control requirements), then the Plan Approval Authority¹ within the Local Government should require that other BMPs be implemented, as appropriate.

The Plan Approval Authority may allow development of generic Construction SWPPP's that apply to commonly conducted public road activities, such as road surface replacement, that trigger this minimum requirement. They may also develop an abbreviated SWPPP format for project sites that will disturb less than 1 acre.

Based on the information provided and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. The local permitting authority shall take enforcement action - such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:

- If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or
- If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

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 Construction SWPPP.

Element #13, Protect Low Impact Development BMPs, is not yet included as a permit condition in the NPDES Construction Stormwater General Permit. That permit is not scheduled for reissuance until December, 2015. Until that permit is reissued with element #13 added as a permit condition, the element may be enforceable only through the requirements of local stormwater codes that may have been updated to include it. Municipal Stormwater Permittees must incorporate this element into local requirements per the timelines in their Municipal Stormwater Permit.

¹ The Plan Approval Authority is defined as that department within a local government that has been delegated authority to approve stormwater site plans.

2.5.3 Minimum Requirement #3: Source Control of Pollution

All known, available and reasonable source control BMPs ~~shall~~**must** be applied to all projects. Source control BMPs ~~shall~~**must** be selected, designed, and maintained according to this manual.

Objective

The ~~intention~~**intent** of source control BMPs is to prevent stormwater from coming in contact with pollutants. They are a cost-effective means of reducing pollutants in stormwater, and, therefore, should be a first consideration in all projects.

Supplemental Guidelines

An adopted and implemented basin plan (~~Minimum Requirement #9~~) or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) may be used to develop more stringent source control requirements that are tailored to a specific basin.

Source Control BMPs include Operational BMPs and Structural Source Control BMPs. See Volume IV for design details of these BMPs. For construction sites, see Volume II, Chapter 4.

Structural source control BMPs should be identified in the stormwater site plan and should be shown on ~~site~~**all applicable** plans submitted for local government review **and approval**.

2.5.4 Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls

Natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable. The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters and downgradient properties. All outfalls require energy dissipation.

Objective

To preserve and utilize natural drainage systems to the fullest extent because of the multiple stormwater benefits these systems provide; and to prevent erosion at and downstream of the discharge location.

Supplemental Guidelines

Creating new drainage patterns results in more site disturbance and more potential for erosion and sedimentation during and after construction. Creating new discharge points can create significant stream channel erosion problems as the receiving water body typically must adjust to the new flows. Diversions can cause greater impacts than would otherwise occur by discharging runoff at the natural location.

Where no conveyance system exists at the adjacent downgradient property line and the discharge was previously unconcentrated flow or significantly lower concentrated flow, then measures must be taken to prevent downgradient impacts. Drainage easements from downstream property owners may be needed and should be obtained prior to approval of engineering plans.

The following discharge requirement is recommended:

Where no conveyance system exists at the abutting downstream property line and the natural (existing) discharge is unconcentrated, any runoff concentrated by the proposed project must be discharged as follows:

- a) If the 100-year peak discharge is less than or equal to 0.2 cfs (0.3 cfs using 15 minute time steps) under existing conditions and will remain less than or equal to 0.2 cfs under developed conditions, then the concentrated runoff may be discharged onto a rock pad or to any other system that serves to disperse flows.
- b) If the 100-year peak discharge is less than or equal to 0.5 cfs (0.75 cfs using 15 minute time steps) under existing conditions and will remain less than or equal to 0.5 cfs under developed conditions, then the concentrated runoff may be discharged through a dispersal trench or other dispersal system, provided the applicant can demonstrate that there will be no significant adverse impact to downhill properties or drainage systems.
- c) If the 100-year peak discharge is greater than 0.5 cfs for either existing or developed conditions, or if a significant adverse impact to downgradient properties or drainage systems is likely, then a conveyance system must be provided to convey the concentrated runoff across the downstream properties to an acceptable discharge point (i.e., an enclosed drainage system or open drainage feature where concentrated runoff can be discharged without significant adverse impact).

Stormwater control or treatment structures should not be located within the expected 25-year water level elevations for salmonid-bearing waters. Such areas may provide off-channel habitat for juvenile salmonids and salmonid fry. Designs for outfall systems to protect against adverse impacts from concentrated runoff are included in Volume V, Chapter 4.

2.5.5 Minimum Requirement #5: On-site Stormwater Management

Projects shall employ On-site Stormwater Management BMPs in accordance with the following projects thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff onsite ~~on-site~~ to the ~~maximum~~ extent feasible without causing flooding or erosion impacts.

Projects qualifying as flow control exempt in accordance with Section 2.5.7–Roof Downspout Control BMPs, functionally equivalent of this chapter do not have to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List #1 or List #2. However, those projects must implement BMP T5.13; BMPs T5.10A, B, or C; and BMP T5.11 or T5.12, if feasible.

Project Thresholds

Projects triggering only Minimum Requirements #1 through #5 shall either:

- a. Use On-site Stormwater Management BMPs from List #1 for all surfaces within each type of surface in List #1; or
- b. Demonstrate compliance with the LID Performance Standard. Projects selecting this option cannot use Rain Gardens. They may choose to use Bioretention BMPs as described in Chapter 7 of Volume V to achieve the LID Performance Standard.

Projects triggering Minimum Requirements #1 through #9, must meet the requirements in Table 2.5.1.

<u>Table 2.5.1 On-site Stormwater Management Requirements for Projects Triggering Minimum Requirements #1 - #9</u>	
<u>Project Type and Location</u>	<u>Requirement</u>
<u>New development on any parcel inside the UGA, or new development outside the UGA on a parcel less than 5 acres</u>	<u>Low Impact Development Performance Standard and BMP T5.13; or List #2 (applicant option).</u>
<u>New development outside the UGA on a parcel of 5 acres or larger</u>	<u>Low Impact Development Performance Standard and BMP T5.13.</u>
<u>Redevelopment on any parcel inside the UGA, or redevelopment outside the UGA on a parcel less than 5 acres</u>	<u>Low Impact Development Performance Standard and BMP T5.13; or List #2 (applicant option).</u>
<u>Redevelopment outside the UGA on a parcel of 5 acres or larger</u>	<u>Low Impact Development Performance Standard and BMP T5.13.</u>

NOTE: This table refers to the Urban Growth Area (UGA) as designated under the Growth Management Act (GMA) (Chapter 36.70A RCW~~3 of Volume III, and~~ and Dispersion and Soil Quality BMPs, functionally equivalent to those in Chapter 5 of Volume V), of the State of Washington. If the Permittee is located in a county that is not subject to planning under the GMA, the city limits shall be required to reduce the hydrologic disruption of used instead.

I

Low Impact Development Performance Standard

Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. Refer to the Standard Flow Control Requirement section in Minimum Requirement #7 for information about the assignment of the pre-developed condition. Project sites that must also meet minimum requirement #7 – flow control - must match flow durations between 8% of the 2-year flow through the full 50-year flow.

List #1: On-site Stormwater Management BMPs for Projects Triggering Minimum Requirements #1 through #5

For each surface, consider the BMP's in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. Feasibility shall be determined by evaluation against:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and
2. Competing Needs Criteria listed in Chapter 5 of Volume V of this manual.

Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth in accordance with BMP T5.13 in Chapter 5 of Volume V

Roofs:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V, or Downspout Full Infiltration Systems in accordance with BMP T5.10A in Section 3.1.1 in Chapter 3 of Volume III
2. Rain Gardens in accordance with BMP T5.14 in Chapter 5 of Volume V, or Bioretention in accordance with Chapter 7 of Volume V. The rain garden or bioretention facility must have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it.
3. Downspout Dispersion Systems in accordance with BMP T5.10B in Section 3.1.2 in Chapter 3 of Volume III
4. Perforated Stub-out Connections in accordance with BMP T5.10C in Section 3.1.3 in Chapter 3 of Volume III

Other Hard Surfaces:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V

2. Permeable pavement¹ in accordance with BMP T5.15 in Chapter 5 of Volume V, or Rain Gardens in accordance with BMP T5.14 in Chapter 5 of Volume V, or Bioretention in accordance with Chapter 7 of Volume V. The rain garden or bioretention facility must have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it.
3. Sheet Flow Dispersion in accordance with BMP T5.12, or Concentrated Flow Dispersion in accordance with BMP T5.11 in Chapter 5 of Volume V.

List #2: On-site Stormwater Management BMPs for Projects Triggering Minimum Requirements #1 through #9

For each surface, consider the BMPs in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. Feasibility shall be determined by evaluation against:

1. Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and
2. Competing Needs Criteria listed in Chapter 5 of Volume V of this manual.

Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth in accordance with BMP T5.13 in Chapter 5 of Volume V.

Roofs:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V, or Downspout Full Infiltration Systems in accordance with BMP T5.10A in Section 3.1.1 in Chapter 3 of Volume III
2. Bioretention (See Chapter 7 of Volume V) facilities that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.
3. Downspout Dispersion Systems in accordance with BMP T5.10B in Section 3.1.2 in Chapter 3 of Volume III
4. Perforated Stub-out Connections in accordance with BMP T5.10C in Section 3.1.3 in Chapter 3 of Volume III

Other Hard Surfaces:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V

¹ This is not a requirement to pave these surfaces. Where pavement is proposed, it must be permeable to the extent feasible unless full dispersion is employed.

2. Permeable pavement¹ in accordance with BMP T5.15 in chapter 5 of Volume V

3. Bioretention BMP's (See Chapter 7, Volume V of the SMMWW) that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

1-4. Sheet Flow Dispersion in accordance with BMP T5.12, or Concentrated Flow Dispersion in accordance with BMP T5.11 in Chapter 5 of Volume V.

Objective

To use ~~inexpensive~~ practices ~~on individual properties to~~ distributed ~~across a development that~~ reduce the amount of disruption of the natural hydrologic characteristics of the site.

Supplemental Guidelines

"Flooding ~~and/or~~ erosion impacts" include ~~impacts such as~~ flooding of septic systems, crawl spaces, living areas, outbuildings, etc.; increased ice or algal growth on sidewalks/roadways; earth movement/settlement ; ~~increased landslide potential~~; erosion and other potential damage.

Recent research indicates that ~~current~~ traditional development techniques in residential, commercial, and industrial land development cause gross disruption of the natural hydrologic cycle with severe impacts to water and water-related natural resources. Based upon gross level applications of continuous runoff modeling and assumptions concerning minimum flows needed to maintain beneficial uses, watersheds must retain the majority of their natural vegetation cover and soils, and developments must ~~meet the Flow Control Minimum Requirement of this chapter, minimize their disruption of the natural hydrologic cycle~~ in order to avoid significant natural resource degradation in lowland streams.

The ~~Roof Downspout Control~~ BMPs described in Section 3.1 of Volume III, and ~~the Dispersion and Soil Quality BMPs in~~ Section 5.3.1 of Volume V are likely insufficient by themselves to prevent significant hydrologic disruptions and impacts to streams and their natural resources. Therefore, local governments should look for opportunities to ~~encourage and require~~ additional BMPs such as those in Appendix C in Volume III and ~~Section 5.3.1 of Volume V through updates to change~~ their site/local development standards, ~~critical codes~~ to minimize impervious surfaces and retain native vegetation in all development situations. Most importantly, to maintain the beneficial uses of our lowland freshwater systems will require land use planning that targets retention of a majority of a creek's watershed in its natural condition, and retains most of the benefits of headwater areas ordinances, and land use plans, connected wetlands, riparian, and floodplain areas.

2.5.6 Minimum Requirement #6: Runoff Treatment

Thresholds

When assessing a project against the following thresholds, only consider those hard and pervious surfaces that are subject to this minimum requirement as determined in Section 2.4 of this chapter.

The following require construction of stormwater treatment facilities (see Table 2.1):

- Projects in which the total of ~~effective~~, pollution-generating ~~impervious~~ hard surface (PGISPGHS) is 5,000 square feet or more in a threshold discharge area of the project, or
- Projects in which the total of pollution-generating pervious surfaces (PGPS) – not including permeable pavements – is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there ~~is~~ will be a surface discharge in a natural or man-made conveyance system from the site.

PGPS = pollution-generating pervious surfaces
PGIS = pollution-generating impervious surfaces
-sf = square feet

Treatment Facility Sizing

Size stormwater treatment facilities for the entire area that drains to them, even if some of those areas are not pollution-generating, or were not included in the project site threshold decisions (Section 2.4 of this chapter) or the treatment threshold decisions of this minimum requirement.

Water Quality Design Storm Volume:

- The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm. Alternatively, ~~the 91st percentile, 24-hour runoff volume indicated by~~ when using an approved continuous runoff model ~~may, the water quality design storm volume shall be used equal to the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record.~~

Water Quality Design Flow Rate:

- Preceding Detention Facilities or when Detention Facilities are not required: The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated. Design criteria for treatment facilities are assigned

to achieve the applicable performance goal (e.g., 80% TSS removal) at the water quality design flow rate (e.g., 80% TSS removal). At a minimum, 91% of the total runoff volume, as estimated by an approved continuous runoff model, must pass through the treatment facility(ies) at or below the approved hydraulic loading rate for the facility(ies).

- **Downstream of Detention Facilities:** The water quality design flow rate must be the full 2-year release rate from the detention facility.

~~Alternative methods can be used if they identify volumes and flow rates that are at least equivalent.~~

~~That portion of any development project in which the above PGIS or PGPS thresholds are not exceeded in a threshold discharge area shall apply On-site Stormwater Management BMPs in accordance with Minimum Requirement #5.~~

Treatment Facility Selection, Design, and Maintenance

Stormwater treatment facilities shall be:

- Selected in accordance with the process identified in [Chapter 4](#) of Volume I, and Chapter 2 of Volume V,
- Designed in accordance with the design criteria in Volume V, and
- Maintained in accordance with the maintenance schedule in Volume V.

Additional Requirements

Direct discharge of untreated stormwater from pollution-generating ~~impervious~~hard surfaces to ground water is prohibited, except for the discharge achieved by infiltration or dispersion of runoff ~~from residential sites~~ through use of On-site Stormwater Management BMPs, in accordance with Chapter 5, Volume V and Chapter 7, Volume V; or by infiltration through soils meeting the soil suitability criteria in Chapter 3 of Volume III.

Objective

The purpose of runoff treatment is to reduce pollutant loads and concentrations in stormwater runoff using physical, biological, and chemical removal mechanisms so that beneficial uses of receiving waters are maintained and, where applicable, restored. When site conditions are appropriate, infiltration can potentially be the most effective BMP for runoff treatment.

Supplemental Guidelines

See Volume V for more detailed guidance on selection, design, and maintenance of treatment facilities. The water quality design storm

volume and flow rates are intended to capture and effectively treat about 90-95% of the annual runoff volume in western Washington. See [Appendix I-B](#) ~~Appendix I-B~~ for background on their derivation.

Volume V includes performance goals for Basic, Enhanced, Phosphorus, and Oil Control treatment, and a menu of facility options for each treatment type. Treatment facilities that are selected from the appropriate menu and designed in accordance with their design criteria are presumed to meet the applicable performance goals.

An adopted and implemented basin plan (~~Minimum Requirement #9~~), or a Total Maximum Daily Load (TMDL - also known as a Water Clean-up Plan) may be used to develop runoff treatment requirements that are tailored to a specific basin. However, treatment requirements shall not be less than that achieved by facilities in the Basic Treatment Menu (see Volume V, Chapter 3).

Treatment facilities applied consistent with this manual are presumed to meet the requirement of state law to provide all known available and reasonable methods of treatment ([RCW 90.52.040](#), [RCW 90.48.010](#) ~~(RCW 90.52.040, RCW 90.48.010)~~). This technology-based treatment requirement does not excuse any discharge from the obligation to apply whatever technology is necessary to comply with state water quality standards, [Chapter 173-201A WAC](#) ~~Chapter 173-201A WAC~~; state ground water quality standards, [Chapter 173-200 WAC](#) ~~Chapter 173-200 WAC~~; state sediment management standards, [Chapter 173-204 WAC](#) ~~Chapter 173-204 WAC~~; and the underground injection control program, [Chapter 173-218 WAC](#) ~~Chapter 173-218 WAC~~. Additional treatment to meet those standards may be required by federal, state, or local governments.

Infiltration through use of On-site Stormwater Management BMPs can provide both treatment of stormwater, through the ability of certain soils to remove pollutants, and volume control of stormwater, by decreasing the amount of water that runs off to surface water. Infiltration through engineered treatment facilities that utilize the natural soil profile can also be very effective at treating stormwater runoff, but pretreatment must be applied and soil conditions must be appropriate to achieve effective treatment while not impacting ground water resources. See Chapter 6 of Volume V for [pretreatment](#) design details.

Discharge of pollution-generating surfaces into a dry well, after pretreatment for solids reduction, can be acceptable if the soil conditions provide sufficient treatment capacity. Dry wells into gravelly soils are not likely to have sufficient treatment capability. They must be preceded by at least a basic treatment BMP. See Volume V, Chapters 2 and 7 for details.

Impervious surfaces that are “fully dispersed” in accordance with BMP T5.30 in Volume V are not considered effective impervious surfaces. ~~PGIS~~ [Impervious](#) surfaces that are “dispersed” in accordance with ~~the~~ BMPs

T5.10B, T5.11, and T5.12 in Section 5.3.1 of Volume V are still considered effective ~~impervious~~ surfaces. ~~Porous pavers and Modular grid pavements are assigned though they may be modeled as pervious surfaces if flow path lengths meet the specified minima. See Volume III, Appendix III-C for a lower curve number (if using single event hydrology to size wetpools) and lower surface runoff calibrations (if more complete description of hydrologic representation of On-site Stormwater Management BMPs. ——— using continuous runoff modeling). See Volume III for a more complete description of hydrologic credits for Onsite Stormwater Management BMPs.~~

2.5.7 Minimum Requirement #7: Flow Control

Applicability

Projects must provide flow control to reduce the impacts of stormwater runoff from ~~impervious~~hard surfaces and land cover conversions. The requirement below applies to projects that discharge stormwater directly, or indirectly through a conveyance system, into a fresh ~~water—except~~waterbody.

Flow Control is not required for projects that discharge directly to, or indirectly to a water listed in Appendix I-E. ~~Appendix I-E - Flow Control-Exempt Receiving Waters in accordance with~~subject to the following restrictions:

- Direct discharge to the exempt receiving water does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types “S”, “F”, or “Np” in the Permanent Water Typing System, or from any category I, II, or III wetland; and
- Flow splitting devices or drainage BMP’s are applied to route natural runoff volumes from the project site to any downstream Type 5 stream or category IV wetland:
 - Design of flow splitting devices or drainage BMP’s will be based on continuous hydrologic modeling analysis. The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
 - Flow splitting devices or drainage BMP’s that deliver flow to category IV wetlands will also be designed using continuous hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction; and

- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection, etc.) and extends to the ordinary high water line of the exempt receiving water; and
- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

If the discharge is to a stream that leads to a wetland, or to a wetland that has an outflow to a stream, both this requirement and Minimum Requirement #8 apply.

Local governments may petition Ecology to exempt projects in additional areas. A petition must justify the proposed exemption based upon a hydrologic analysis that demonstrates that the potential stormwater runoff from the exempted area will not significantly increase the erosion forces on the stream channel nor have near field impacts.

Thresholds

When assessing a project against the following thresholds, consider only those impervious, hard, and pervious surfaces that are subject to this minimum requirement as determined in Section 2.4 of this chapter.

The following circumstances require construction of flow control facilities and/or land use management BMPs that will achieve achievement of the standard flow control requirement for western Washington (see Table 2.2):

- Projects in which the total of effective impervious surfaces is 10,000 square feet or more in a threshold discharge area, or
- Projects that convert $\frac{3}{4}$ acres or more of ~~native~~ vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site, or
- Projects that through a combination of effective ~~impervious~~hard surfaces and converted ~~pervious surfaces~~vegetation areas cause a 0.110 cubic feet per second increase in the 100-year flow frequency from a threshold discharge area as estimated using the Western Washington Hydrology Model or other approved model ~~and one-~~

hour time steps (or a 0.15 cfs increase using 15-minute time steps).
2

~~That portion of any development project in which the above thresholds are not exceeded in a threshold discharge area shall apply Onsite Stormwater Management BMPs in accordance with Minimum Requirement #5.~~

Standard Flow Control Requirement

The following requirement applies to the ~~geographic areas west of the Cascades, including all of~~ the following counties:

Clallam	Jefferson	Pacific	Snohomish
Clark	King	Pierce	Thurston
Cowlitz	Kitsap	San Juan	Wahkiakum
Grays Harbor	Lewis	Skagit	Whatcom
Island	Mason	Skamania	

Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. The pre-developed condition to be matched shall be a forested land cover unless:

- ~~1)~~ Reasonable, historic information is provided that indicates the site was prairie prior to settlement (modeled as “pasture” in the Western Washington Hydrology Model); or,
- ~~2)~~ The drainage area of the immediate stream and all subsequent downstream basins have had at least 40% total impervious area since 1985. In this case, the pre-developed condition to be matched shall be the existing land cover condition. The map in Appendix I-F depicts those areas which meet this criterion. Where basin-specific studies determine a stream channel to be unstable, even though the above criterion is met, the pre-developed condition assumption shall be the “historic” land cover condition, or a land

² The 0.10 cfs (one-hour time steps) or 0.15 cfs (15-minute time steps) increase should be a comparison of the post-project runoff to the existing condition runoff. For the purpose of applying this threshold, the existing condition is either the pre-project land cover, or the land cover that existed at the site as of a date when the local jurisdiction first adopted flow control requirements into code or rules.

cover condition commensurate with achieving a target flow regime identified by an approved basin study.

This standard requirement is waived for sites that will reliably infiltrate all the runoff from ~~impervious~~hard surfaces and converted ~~pervious surfaces~~vegetation areas.

Western Washington Alternative Requirement

An alternative requirement may be established through application of watershed-scale hydrological modeling and supporting field observations. Possible reasons for an alternative flow control requirement include:

- Establishment of a stream-specific threshold of significant bedload movement other than the assumed 50% of the 2-year peak flow;
- Zoning and Land Clearing Ordinance restrictions that, in combination with an alternative flow control standard, maintain or reduce the naturally occurring erosive forces on the stream channel; or
- A duration control standard is not necessary for protection, maintenance, or restoration of designated and existing beneficial uses or Clean Water Act compliance.

Additional Requirement

Flow Control BMPs shall be selected, designed, and maintained according to Volume III or a local government manual deemed equivalent to this manual.

Objective

To prevent increases in the stream channel erosion rates that are characteristic of natural conditions (i.e., prior to disturbance by European settlement). The standard intends to maintain the total amount of time that a receiving stream exceeds an erosion-causing threshold based upon historic rainfall and natural land cover conditions. That threshold is assumed to be 50% of the 2-year peak flow. Maintaining the naturally occurring erosion rates within streams is vital, though by itself insufficient, to protect fish habitat and production.

Supplemental Guidelines

Reduction of flows through infiltration decreases stream channel erosion and helps to maintain base flow throughout the summer months. However, infiltration should ~~only be used where~~follow the guidance in this manual to reduce the chance that ground water quality is ~~not~~ threatened by such discharges.

Volume III includes a description of the Western Washington Hydrology Model. The model provides ~~credits for use of certain~~ Onsite ways to

~~represent On-site~~ Stormwater Management BMPs described in ~~Volume V, Volumes III and other low impact development techniques described in Appendix C of Volume III-V.~~ Using those BMPs ~~reduces the predicted runoff rates and LID techniques~~ volumes and thus also reduces the size of the required flow control facilities.

Application of sufficient types of ~~Onsite~~ On-site Stormwater Management BMPs can result in reducing the effective impervious area and the converted ~~pervious~~ vegetation areas such that a flow control facility is not required. Application of “Full Dispersion”, BMP T5.30, also results in eliminating the flow control facility requirement for those areas that are “fully dispersed.”

See the ~~supplemental~~ guidelines in Appendix I-D for Minimum Requirement #8, and directions concerning use of the Western Washington Hydrology Model for information about ~~tracking~~ the approach for protecting wetland hydrologic conditions.

Diversions of flow from perennial streams and from wetlands can be considered if significant existing (i.e., pre-project) flooding, stream stability, water quality, or aquatic habitat problems would be solved or significantly mitigated by bypassing stormwater runoff rather than providing stormwater detention and discharge to natural drainage features. Bypassing should not be considered as an alternative to applicable flow control or treatment if the flooding, stream stability, water quality or habitat problem to be solved would be caused by the project. In addition, the proposal should not exacerbate other water quality/quantity problems such as inadequate low flows or inadequate wetland water elevations. The existing problems and their solution or mitigation as a result of the direct discharge should be documented by a stormwater engineer or scientist after review of any available drainage reports, basin plans, or other relevant literature. The restrictions in this minimum requirement on conveyance systems that transfer water to an exempt receiving water are applicable in these situations. Approvals by all regulatory authorities with relevant permits applicable to the project are necessary.

~~———In regard to implementation of the revised flow control requirement for highly urbanized basins, the Dept. of Ecology hopes to publish a listing of total impervious area for basins in western Washington. Lists will be developed from satellite images taken in 1990, 1995, and 2000. Images from 2005 may be available for TIA evaluation in 2006. Local governments will have to use historical records to estimate TIA for basins in 1985. Local governments can use these information sources to identify basins that meet the 40% TIA/20 year criterion.~~

~~The Dept. of Ecology hopes to publish guidance concerning basin studies to develop basin-specific flow control strategies intended to stabilize stream channels and provide flows intended to protect and restore beneficial uses such as fish resources. —Until such guidance is published,~~

~~the reader can review procedures used in the Des Moines Creek basin plan.~~ The recommendations made in basin plans should be consistent with the requirements and intent of the federal Clean Water Act, the State Water Pollution Control Act, and any other applicable natural resources statutes, such as the Federal Endangered Species Act.

2.5.8 Minimum Requirement #8: Wetlands Protection

Applicability

The requirements below apply only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system. ~~These requirements must be met in addition to meeting Minimum Requirement #6, Runoff Treatment.~~

Thresholds

The thresholds identified in Minimum Requirement #6 – Runoff Treatment, and Minimum Requirement #7 – Flow Control shall also be applied ~~for to determine the applicability of this requirement to~~ discharges to wetlands.

Standard Requirement

~~Discharges to wetlands shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses. Projects shall comply with Guide Sheets #1 through #3 in Appendix I-D.~~ The hydrologic analysis shall use the existing land cover condition to determine the existing hydrologic conditions unless directed otherwise by a regulatory agency with jurisdiction. ~~A wetland can be considered for hydrologic modification and/or stormwater treatment in accordance with Guide Sheet 1B in Appendix I-D.~~

Additional Requirements

~~The standard requirement does not excuse any discharge from the obligation to apply whatever technology is necessary to comply with state water quality standards, Chapter 173-201A WAC, or state ground water standards, Chapter 173-200 WAC. Additional treatment requirements to meet those standards may be required by federal, state, or local governments.~~

Stormwater treatment and flow control facilities shall not be built within a natural vegetated buffer, except for:

- Necessary conveyance systems as approved by the local government; or
- As allowed in wetlands approved for hydrologic modification and/or treatment in accordance with Guide Sheet 2 in Appendix I-D ~~Guidesheet 1B.~~

An adopted and implemented basin plan (~~Minimum Requirement #9~~), or a Total Maximum Daily Load (TMDL, also known as a Water Clean-up Plan) may be used to develop requirements for wetlands that are tailored to a specific basin.

Objective

To ensure that wetlands receive the same level of protection as any other waters of the state. Wetlands are extremely important natural resources which provide multiple stormwater benefits, including ground water recharge, flood control, and stream channel erosion protection. They are easily impacted by development unless careful planning and management are conducted. Wetlands can be severely degraded by stormwater discharges from urban development due to pollutants in the runoff and also due to disruption of natural hydrologic functioning of the wetland system. Changes in water levels and the frequency and duration of inundations are of particular concern.

Supplemental Guidelines

[Appendix I-D Guidelines for Wetlands when Managing](#)

[Stormwater](#) Appendix I-D, "Wetlands and Stormwater Management Guidelines" is an amended version of Chapter 14 of the publication, "Wetlands and Urbanization, Implications for the Future", the final report of the Puget Sound Wetland and Stormwater Management Research Program, 1997. It ~~should~~ shall be used for discharges to natural wetlands and wetlands constructed as mitigation. ~~The amendments were added to Guidesheets 1A, 2B, and 2C to improve clarity of intent and to make them compatible with the updated manual.~~ While it is always necessary to pre-treat stormwater prior to discharge to a wetland, there are limited circumstances where wetlands may be used for additional treatment and detention of stormwater. These situations are considered in Guide Sheet ~~1B2~~ of [Appendix I-D](#) ~~the guidelines.~~

Note that if selective runoff bypass is an alternative being considered to maintain the hydroperiod, the hydrologic analysis must consider the impacts of the bypassed flow. For instance, if the bypassed flow is eventually directed to a stream, the flow duration standard, Minimum Requirement #7, applies to the bypass.

2.5.9 Minimum Requirement #9: Basin/Watershed Planning

~~Projects may be subject to equivalent or more stringent minimum requirements for erosion control, source control, treatment, and operation and maintenance, and alternative requirements for flow control and wetlands hydrologic control as identified in Basin/Watershed Plans. Basin/Watershed plans shall evaluate and include, as necessary, retrofitting urban stormwater BMPs into existing development and/or redevelopment in order to achieve watershed-wide pollutant reduction and flow control goals that are~~

~~consistent with requirements of the federal Clean Water Act. Standards developed from basin plans shall not modify any of the above minimum requirements until the basin plan is formally adopted and implemented by the local governments within the basin, and approved or concurred with by Ecology.~~

~~———Objective~~

~~———To promote watershed-based planning as a means to develop and implement comprehensive, water quality protection measures. Primary objectives of basin planning are to reduce pollutant loads and hydrologic impacts to surface and ground waters in order to protect beneficial uses.~~

~~———Supplemental Guidelines~~

~~———Though Minimum Requirements #1 through #8 establish general standards for individual sites, they do not evaluate the overall pollution impacts and protection opportunities that could exist at the watershed level. In order for a basin plan to serve as a means of modifying the minimum requirements the following conditions must be met:~~

- ~~● the plan must be formally adopted by all jurisdictions with responsibilities under the plan and~~
- ~~● all ordinances or regulations called for by the plan must be in effect.~~

~~———This is what is meant by an adopted and implemented basin plan.~~

~~———Basin planning provides a mechanism by which the minimum requirements and implementing BMP's can be evaluated and refined based on an analysis of an entire watershed. Basin plans are especially well suited to develop control strategies to address impacts from future development and to correct specific problems whose sources are known or suspected. Basin plans can be effective at addressing both long-term cumulative impacts of pollutant loads and short-term acute impacts of pollutant concentrations, as well as hydrologic impacts to streams, wetlands, and ground water resources. The USGS has developed software called "GenSen" (Generation and Analysis of Model Simulation Scenarios) that can facilitate basin planning. The program is a Windows-based use of HSPF that predicts water quality and quantity changes for multiple scenarios of land use and water management within a basin.~~

~~———Examples of how Basin Planning can alter the minimum requirements of this manual are given in Appendix I-A.~~

2.5.10 Minimum Requirement #10: Operation and Maintenance

An operation and maintenance manual that is consistent with the provisions in Volume V ~~of this manual~~ shall be provided for ~~all~~ proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified. At private facilities, a copy of the operation and maintenance manual shall be retained ~~onsite~~on-site or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the operation and maintenance manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken shall be kept and be available for inspection by the local government.

Objective

To ensure that stormwater control facilities are adequately maintained and operated properly.

Supplemental Guidelines

Inadequate maintenance is a common cause of failure for stormwater control facilities. The description of each BMP in Volumes II, III, and V includes a section on maintenance. Chapter 4 of Volume V includes a schedule of maintenance standards for drainage facilities. Local governments should consider more detailed requirements for maintenance logs, such as a record of where wastes were disposed.

2.6 Optional Guidance

The following guidance is offered as recommendations to local governments. Ecology considers their use to be in the best interest of the general public and the environment but will not make their implementation a requirement for manual equivalency.

2.6.1 Optional Guidance #1: Financial Liability

Performance bonding or other appropriate financial guarantees shall be required for all projects to ensure construction of drainage facilities in compliance with these standards. In addition, a project applicant shall post a two-year financial guarantee of the satisfactory performance and maintenance of any drainage facilities that are scheduled to be assumed by the local government for operation and maintenance.

Objective

To ensure that development projects have adequate financial resources to fully implement stormwater management plan requirements and that liability is not unduly incurred by local governments.

Supplemental Guidelines

The type of financial instrument required is less important than ensuring that there are adequate funds available in the event that non-compliance occurs.

2.6.2 Optional Guidance #2: Off Site Analysis and Mitigation

Development projects that discharge stormwater ~~offsite~~off-site shall submit an ~~offsite~~off-site analysis report that assesses the potential off-site water quality, erosion, slope stability, and drainage impacts associated with the project and that proposes appropriate mitigation of those impacts. An initial qualitative analysis shall extend downstream for the entire flow path from the project site to the receiving water or up to one mile, whichever is less. If a receiving water is within one-quarter mile, the analysis shall extend within the receiving water to one-quarter mile from the project site. The analysis shall extend one-quarter mile beyond any improvements proposed as mitigation. The analysis must extend upstream to a point where any backwater effects created by the project cease. Upon review of the qualitative analysis, the local ~~administrator~~project reviewer may require that a quantitative analysis be performed.

The existing or potential impacts to be evaluated and mitigated shall include:

- Conveyance system capacity problems;
- Localized flooding;
- Upland erosion impacts, including landslide hazards;
- Stream channel erosion at the outfall location;
- Violations of surface water quality standards as identified in a Basin Plan or a TMDL (Water Clean-up Plan); or violations of ground water standards in a wellhead protection area.

Objective

To identify and evaluate ~~offsite~~off-site water quality, erosion, slope stability, and drainage impacts that may be caused or aggravated by a proposed project, and to determine measures for preventing impacts and for not aggravating existing impacts. Aggravated shall mean increasing the frequency of occurrence and/or severity of a problem.

Supplemental Guidelines

Ecology highly recommends that local governments adopt similar ~~offsite~~off-site analysis requirements. Some of the most common and potentially destructive impacts of land development are erosion of downgradient properties, localized flooding, and slope failures. These are caused by increased surface water volumes and changed runoff patterns. Because these problems frequently do not have a related water quality impact, Ecology is not listing ~~offsite~~off-site analysis as a minimum

requirement. However, taking the precautions of ~~off-site~~ off-site analysis could prevent substantial property damage and public safety risks.

Projects should be required to initially submit, with the permit application, a qualitative analysis of each downstream system leaving a site. The analysis should accomplish four tasks:

Task 1 – Define and map the study area

Submission of a site map showing property lines; a topographic map (at a minimum a USGS 1:24000 Quadrangle Topographic map) showing site boundaries, study area boundaries, downstream flowpath, and potential/existing problems.

Task 2 – Review all available information on the study area

This should include all available basin plans, ground water management area plans, drainage studies, floodplain/floodway FEMA maps, wetlands inventory maps, Critical Areas maps, stream habitat reports, salmon distribution reports, etc.

Task 3 – Field inspect the study area

The design engineer should physically inspect the existing on- and off-site drainage systems of the study area for each discharge location for existing or potential problems and drainage features. An initial inspection and investigation should include:

- Investigate problems reported or observed during the resource review
- Locate existing/potential constrictions or capacity deficiencies in the drainage system
- Identify existing/potential flooding problems
- Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation
- Identify significant destruction of aquatic habitat (e.g., siltation, stream incision)
- Collect qualitative data on features such as land use, impervious surface, topography, soils, presence of streams, wetlands
- Collect information on pipe sizes, channel characteristics, drainage structures
- Verify tributary drainage areas identified in task 1
- Contact the local government office with drainage review authority, neighboring property owners, and residents about drainage problems
- Note date and weather at time of inspection

Task 4 – Describe the drainage system, and its existing and predicted problems

For each drainage system component (e.g., pipe, culvert, bridges, outfalls, ponds, vaults) the following should be covered in the analysis: location, physical description, problems, and field observations.

All existing or potential problems (e.g., ponding water, erosion) identified in tasks 2 and 3 above should be described. The descriptions should be used to determine whether adequate mitigation can be identified, or whether more detailed quantitative analysis is necessary. The following information should be provided for each existing or potential problem:

- Magnitude of or damage caused by the problem
- General frequency and duration
- Return frequency of storm or flow when the problem occurs (may require quantitative analysis)
- Water elevation when the problem occurs
- Names and concerns of parties involved
- Current mitigation of the problem
- Possible cause of the problem
- Whether the project is likely to aggravate the problem or create a new one.

Upon review of this analysis, the local government may require mitigation measures deemed adequate for the problems, or a quantitative analysis, depending upon the presence of existing or predicted flooding, erosion, or water quality problems, and on the proposed design of the ~~onsite~~on-site drainage facilities. The analysis should repeat tasks 3 and 4 above, using quantitative field data including profiles and cross-sections.

The quantitative analysis should provide information on the severity and frequency of an existing problem or the likelihood of creating a new problem. It should evaluate proposed mitigation intended to avoid aggravation of the existing problem and to avoid creation of a new problem.

2.7 Adjustments

Adjustments to the Minimum Requirements may be granted prior to permit approval and construction. The drainage manual administrator ~~of the local government~~ may grant an adjustment provided that a written finding of fact is prepared, that addresses the following:

- The adjustment provides substantially equivalent environmental protection.
- The objectives of safety, function, environmental protection and facility maintenance, based upon sound engineering, are met.

2.8 Exceptions/Variations

Exceptions to the Minimum Requirements may be granted prior to permit approval and construction. The drainage manual ~~administrator of the local government may~~administrator may grant an exception following legal public notice of an application for an exception, legal public notice of the administrator's decision on the application, and a written finding of fact that documents the ~~following:~~administrator's decision to grant an exception.

~~There are special physical circumstances or conditions affecting The administrator may grant an exception to the property minimum requirements if such that the strict application of these provisions would deprive~~imposes a severe and unexpected economic hardship. To determine whether the application imposes a severe and unexpected economic hardship on the project applicant of all reasonable, the administrator must consider and document - with written findings of fact – the following:

- The current (pre-project) use of the parcel of land in question, site, and every effort
- How the application of the minimum requirement(s) restricts the proposed use of the site compared to find creative ways the restrictions that existed prior to meet the intent adoption of the minimum requirements has been made; and
- That the granting of the The possible remaining uses of the site if the exception were not granted; and
- The uses of the site that would have been allowed prior to the adoption of the minimum requirements; and
- A comparison of the estimated amount and percentage of value loss as a result of the minimum requirements versus the estimated amount and percentage of value loss as a result of requirements that existed prior to adoption of the minimum requirements; and
- The feasibility for the owner to alter the project to apply the minimum requirements.

In addition, any exception must meet the following criteria:

- The exception will not be detrimental increase risk to the public health and welfare, nor be injurious to other properties in the

vicinity and/or downstream, and to the quality of waters of the state; and

- **The exception is the least possible exception that could be granted to comply with the intent of the Minimum Requirements.**

Supplemental Guidelines

The adjustment and exception provisions are an important element of the plan review and enforcement programs. They are intended to maintain a necessary flexible working relationship between local officials and applicants. Plan Approval Authorities should consider these requests judiciously, keeping in mind both the need of the applicant to maximize cost-effectiveness and the need to protect off-site properties and resources from damage.

Chapter 3 - Preparation of Stormwater Site Plans

The Stormwater Site Plan is the comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics. ~~Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics.~~

The scope of the Stormwater Site Plan also varies depending on the applicability of Minimum Requirements (see [Section 2.4](#) ~~Section 2.4~~).

This chapter describes the contents of a Stormwater Site Plan and provides a general procedure for how to prepare the plan. The specific BMPs and design methods and standards to be used are contained in Volumes II-V. The content of, and the procedures for preparing a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) are covered in detail in Chapter 3 of Volume II. Guidelines for selecting [treatment, flow control, and source control](#) BMPs are given in [Chapter 4](#) ~~Chapter 4~~ of this Volume ~~, and Chapter 2 of Volume V.~~

The goal of this chapter is to provide a framework for uniformity in plan preparation. Such uniformity will promote predictability throughout the region and help secure prompt governmental review and approval. Properly drafted engineering plans and supporting documents will also facilitate the operation and maintenance of the proposed system long after its review and approval.

State law requires that engineering work be performed by or under the direction of a professional engineer licensed to practice in Washington State. Plans involving construction of treatment facilities or flow control facilities (detention ponds or infiltration basins), structural source control BMPs, or drainage conveyance systems generally involve engineering principles and should be prepared by or under the direction of a licensed engineer. Construction Stormwater Pollution Prevention Plans (SWPPPs) that involve engineering calculations must also be prepared by or under the direction of a licensed engineer.

3.1 Stormwater Site Plans: Step-By-Step

The steps involved in developing a Stormwater Site Plan are listed below.

1. [Site Analysis](#): Collect and Analyze Information on Existing Conditions
2. Prepare Preliminary Development Layout
3. Perform Off-site Analysis (at local government's option)
4. Determine Applicable Minimum Requirements

5. Prepare a Permanent Stormwater Control Plan
6. Prepare a Construction Stormwater Pollution Prevention Plan
7. Complete the Stormwater Site Plan
8. Check Compliance with All Applicable Minimum Requirements

The level of detail needed for each step depends upon the project size as explained in the individual steps. A narrative description of each of these steps follows.

3.1.1 Step 1 – **Site Analysis:** Collect and Analyze Information on Existing Conditions

~~Collect~~ Site analysis results shall be submitted as part of an Existing Conditions Summary and ~~review information on the existing site conditions, including topography, drainage patterns, soils, ground cover, presence of any critical areas, adjacent areas, existing development, existing stormwater facilities, and adjacent on- and off-site utilities. Analyze data to determine site limitations including:~~

- ~~• Areas with high potential for erosion and sediment deposition (based on soil properties, slope, etc.); and~~
- ~~• Locations of sensitive and critical areas (e.g. vegetative buffers, wetlands, steep slopes, floodplains, geologic hazard areas, streams, etc.);~~

~~Delineate these areas on the vicinity map and/or a site map that are required as part of Step 7—Completing a within the Stormwater Site Plan submittal (see Step 7—Prepare an Existing Conditions Summary that will be submitted as part of the Site Plan.).~~ Part of the information ~~collected~~ in this step should be used to help prepare the Construction Stormwater Pollution Prevention Plan. The authorized project reviewer for the local government with jurisdiction may chose to waive certain components required in this section as appropriate.

Purpose of the Site Analysis: Low impact development site design is intended to complement the predevelopment conditions on the site. However, not all sites are appropriate for a complete LID project, as site conditions determine the feasibility of using LID techniques. The development context shall be established by an initial site analysis consistent with the requirements of this section.

The initial inventory and analysis process will provide baseline information necessary to design strategies that utilize areas most appropriate to evaporate, transpire, and infiltrate stormwater, and achieve the goal of minimizing the pre- development natural hydrologic conditions on the site.

The site analysis shall include, at a minimum, the following information for projects required to meet Minimum Requirements 1 – 5:

1. A survey prepared by a registered land surveyor (or other qualified professional) showing:

- Existing public and private development, including utility infrastructure on and adjacent to the site if publicly available.
- Minor hydrologic features, including seeps, springs, closed depression areas, drainage swales.
- Major hydrologic features with a streams, wetland, and water body survey and classification report showing wetland and buffer boundaries consistent with the requirements of the jurisdiction.
Note that site visits should be conducted during winter months and after significant precipitation events to identify undocumented surface seeps or other indicators of near surface ground water.
- Flood hazard areas on or adjacent to the site, if present.
- Geologic Hazard areas and associated buffer requirements as defined by the local jurisdiction
- Aquifer and wellhead protection areas on or adjacent to the site, if present.
- Topographic features that may act as natural stormwater storage, infiltration or conveyance.

Contours for the survey are as follows:

- Up to 10 percent slopes, two-foot contours.
- Over 10 percent to less than 20 percent slopes, five-foot contours.
- Twenty percent or greater slopes, 10-foot contours.
- Elevations shall be at 25-foot intervals.

2. A soils report prepared by a professional soil scientist certified by the Soil Science Society of America (or an equivalent national program), a locally licensed on-site sewage designer, or by other suitably trained persons working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington. The report shall identify:

- a. Underlying soils on the site utilizing soil surveys, soil test pits, soil borings, or soil grain analyses (see <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm> for soil survey information).

b. The results of saturated hydraulic conductivity (K_{sat}) testing to assess infiltration capability and the feasibility of rain gardens, bioretention, and permeable pavement. Use small-scale Pilot Infiltration Tests (PIT), or other small-scale test acceptable to the local jurisdiction. Grain size analyses may substitute for infiltration tests on sites with soils unconsolidated by glacial advance.

Note: The certified soils professional or engineer can exercise discretion concerning K_{sat} testing if in their judgment information exists confirming that the site is unconsolidated outwash material (high infiltration rates) and there is adequate depth to ground water (1 foot minimum from bottom of a rain garden, bioretention, or permeable pavement installation).

c. The results of testing for an hydraulic restriction layer (ground water, soil layer with less than 0.3 in/hr K_{sat} , bedrock, etc) under possible sites for a rain garden, bioretention facility, or permeable pavement. Testing with a monitoring well or an excavated pit must extend to a depth at least 1 foot below the estimated bottom elevation of a rain garden/bioretention excavation and at least 1 foot below the subgrade surface of a permeable pavement. This analysis should be performed in the winter season (December 21 through March 21). The optimum time to test for depth to ground water is usually late winter and shortly after an extended wet period. Site historic information and evidence of high ground water in the soils can also be used.

3. If there are native soil and vegetation protection areas proposed for the site, provide a survey of existing native vegetation cover by a licensed architect, arborist, qualified biologist or project proponent identifying any forest areas on the site and a plan to protect those areas. The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.

The site analysis shall include, at a minimum, the following information for projects required to meet Minimum Requirements 1 – 9:

1. A survey prepared by a registered land surveyor or civil engineer showing:

- Existing public and private development, including utility infrastructure on and adjacent to the site if publicly available.
- Minor hydrologic features, including seeps, springs, closed depression areas, drainage swales.
- Major hydrologic features with a streams, wetland, and water body survey and classification report showing wetland and

buffer boundaries consistent with the requirements of the jurisdiction.

Note that site visits should be conducted during winter months and after significant precipitation events to identify undocumented surface seeps or other indicators of near surface ground water.

- Flood hazard areas on or adjacent to the site, if present.
- Geologic Hazard areas and associated buffer requirements as defined by the local jurisdiction
- Aquifer and wellhead protection areas on or adjacent to the site, if present.
- Topographic features that may act as natural stormwater storage, infiltration or conveyance.

Contours for the survey are as follows:

- Up to 10 percent slopes, two-foot contours.
- Over 10 percent to less than 20 percent slopes, five-foot contours.
- Twenty percent or greater slopes, 10-foot contours.
- Elevations shall be at 25-foot intervals.

2. A soils report prepared by a professional soil scientist certified by the Soil Science Society of America (or an equivalent national program), or by other suitably trained persons working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington. The report shall identify:

- a. Underlying soils on the site utilizing soil surveys, soil test pits, or soil grain analyses (see <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm> for soil survey information).

Prepare detailed logs for each test pit or soil boring and a map showing the location of the test pits or borings. Logs must include depth of pit or boring, soil descriptions, depth to water (if present), and presence of stratification. Depth should extend to 5 feet below estimated bottom elevation of bioretention facilities and road subgrade. Logs must substantiate whether stratification does or does not exist. The licensed professional may consider additional methods of analysis to substantiate the presence of stratification.

Soil stratigraphy should be assessed for low permeability layers, highly permeable sand/gravel layers, depth to ground water, and other soil structure variability necessary to assess subsurface flow patterns. Soil characterization for each soil unit (soil strata with the same texture, color, density, compaction, consolidation and permeability) should include:

- Grain size distribution
- Textural class
- Percent clay content
- Cation exchange capacity
- Color/mottling
- Variations and nature of stratification

- b. The results of saturated hydraulic conductivity (K_{sat}) testing to assess infiltration capability and the feasibility of bioretention, and permeable pavement. Use small-scale Pilot Infiltration Tests (PIT), or other small-scale test acceptable to the local jurisdiction. Grain size analyses may substitute for infiltration tests on sites with soils unconsolidated by glacial advance.

Placement of K_{sat} tests should be carefully considered to reduce cost. A few strategically placed soil test pits and saturated hydraulic conductivity test sites are generally adequate for initial site assessment and for smaller sites (e.g. less than an acre). On larger project sites, a more detailed soil assessment and additional K_{sat} testing may be necessary to direct placement of impervious surfaces such as structures away from soils that can most effectively infiltrate stormwater, and placement of permeable pavement roads, parking lots, driveways, walks, and bioretention/rain gardens over those soils. See Section 3.4 in Volume III of this manual for more details. The K_{sat} tests are also necessary as input to the runoff model to predict the benefits of LID BMPs which infiltrate.

Note: The certified soils professional or engineer can exercise discretion concerning K_{sat} testing if in their judgment information exists confirming that the site is unconsolidated outwash material (high infiltration rates) and there is adequate depth to ground water (1 foot minimum from bottom of a rain garden, bioretention, or permeable pavement installation).

- c. The results of testing for an hydraulic restriction layer (ground water, soil layer with less than 0.3 in/hr K_{sat} , bedrock, etc) under possible sites for a bioretention facility, or permeable pavement. If the general site assessment cannot confirm that the seasonal high ground water or hydraulic restricting layer is

greater than 5 feet below the bottom of the bioretention or permeable pavement (subgrade surface) monitoring wells or excavated pits should be placed strategically to assess depth to ground water. This analysis should be performed during the wet season prior to construction. Monitoring with a continuously logging censor between Dec. 21 and Mar. 21 provides the most thorough information. Monitoring for lesser time periods can be accepted but increases risk. Site historical data regarding ground water levels can be used in lieu of field testing if the data are reliable and sufficient. Also, soil evidence of historical ground water elevations may be used.

Special considerations are necessary for highly permeable gravel areas. Signs of high ground water will likely not be present in gravelly soils lacking finer grain material such as sand and silt. Test pit and monitoring wells may not show high ground water levels during low precipitation years. Accordingly, sound professional judgment, considering these factors and water quality treatment needs, is required to design multiple and dispersed infiltration facilities on sites with gravel deposits.

- d. If on-site infiltration may result in shallow lateral flow (interflow), the conveyance and possible locations where that interflow may re-emerge should be assessed by a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington. This will likely require placement of ground water monitoring wells to determine existing ground water gradients and flow. In general, a minimum of three wells associated with three hydraulically connected surface or ground water features, are needed to determine the direction of flow and gradient.
3. If there are native soil and vegetation protection areas proposed for the site, provide a survey of existing native vegetation cover by a licensed architect, arborist, or qualified biologist identifying any forest areas on the site and a plan to protect those areas. The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.

3.1.2 Step 2 – Prepare Preliminary Development Layout

Based upon the analysis of existing site conditions, locate the buildings, roads, parking lots, ~~and~~ landscaping features, on-site stormwater management BMPs, and preliminary location of stormwater treatment and retention/detention facilities for the proposed development. Consider the following points when laying out the site:

- Fit development to the terrain to minimize land disturbance; Confine construction activities to the least area necessary, and away from critical areas.
- Preserve areas with natural vegetation (especially forested areas) as much as possible.
- On sites with a mix of soil types, locate impervious areas over less permeable soil (e.g., till), and try to restrict development over more porous soils (e.g., outwash); or take advantage of them by locating bioretention/rain gardens and permeable pavement over them.
- Cluster buildings together.
- Minimize impervious areas.
- Maintain and utilize the natural drainage patterns.

The development layout designed here will be used for determining threshold discharge areas, for calculating whether size and flow rate thresholds under Minimum Requirements #6, #7, and #8 are exceeded (see Chapter 2 Chapter 2), and for the drawings and maps required for the Stormwater Site Plan.

3.1.3 Step 3 – Perform an Offsite/Off-site Analysis

The Department of Ecology (Ecology) recommends that local governments require an offsite/off-site analysis for projects that add 5,000 square feet or more of new impervious/hard surface, or that convert ¾ acres of pervious surfaces/vegetation to lawn or landscaped areas, or convert 2.5 acres of forested area to pasture.

The phased offsite/off-site analysis approach outlined in Optional Guidance #2 is recommended. This phased approach relies first on a qualitative analysis. If the qualitative analysis indicates a potential problem, the local government may require mitigation or a quantitative analysis. For more information, see Section 2.6.2 Section 2.6.2.

3.1.4 Step 4 – Determine and Read the Applicable Minimum Requirements

Section 2.4 Section 2.5 establishes project size thresholds for the application of Minimum Requirements to new development and redevelopment projects. Figures 2.4.1 Figures 2.2 and 2.4.22-3 provide the same thresholds in a flow chart format. Based on the preliminary layout, determine whether Minimum Requirements #1 through #5 apply to the project; or, whether Minimum Requirements #1 through #9 apply.

3.1.5 Step 5 – Prepare a Permanent Stormwater Control Plan

Select on-site stormwater control BMPs (all projects), and treatment and flow control facilities (projects subject to minimum requirements #1 through #9) that will serve the project site in its developed condition. ~~This~~The selection process ~~is for treatment and flow control facilities is~~ presented in detail in Chapter 4~~Chapter 4~~ of this Volume~~-, and Chapter 2 of Volume V.~~

A preliminary design of the On-site Stormwater Management BMPs and treatment/flow control facilities is necessary to determine how they will fit within and serve the ~~entire~~ preliminary development layout. After a preliminary design is developed, the designer may want to reconsider the site layout to reduce the need for construction of facilities, or the size of the facilities by reducing the amount of hard – especially impervious ~~-~~ surfaces created, and increasing the areas to be left undisturbed. After the designer is satisfied with the BMP and facilities selections, the information must be presented within a Permanent Stormwater Control Plan. The Permanent Stormwater Control Plan should contain the following sections:

Permanent Stormwater Control Plan – Existing Site Hydrology

If flow control facilities are proposed to comply with Minimum Requirement #7, provide a listing of assumptions and site parameters used in analyzing the pre-developed site hydrology. The acreage, soil types, and land covers used to determine the pre-developed flow characteristics, along with basin maps, graphics, and exhibits for each subbasin affected by the project should be included. The pre-developed condition to be matched shall be a forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

Provide a topographic map, of sufficient scale and contour intervals to determine basin boundaries accurately, and showing:

- Delineation and acreage of areas contributing runoff to the site;
- Flow control facility location;
- Outfall;
- Overflow route; and
- All natural streams and drainage features.

The direction of flow, acreage of areas contributing drainage, and the limits of development should be indicated. Each basin within or flowing through the site should be named and model input parameters referenced.

Permanent Stormwater Control Plan – Developed Site Hydrology

All Projects:

Reporting totals of new hard surfaces, replaced hard surfaces, and converted pervious surfaces are necessary to determine which minimum requirements initially apply to the project.

Projects that apply only Minimum Requirements #1 through #5:

Provide a scale drawing of the lot or lots, and any public-right-of-way that displays the location of On-site Stormwater Management BMPs and the areas served by them. These documents must be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement associated with each lot that includes On-site Stormwater Management BMPs.

Provide design details, figures, and maintenance instructions for each On-site Stormwater Management BMP. These documents must also be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement associated with each lot.

Provide a written summary of the proposed project and how it complies with the applicable stormwater management requirements. If using List #1 or List #2 (necessary for threshold discharge areas of projects that have triggered Minimum Requirements #1 - #9, but do not exceed the thresholds in Minimum Requirements #6, #7) to comply with Minimum Requirement #5, provide written justification, including citation of site conditions identified in a soils report, for any On-site Stormwater Management BMPs that are determined to be “infeasible” for the project site.

If the applicant elects or must use the LID performance standard option of Minimum Requirement #5, they shall provide design details of all BMP's that are used to help achieve the standard, and a complete computer model report including input files and output files. Projects taking an impervious surface reduction credit for newly planted or retained trees must provide those calculations and documentation on site plans for the locations of the trees. Projects using full dispersion or full downspout infiltration BMPs must provide information to confirm conformance with design requirements that allow removal of the associated drainage areas from computer model input.

Skip down to [Section 3.1.6 - Step 6](#) surfaces.

Projects that are subject to Minimum Requirements #1 through #9:

a. Summary Section

~~By threshold discharge area, provide totals of new pollution-generating hard surfaces, replaced pollution-generating hard surfaces (where the replaced hard surfaces have been determined to be subject to requirements per [Section 2.4.1](#) or [2.4.2](#)), effective impervious surfaces, and pollution-generating pervious surfaces must be tabulated for each threshold discharge area for which On-site Stormwater Management BMPs are the sole stormwater management approach. These are needed~~

~~to verify that the thresholds for application of converted vegetated areas to determine whether treatment (Minimum Requirement #6) and/or flow control facilities (Minimum Requirement #7) are necessary for those areas. See Chapter 4 facilities (Minimum Requirements #6 and #8) of this Volume for more specific directions concerning treatment and flow control requirements, and selection of treatment and flow control facilities (For those threshold discharge areas that do not trigger Minimum Requirement Requirements #6, #7 and, or #8) are not exceeded.~~

~~_____ follow the directions above for Projects and Threshold Discharge Areas within Projects That Require Treatment and Flow Control Facilities:~~

~~that apply only Minimum Requirements #1 through #5. Otherwise, provide narrative, mathematical, and graphic presentations of computer model input parameters selected for each threshold discharge area of the developed site condition, including acreage, soil types, and land covers, road layout, and all drainage facilities.~~

~~Developed basin areas, threshold discharge areas, and flows flow routing should be shown on a map and cross-referenced to computer input screens and printouts or calculation sheets. -Developed basin flows should be listed and tabulated.~~

Any documents used to determine the developed site hydrology should be included. Whenever possible, maintain the same basin name as used for the pre-developed site hydrology. If the boundaries of a basin have been modified by the project, that should be clearly shown on a map and the name modified to indicate the change.

Final grade topographic maps shall be provided. Ecology recommends local governments also require finished floor elevations.

~~a-b.~~ *Permanent Stormwater Control Plan – Performance Standards and Goals*

If treatment facilities are proposed, provide a listing of the water quality menus used (Chapter 3, Volume V). If flow control facilities are proposed, provide a confirmation of the flow control standard being achieved (e.g., the Ecology flow duration standard). Indicate whether using the mandatory list or the LID performance standard option for Minimum Requirement #5.

c. Permanent Stormwater Control Plan – Low Impact Development Features.

A description of the proposed project including:

1. Project narrative showing how the project will fulfill the requirement for on-site management of stormwater to the extent feasible.

2. Total area of Native Vegetation retained.
3. Provide a scale drawing of the lot or lots, and any public-right-of-way that displays the location of On-site Stormwater Management BMPs and the areas served by them. These documents must be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement associated with each lot that includes On-site Stormwater Management BMPs.
4. For projects using the list option for Minimum Requirement #5, an explanation and documentation, including citation of site conditions identified in a soils report, for any determination that an On-site Stormwater Management BMP was considered infeasible for the site.
5. Provide design details, figures, and maintenance instructions for each On-site Stormwater Management BMP. These documents must also be suitable to serve as a recordable document that can be attached to a declaration of covenant and grant of easement associated with each lot.
6. A summary of proposed public or private ownership of On-site Stormwater Management BMPs and areas serving a stormwater function within the project site both during and after construction.
7. Areas of disturbed soils to be amended. (NOTE: All lawn and landscaped areas are to meet BMP T5.13. Use of compost is one way to meet the requirement).
8. Retained trees and newly planted trees for which impervious reduction credits are claimed.

~~b-d.~~ Permanent Stormwater Control Plan – Flow Control System

Provide a drawing of the flow control facility and its appurtenances. This drawing must ~~show~~be accompanied by basic measurements necessary to calculate the storage volumes available from zero to the maximum head, all orifice/restrictor sizes and head relationships, control structure/restrictor placement, and placement on the site. Provide sufficient details on the drawings to show how the facility conforms with design criteria in Volume III for detention facilities or infiltration facilities. If distributed bioretention facilities and/or storage below permeable pavement are used to help meet the LID performance standard option of minimum requirement #5, and/or minimum requirement #7, drawings are necessary to confirm accurate representation in the runoff model. Identify locations and approximate size of all permeable pavement surfaces and bioretention facilities to be installed as part of this project, including those that will be installed on individual lots by subsequent contractors. Identify locations and species types for newly planted or retained trees for which impervious

surface reduction credits are claimed. Supporting areas such as the flow paths for dispersion BMPs should also be shown.”

Include computer printouts, calculations, equations, references, storage/volume tables, graphs as necessary to show results and methodology used to determine the storage facility volumes. Where the Western Washington Hydrology Model (WWHM), or other approved runoff model, is used, its documentation input and output files ~~should~~must be included.

4.2.2. Permanent Stormwater Control Plan – Water Quality System

Provide a drawing of the proposed treatment facilities, and any structural source control BMPs. The drawing must show overall measurements and dimensions, placement on the site, location of inflow, bypass, and discharge systems. If distributed bioretention facilities and/or infiltration below pollution-generating hard surfaces are used to help meet treatment requirements, drawings are necessary to confirm accurate representation in the runoff model. Identify locations and approximate dimensions of those facilities to be installed as part of this project, including those that will be installed on individual lots by subsequent contractors.

Include WWHM or other approved model printouts, calculations, equations, references, and graphs as necessary to show the facilities are designed consistent with the Volume V requirements and design criteria. If bioretention and/or infiltration through adequate soils (see Site Suitability Criteria in Section 3.3, Volume III) below pollution-generating hard surfaces will be used to help meet treatment requirements, the runoff model output files must include the volume of water that has been treated through those BMPs. The summation of those volumes and the volume treated through a centralized, conventional treatment system must meet or exceed 91% of the total stormwater runoff file. The total stormwater runoff file includes:

- Stormwater that has infiltrated through a bioretention facility, and stormwater that has infiltrated through adequate soils below pollution-generating hard surfaces.
- Stormwater that passes through a properly sized treatment facility. Note that stormwater that is re-collected below a bioretention facility and routed to a centralized treatment facility should not be counted twice.
- Stormwater that does not receive treatment due to bypass of, or overflow from a treatment facility or a bioretention facility (if the overflow is not subsequently routed to a treatment facility).

4.2.3. Permanent Stormwater Control Plan – Conveyance System Analysis and Design

Present an analysis of any existing conveyance systems, and the analysis and design of the proposed stormwater conveyance system for the project. At a minimum, present an analysis of on-site hydrologic connectivity of surficial conveyance channels and/or pipes, and points of concentration. If the local government requires an off-site analysis, include the results of that analysis here. This information should be presented in a clear, concise manner that can be easily followed, checked, and verified. All pipes, culverts, catch basins, channels, swales, and other stormwater conveyance appurtenances must be clearly labeled and correspond directly to the engineering plans.

3.1.6 Step 6 – Prepare a Construction Stormwater Pollution Prevention Plan

The Construction SWPPP for projects adding or replacing 2,000 square feet of ~~impervious~~hard surface or more, or clearing 7,000 square feet or more, must contain sufficient information to satisfy the local government Plan Approval Authority that the potential pollution problems have been adequately addressed for the proposed project. Local governments may adopt a standard SWPPP format for use by projects less than 1 acre. An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. The narrative contains concise information concerning existing site conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings and notes describe where and when the various BMPs should be installed, the performance the BMPs are expected to achieve, and actions to be taken if the performance goals are not achieved.

The ~~12~~¹³ Elements listed in Section 2.5.2 below - Minimum Requirement #2 - must be considered in the development of the Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the Construction SWPPP. These elements are described in detail in Section 2.5.2-Volume II, Chapter 3. They cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources.

~~————The 12 Elements are:~~

- ~~• Mark Clearing Limits~~
- ~~• Establish Construction Access~~
- ~~• Control Flow Rates~~
- ~~• Install Sediment Controls~~
- ~~• Stabilize Soils~~
- ~~• Protect Slopes~~
- ~~• Protect Drain Inlets~~
- ~~• Stabilize Channels And Outlets~~

- ~~Control Pollutants~~
- ~~Control De-Watering~~
- ~~Maintain BMPs~~
- ~~Manage the Project~~

~~A complete description and BMPs applicable to each element is given in Volume II, Chapter 3.~~

On construction sites that discharge to surface water, the primary consideration in the preparation of the Construction SWPPP is compliance with the State Water Quality Standards. The step-by-step procedure outlined in Volume II, Section 3.23 is recommended for the development of these Construction SWPPPs. A checklist is contained in Volume II, Section 3.3 that may be helpful in preparing and reviewing the Construction SWPPP.

On construction sites that infiltrate all stormwater runoff, the primary consideration in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

3.1.7 Step 7 – Complete the Stormwater Site Plan

The Stormwater Site Plan encompasses the entire submittal to the local government agency with drainage review authority. It includes the following documents

Project Overview

The project overview must provide a general description of the project, predeveloped and developed conditions of the site, site area and size of the improvements, and the pre- and post-developed stormwater runoff conditions. The overview should summarize difficult site parameters, the natural drainage system, and drainage to and from adjacent properties, including bypass flows.

A vicinity map should clearly locate the property, identify all roads bordering the site, show the route of stormwater off-site to the local natural receiving water, and show significant geographic features and sensitive/critical areas (streams, wetlands, lakes, steep slopes, etc.).

A site map using a minimum USGS 1:2400 topographic map as a base, should display:

- Acreage and outlines of all drainage basins;
- Existing stormwater drainage to and from the site;

- Routes of existing, construction, and future flows at all discharge points; and
- The length of travel from the farthest upstream end of a proposed storm drainage system to any proposed flow control and treatment facility.

A soils map should show the soils within the project site. ~~Soil Survey maps may be used. However, as verified by field testing.~~ It is the designer's responsibility to ensure that the soil types of the site are properly identified and correctly used in the hydrologic analysis.

Existing Conditions Summary

This is the summary described in [Section 3.1.1](#) ~~Section 3.1.1~~ above. If the local government does not require a detailed ~~offsite~~off-site analysis, this summary should also describe:

- The natural receiving waters that the stormwater runoff either directly or eventually (after flowing through the downstream conveyance system) discharges to, and
- Any area-specific requirements established in local plans, ordinances, or regulations or in Water Clean-up Plans approved by Ecology.

Off-site Analysis Report

This is the report described under [Section 3.1.3](#) ~~Section 3.1.3~~ above.

Permanent Stormwater Control Plan

This is the plan described in [Section 3.1.5](#) ~~Section 3.1.5~~ above.

Construction Stormwater Pollution Prevention Plan

This is the plan described in [Section 3.1.6](#) ~~Section 3.1.6~~ above.

Special Reports and Studies

Include any special reports and studies conducted to prepare the Stormwater Site Plan (e.g., ~~soil testing; a soils report that could include the results of soil sampling and testing, infiltration tests and/or soil gradation analyses, depth to ground water;~~ wetlands delineation).

Other Permits

Include a list of other necessary permits and approvals as required by other regulatory agencies, if those permits or approvals include conditions that affect the drainage plan, or contain more restrictive drainage-related requirements.

Operation and Maintenance Manual

Submit an operations and maintenance manual for each flow control and treatment facility~~-, including any distributed bioretention facilities that are used to help meet flow control and/or treatment requirements.~~. The manual should contain a description of the facility, what it does, and how it works.

The manual must identify and describe the maintenance tasks, and the frequency of each task. The maintenance tasks and frequencies must meet the standards established in this manual or an equivalent manual adopted by the local government agency with jurisdiction.

Include a recommended format for a maintenance activity log that will indicate what actions will have been taken.

The manual must prominently indicate where it should be kept, and that it must be made available for inspection by the local government.

Declaration of Covenant for Privately Maintained Flow Control and Treatment Facilities

To ensure future maintenance and allow access for inspection by the local government, any flow control and treatment facilities for which the applicant identifies operation and maintenance to be the responsibility of a private party must have a declaration of covenant and grant of easement. After approval by the local government, the declaration of covenant and grant of easement must be signed and recorded at the appropriate records office of the local government.

Declaration of Covenant for Privately Maintained On-site Stormwater Management BMPs

To ensure future maintenance and allow access for inspection by the local government, any On-site Stormwater Management BMPs for which the applicant identifies operation and maintenance to be the responsibility of a private party must have a declaration of covenant and grant of easement. Design details, figures, and maintenance instructions for each On-site Stormwater Management BMP shall be attached. A map showing the location of newly planted and retained trees claimed as flow reduction credits shall also be attached. This applies to every lot within a subdivision on which an On-site Stormwater Management BMP is proposed. After approval by the local government, the declaration of covenant and grant of easement must be signed and recorded at the appropriate records office of the local government.

Bond Quantities Worksheet

If the local government adopts a requirement for a performance bond (or other financial guarantee) for proper construction and operation of construction site BMPs, and proper construction of permanent drainage facilities, the designer shall provide documentation to establish the appropriate bond amount.

3.1.8 Step 8 – Check Compliance with All Applicable Minimum Requirements

A Stormwater Site Plan as designed and implemented should specifically fulfill all Minimum Requirements applicable to the project. The

Stormwater Site Plan should be reviewed to check that these requirements are satisfied.

3.2 Plans Required After Stormwater Site Plan Approval

This section includes the specifications and contents required of those plans submitted after the local government agency with jurisdiction has approved the original Stormwater Site Plan.

3.2.1 Stormwater Site Plan Changes

If the designer wishes to make changes or revisions to the originally approved stormwater site plan, the proposed revisions shall be submitted to the local government agency with review authority prior to construction. The submittals should include the following:

1. Substitute pages of the originally approved Stormwater Site Plan that include the proposed changes.
2. Revised drawings showing any structural changes.
3. Any other supporting information that explains and supports the reason for the change.

3.2.2 Final Corrected Plan Submittal

If the project included construction of conveyance systems, treatment facilities, flow control facilities, ~~or~~ structural source control BMPs ~~(i.e., this does not extend to construction of On-site Stormwater Management BMPs)~~, bioretention facilities, permeable pavement, vegetated roofs, a rainwater harvest system, and/or newly planted or retained trees for which a flow reduction credit was taken, the applicant shall submit a final corrected plan (“as-builts”) to the local government agency with jurisdiction when the project is completed. These should be engineering drawings that accurately represent the stormwater infrastructure of the project as constructed. These corrected drawings must be professionally drafted revisions that are stamped, signed, and dated by a licensed civil engineer registered in the state of Washington.

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Chapter 4 - BMP and Facility Selection Process for Permanent Stormwater Control Plans

4.1 Purpose

The purpose of this chapter is to provide guidance for selecting permanent BMPs and facilities for new development and redevelopment sites (including retrofitting of redevelopment sites). The task of selecting BMPs and facilities is necessary to complete the Permanent Stormwater Control Plan - one of the major components of a Stormwater Site Plan. The details for how to complete the other major component - a Construction Stormwater Pollution Prevention Plan - are included in Chapter 3 of Volume II of this manual.

The Department of Ecology's (Ecology) pollution control strategy is to emphasize pollution prevention first, through the application of source control BMPs. Then the application of appropriate on-site, treatment, and flow control facilities fulfills the statutory obligation to provide "all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the State of Washington." ([RCW 90.48.010](#) (~~RCW 90.48.010~~)). This statutory requirement is generally known by an acronym – AKART.

The remainder of this chapter presents seven steps in selecting BMPs, Treatment Facilities, and Flow Control Facilities.

4.2 BMP and Facility Selection Process

Step I: Determine and Read the Applicable Minimum Requirements

[Section 2.4](#) ~~Section 2.5~~ establishes project size thresholds for the application of Minimum Requirements to new development and redevelopment projects. [Figures 2.4.1](#) ~~Figures 2.2~~ and [2.4.22.3](#) provide the same thresholds in a flow chart format. Total new hard surfaces, replaced hard surfaces, and converted vegetation areas to determine which minimum requirements apply to the project.

Step II: Select Source Control BMPs

Note: If your project is a residential development, you may skip this step.

Refer to Volume IV. If the project involves construction of areas or facilities to conduct any of the activities described in Section 2.2 of Volume IV, the "applicable" structural source control BMPs described in that section must be constructed as part of the project. In addition, if the specific business enterprise that will occupy the site is known, the

“applicable” operational source control BMPs must also be described. Structural source control BMPs should be identified in the stormwater site plan and should be shown on all applicable plans submitted for local government review and approval.

The project may have additional source control responsibilities as a result of area-specific pollution control plans (e.g., watershed or basin plans, water clean-up plans, ~~groundwater~~ground water management plans, lakes management plans), ordinances, and regulations.

Step III: Determine Threshold Discharge Areas and Applicable Requirements for Treatment, Flow Control, and Wetlands Protection

Minimum Requirements #6 (Runoff Treatment) and #7 (Flow Control) have size thresholds that determine their applicability (see Sections 2.5.6~~Sections 2.5.6 and 2.5.7~~2.5.7). Minimum Requirement #8 (wetlands protection) uses the same size thresholds as those used in #6 and #7. Those thresholds determine whether certain areas (called “threshold discharge areas”) of a project must use treatment and flow control facilities, designed by a professional engineer, or whether just Minimum Requirement #5 (On-Site Stormwater Management BMPs) ~~can be applied instead~~applies (see Section 2.5.5~~Section 2.5.5~~).

Step 1: Read the definitions in Section 2.3~~Section 2.3 for to become acquainted with~~ the following terms: effective impervious surface, impervious surface, hard surface, pollution-generating impervious surface (PGIS), pollution-generating hard surface, pollution-generating pervious surface (PGPS), converted vegetation areas, and threshold discharge area.

Step 2: Outline the threshold discharge areas for your project site.

Step 3: Determine the amount of ~~effective~~ pollution-generating ~~impervious~~hard surfaces (including pollution-generating permeable pavements) and ~~pollution—~~generating pervious surfaces (not including permeable pavements) in each threshold discharge area. Compare those totals to the ~~categories~~project thresholds in Section 2.5.6~~2.5.6 (Table 2.1)~~ to determine where treatment facilities are necessary. Note that On-site Stormwater Management BMPs (Minimum Requirement #5) are always applicable.

Step 4: ~~Determine~~Compute the ~~amount of~~totals for effective impervious ~~surfaces~~surface and converted ~~pervious surfaces~~vegetation areas in each threshold discharge area. ~~Using an approved continuous runoff simulation model, estimate the increase in the 100-year flow frequency within each threshold discharge area.~~

Compare those totals to the ~~categories~~project thresholds in Section 2.5.7 (Table 2.2) to determine ~~where~~if flow control facilities (Minimum Requirement #7 and #8) are needed. If neither threshold for flow control

facilities ~~are necessary.~~ ~~Note that On-site Stormwater Management BMPs are always applicable~~(Minimum Requirement #7) is exceeded, proceed to Step 5. If one of the thresholds is exceeded, proceed to Step IV below.

Step 5: For each threshold discharge area, use an approved continuous runoff model (e.g., WWHM, MGS Flood) to determine whether there is an increase of 0.1 cfs in the 100-year return frequency flow. (Note: this is the threshold using 1-hour time steps. If using 15-minute time steps, the threshold is a 0.15 cfs increase.) This requires a comparison to the 100-year return frequency flow predicted for the existing (pre-project; not the historic) land cover condition of the same area. If the above threshold is exceeded, flow control – Minimum Requirements #7 and #8 – is potentially required. See the “Applicability” sections of those minimum requirements. Note that On-site Stormwater Management BMPs (Minimum Requirement #5) are always applicable.

This task requires properly representing the hard surfaces, and the converted vegetation areas in the runoff model. Hard surfaces include impervious surfaces, permeable pavements, and vegetated roofs. Impervious surface area totals are entered directly. Permeable pavements are entered as lawn/landscaping areas over the project soil type if they do not have any capability for storage in the gravel base (more typical of private walks, patios, and private residential driveways). Permeable pavements with storage capability should use the permeable pavement “element” in the model. An “element” is provided for vegetated roofs also. See Appendix III-C in Volume III, and the WWHM users manual for guidance concerning proper representation of LID BMPs in approved computer models.

Step IV: Select Flow Control BMPs and Facilities

A determination should have already been made whether Minimum Requirement #7, and/ or Minimum Requirement #8 ~~applies~~apply to the project site. ~~If one or both of them apply,~~ On-site Stormwater Management BMPs ~~from Chapter 5 of Volume V, and Roof Downspout Controls from Chapter 3 of Volume III~~ must be applied in accordance with Minimum Requirement #5. In addition, flow control facilities must be provided for discharges from those threshold discharge areas that ~~exceeded~~exceed the thresholds outlined in Section 2.5.7 Table 2.2. Use an approved continuous runoff model (e.g. the Western Washington Hydrology Model) and the details in Chapter 3 of Volume III to size and design the facilities.

The following describes a selection process for those facilities.

Step 1: Determine whether you can infiltrate.

There are two possible options for infiltration.

The first option is to infiltrate through rapidly draining soils that do not meet the site characterization and site suitability criteria for providing adequate treatment. See Chapter 3 of Volume III for design criteria for infiltration facilities intended to provide flow control without treatment. In this case, a treatment facility must be provided prior to discharge to the ground for infiltration. The treatment facility could be located off-line with a capacity to treat the water quality design flow rate or volume (See Volume V, Chapter 4) to the applicable performance goal (See Volume V, Chapter 3). Volumes or flow rates in excess of the design volume or flow rate would bypass untreated into the infiltration basin. (Note that wetpool treatment facilities are always designed to be on-line.) The infiltration facility must provide adequate volume such that the flow duration standard of Minimum Requirement #7, or the water surface elevation requirements of Minimum Requirement #8 will be achieved.

The second option is to infiltrate through soils that meet the site characterization and site suitability criteria in Chapter 3 of Volume III. The facility would be designed to meet the requirements for treatment and flow control. However, since such a facility would have to be located on-line it would be quite large in order to achieve the flow duration standard of Minimum Requirement #7. ~~Therefore this option will, in most cases, be cost and space prohibitive.~~

If infiltration facilities for flow control are planned, the flow control requirement has been met. Proceed to Step V. If infiltration facilities are not planned, proceed to Step 2.

Step 2: Use the Western Washington Hydrology Model to size a detention facility.

Refer to Chapter 2, of Volume III for an explanation of the use of the Western Washington Hydrology Model. Detailed guidance concerning proper use of the model is provided in a separate document. Ecology recommends attendance at WWHM training classes.

Note that the more the site is left undisturbed, and the less impervious surfaces are created, the smaller the detention facility. ~~Additional incentives are given within~~Also, the ~~model for reducing greater the disruption use of~~ On-site Stormwater Management BMPs, the natural hydrology smaller the detention facility.

Step V: Select Treatment Facilities

~~**Note: This step-by-step process also appears in Volume V, Chapter 2.**~~

~~—Please refer to Figure 4.1. Use the step-by-step process outlined below to determine the type~~Chapter 2 ~~of treatment facilities applicable to the project.~~

~~—————*Step 1: Determine the Receiving Waters and Pollutants* Volume V
of *Concern Based on Off-Site Analysis.*~~

~~—————To obtain a more complete determination of the potential impacts of a stormwater discharge, Ecology encourages local governments to require an Offsite Analysis similar to that in Chapter 2, Volume I. Even without an offsite analysis requirement, the project proponent must determine the natural receiving waters this manual for the stormwater drainage from the project site (ground water, wetland, lake, stream, salt water). This is necessary to determine the applicable treatment menu from which to select treatment facilities. The identification of receiving waters should be verified by the local government agency with review responsibility. If the discharge is to the local municipal storm drainage system, the receiving waters for the drainage system must be determined.~~

~~—————The local government should verify whether any type of water quality management plans and/or local ordinances or regulations have established specific requirements for the receiving waters. Examples of plans to be aware of include:~~

- ~~• Watershed or Basin Plans: These can be developed to cover a wide variety of geographic scales (e.g., Water Resource Inventory Areas, or sub-basins of a few square miles). They can be focused solely on establishing stormwater requirements (e.g., “Stormwater Basin Plans”), or can address a number of pollution and water quantity issues, including urban stormwater (e.g., Puget Sound Non-Point Action Plans).~~
- ~~• Water Clean-up Plans: These plans are written to establish a Total Maximum Daily Load (TMDL) of a pollutant or pollutants in a specific receiving water or basin, and to identify actions necessary to remain below that maximum loading. The plans may identify discharge limitations or management limitations (e.g., use of specific treatment facilities) for stormwater discharges from new and redevelopment projects.~~
- ~~• Groundwater Management Plans (Wellhead Protection Plans): To protect groundwater quality and/or quantity, these plans may identify actions required of stormwater discharges.~~
- ~~• Lake Management Plans: These plans are developed to protect lakes from eutrophication due to inputs of phosphorus from the drainage basin. Control of phosphorus from new development is a likely requirement in any such plans.~~

~~An analysis of the proposed land use(s) of the project should also be used to determine the stormwater pollutants of concern. Table 4.1 lists the pollutants of concern from various land uses. Refer to this table for example treatment options after determining whether “basic,” “enhanced,”~~

or “phosphorus” treatment requirements apply to the project. Those decisions are made in the steps below.

~~————~~ ***Step 2: Determine if an Oil Control Facility/Device is Required***

~~————~~ The use of oil control devices and facilities is dependent upon the specific land use proposed for development.

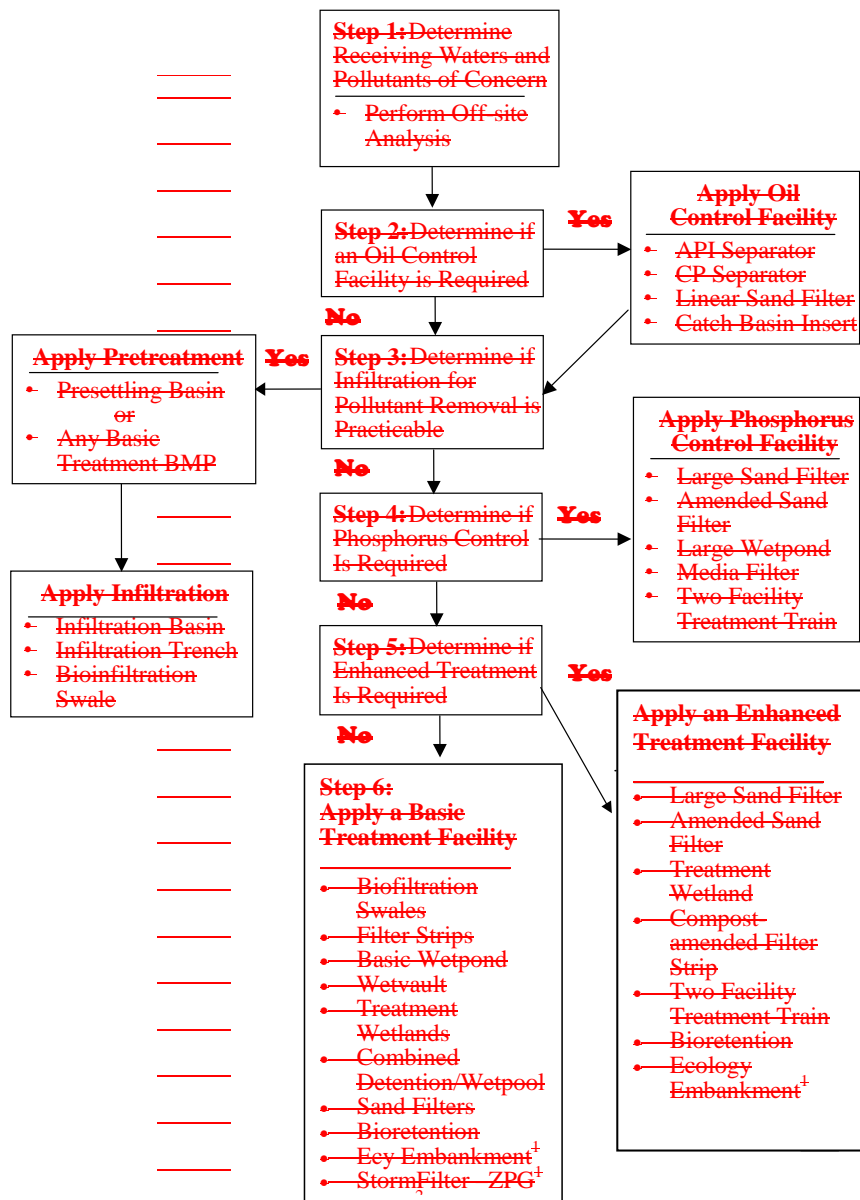
~~————~~ The Oil Control Menu (Volume V, Section 3.2) applies to projects that have “high use sites.” High use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High use sites include:

- ~~•~~ An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;
- ~~•~~ An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;
- ~~•~~ **An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);**
- ~~•~~ A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

~~————~~ Note: The traffic count can be estimated using information from “Trip Generation,” published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

~~————~~ Please refer to the Oil Control Menu for a listing of oil control facility options. Then see Chapter 11 of Volume V for step-by-step guidance ~~on the proper to~~ selection of options and design details.

Note that some land use types require the use of a spill control (SC type) oil/water separator. Those situations are described in Volume IV and are separate from this treatment requirement. While a number of activities may be required to use spill control (SC type) separators, only a few will necessitate American Petroleum Institute (API) or coalescing plate (CP) type separators for treatment. The following urban land uses are likely to have areas that fall within the definition of “high use sites” or have sufficient quantities of free oil present that can be treated by an API or CP type oil/water separator.



⁺ See Section 3.5, Chapter 3 of Volume V for more information

Figure 4.1 Treatment Facility Selection Flow Chart

- ~~Industrial Machinery and Equipment, and Railroad Equipment Maintenance~~
- ~~Log Storage and Sorting Yards~~
- ~~Aircraft Maintenance Areas~~
- ~~Railroad Yards~~
- ~~Fueling Stations~~
- ~~Vehicle Maintenance and Repair~~
- ~~Construction Businesses (paving, heavy equipment storage and maintenance, storage of petroleum products)~~

~~—— If oil control is required for the site, please refer to the General Requirements in Chapter 4, Volume V. These requirements may affect the design and placement of facilities on the site (e.g., flow splitting).~~

~~**If an Oil Control Facility is required, select and apply an Oil Control Facility. Please refer to the Oil Control Menu in Volume V. After selecting an Oil Control Facility, proceed to Step 3.**~~

~~**If an Oil Control Facility is not required, proceed directly to Step 3.**~~

~~—— **Step 3: Determine if Infiltration for Pollutant Removal is Practicable.** Please check the infiltration treatment design criteria in Chapter 3 of Volume III. Infiltration can be effective at treating stormwater runoff, but soil properties must be appropriate to achieve effective treatment while not adversely impacting ground water resources. The location and depth to bedrock, the water table, or impermeable layers (such as glacial till), and the proximity to wells, foundations, septic tank drainfields, and unstable slopes can preclude the use of infiltration. Infiltration treatment facilities must be preceded by a pretreatment facility such as a presettling basin or vault, to reduce the occurrence of plugging. An oil/water separator may serve for pre settling if it is also necessary for oil control. More frequent maintenance would be necessary to remove solids. Any of the basic treatment facilities, and detention ponds designed to meet flow control requirements, can also be used for pre treatment.~~

~~—— If infiltration is planned, please refer to the General Requirements in Chapter 4 of Volume V. They can affect the design and placement of facilities on your site. For non-residential developments, if the infiltration site is within ¼ mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, please refer to the Enhanced Treatment Menu (Volume V, Section 3.4). Read the “Where Applied” paragraph in that section to determine if the Enhanced Treatment Menu applies to part of the site or the entire site. If it applies, read the “Note” under “Infiltration with~~

appropriate pretreatment” to identify special pretreatment needs. If the infiltration site is within ¼ mile of phosphorus-sensitive receiving water, please refer to the Phosphorus Treatment Menu (Volume V, Section 3.3) for special pretreatment needs.

———Note: Infiltration through soils that do not meet the site suitability criteria in Chapter 3 of Volume III is allowable as a flow control BMP (see Chapter 3 of Volume III). However, the infiltration must be preceded by at least a basic treatment facility. Following a basic treatment facility (or an enhanced treatment or phosphorus treatment facility in accordance with the previous paragraph) infiltration through the bottom of a detention/retention facility for flow control can also be acceptable as a way to reduce direct discharge volumes to streams and to reduce the size of the facility.

If infiltration is practicable, select and apply pretreatment and an infiltration facility.

If infiltration is not practicable, proceed to Step 4.

———***Step 4: Determine if Control of Phosphorous is Required.***

———Please refer to the plans, ordinances and regulations referred to in Step 1 as sources of information.

———The requirement to provide phosphorous control is determined by the local government with jurisdiction, the Department of Ecology or the USEPA. The local government may have developed a management plan and implementing ordinances or regulations for control of phosphorus from new/redevelopment for the receiving water(s) of the stormwater drainage. The local government can use the following sources of information for pursuing plans and implementing ordinances and/or regulations:

- Those waterbodies reported under section 305(b) of the Clean Water Act, and designated as not supporting beneficial uses due to phosphorous;
- Those listed in Washington State's Nonpoint Source Assessment required under section 319(a) of the Clean Water Act due to nutrients.

———If phosphorus control is required, select and apply a phosphorus treatment facility. Please refer to the Phosphorus Treatment Menu in Volume V, Section 3.3. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site. You may also use Tables 4.1 through 4.3 in this chapter as an initial screening of options.

—— If you have selected a phosphorus treatment facility, please refer to the General Requirements in Chapter 4 of Volume V. They may affect the design and placement of the facility on the site.

Note: Project sites subject to the Phosphorus Treatment requirement could also be subject to the Enhanced Treatment removal requirement (see Step 5). In that event, apply a facility or a treatment train that is listed in both the Enhanced Treatment Menu and the Phosphorus Treatment Menu.

If phosphorus treatment is not required for the site, proceed to Step 5.

—— ***Step 5: Determine if Enhanced Treatment is Required.***

Enhanced treatment is required for the following project sites that discharge to fish-bearing streams, lakes, or to waters or conveyance systems tributary to fish-bearing streams or lakes:

- Industrial project sites;
- Commercial project sites;
- Multi-family project sites; and
- High AADT roads as follows:

Within Urban Growth Management Areas:

- Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more
- All other roads with an AADT of 7,500 or greater

Outside of Urban Growth Management Areas:

- Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger;
- Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

However, such sites listed above that discharge directly (or, indirectly through a municipal storm sewer system) to Basic Treatment Receiving Waters (Appendix I-C), and areas of the above-listed project sites that are identified as subject to Basic Treatment requirements (see Step 6) are also not subject to Enhanced Treatment requirements. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprise 50% or more of the total runoff within a threshold discharge area.

—— If the project must apply Enhanced Treatment, select and apply an appropriate Enhanced Treatment facility. Please refer to the Enhanced

Treatment Menu in Volume V, Section 3.4. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site. You may also use Tables 4.1 through 4.3 in this chapter for an initial screening of options.

———Note: Project sites subject to the Enhanced Treatment requirement could also be subject to a phosphorus removal requirement if located in an area designated for phosphorus control. In that event, apply a facility or a treatment train that is listed in both the Enhanced Treatment Menu and the Phosphorus Treatment Menu.

———If you have selected an Enhanced Treatment facility, please refer to the General Requirements in Chapter 4 of Volume V. They may affect the design and placement of the facility on the site.

If Enhanced Treatment does not apply to the site, please proceed to Step 6.

———***Step 6: Select a Basic Treatment Facility.***

The Basic Treatment Menu is generally applied to:

- Project sites that discharge to the ground (see Step 3), **UNLESS**:
 - The soil suitability criteria for infiltration treatment are met (use infiltration treatment; see Chapter 3 of Volume III), or
 - The project uses infiltration strictly for flow control—not treatment—and the discharge is within ¼ mile of a phosphorus sensitive lake (use the Phosphorus Treatment Menu), or within ¼ mile of a fish-bearing stream, or a lake (use the Enhanced Treatment Menu);
- Residential projects not otherwise needing phosphorus control in Step 4 as designated by USEPA, the Department of Ecology, or a local government; and
- Project sites discharging directly to salt waters, river segments, and lakes listed in Appendix I C; and
- Project sites that drain to streams that are not fish-bearing, or to waters not tributary to fish-bearing streams;
- Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites that do not involve pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals) other than parking of employees' private vehicles. For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprise 50% or more of the total runoff within a threshold discharge area.

———Please refer to the Basic Treatment Menu in Volume V, Section 3.5. Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility

with the site. You may also use Tables 4.1 through 4.3 in this chapter as an initial screening of options.

After selecting a Basic Treatment Facility, please refer to the General Requirements in Chapter 4 of Volume V. They may affect the design and placement of the facility on the site.

Note: For guidance on additional factors that can affect treatment facility selection, please refer to Section 2.2 of Volume V.

You have completed the treatment facility selection process. treatment facilities.

Step VI: Review Selection of BMPs and Facilities

The list of on-site, treatment and flow control facilities, and the list of source control BMPs should be reviewed. The site designer may want to re-evaluate site layout to reduce the need for construction of facilities, or the size of the facilities by reducing the amount of impervious surfaces created, making more use of On-site Stormwater Management BMPs, and increasing the areas to be left undisturbed.

Step VII: Complete Development of Permanent Stormwater Control Plan

The design and location of the BMPs and facilities on the site must be determined using the detailed guidance in Volumes III, IV, and V. Operation and Maintenance manuals for each treatment and flow control facility are necessary. Please refer to Chapter 3Chapter 3 for guidance on the contents of the Stormwater Site Plan which includes the Permanent Stormwater Control Plan and the Erosion and Sediment Control Plan.

Notes:

1—Though phosphorus is not typically listed as a pollutant of concern, it is present in most urban runoff situations. It becomes a pollutant of concern when identified by USEPA, the Department of Ecology, or a local government in a local management plan and when requirements are established in local ordinance or rules. If phosphorus is identified as a pollutant of concern, consider the treatment options listed here.

2—Application of effective source control measures per BMP S2.70 in Volume IV is the preferred approach for pollutant reduction. Where source control measures are not used, or where they are ineffective, stormwater treatment is necessary.

Legend:

ASF = Amended Sand Filter	INF = Infiltration
BF = Biofilter (includes swales and strips)	CBI = Catch Basin Insert, if applicable (See Chapter 12, Volume V)
Cu = Copper	Com/Ind = Commercial or industrial
LSF = Large Sand Filter	LinSF = Linear Sand Filter
LWP = Large Wet Pond	O & G = Oil and Grease
OWS = Oil & Water Separator	PAH = Polycyclic Aromatic Hydrocarbons
PSB = Presettling Basin	PGPS = Pollution-generating pervious surface
SF = Sand Filter	STW = Stormwater Treatment Wetland
TSS = Total Suspended Solids	WP = Wet Pond
WV = Wetvault	Zn = Zinc

/ = or : The slashes between the abbreviations for treatment types are intended to indicate equivalent treatment options

Additional Notes: If a detention facility is needed for flow control to meet Min. Requirement #7 or #8, a combined detention and Wetpool (Basic or Large depending upon the discharge circumstance) facility should be considered.

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Appendix I-A Guidance for Altering the Minimum Requirements through Basin Planning

Basin Planning Applied to Source Control

(Minimum Requirement #3)

Basin plans can identify potential sources of pollution and develop strategies to eliminate or control these sources to protect beneficial uses. A basin plan can include the following source control strategies:

1. Detection and correction of illicit discharges to storm sewer systems, including the use of dry weather sampling and dye-tracing techniques;
2. Identification of existing businesses, industries, utilities, and other activities that may store materials susceptible to spillage or leakage of pollutants into the storm sewer system or to the ground via wells, drains, or sumps;
3. Elimination or control of pollutant sources identified in (2);
4. Identification and control of future businesses, industries, utilities, and other activities which may store materials susceptible to spillage or leakage of pollutants into the storm sewer system; and
5. Training and public education

Basin Planning Applied to Runoff Treatment

(Minimum Requirement #6)

Basin plans can develop different runoff treatment requirements and performance standards to reduce pollutant concentrations or loads based on an evaluation of the beneficial uses to be protected within or downstream of a watershed. Consideration must be given to the antidegradation provisions of the Clean Water Act and implementing state water quality standards. The evaluation should include an analysis of existing and future conditions. Basin specific requirements and performance standards can be developed based on an evaluation of pollutant loads and modeling of receiving water conditions.

The Basic Treatment Level is viewed as a minimum technology-based requirement that must be applied regardless of the quality of the receiving waters. Additional levels of control beyond the Basic Treatment Level of Minimum Requirement #6 may be justified in order to control the impacts of future development.

Runoff treatment requirements and performance standards developed from a basin plan should apply to individual development sites. Regional treatment facilities can be considered an acceptable substitute for on-site treatment facilities if they can meet the identified treatment requirements

and performance standards. A limitation to the use of regional treatment systems is that the conveyances used to transport the stormwater to the facility must not include waters of the state that have existing or attainable beneficial uses other than drainage.

The above text describes how Basin Planning can influence requirements for new and redevelopment. Basin Planning can also be used to identify prevention, structural retrofit, and redevelopment strategies for reducing the effects of existing development on the aquatic resources.

Basin Planning Applied to Flow Control

(Minimum Requirement #7)

Basin planning is well-suited to control stream channel erosion for both existing and future conditions. Flow control standards developed from a basin plan may include a combination of on-site, regional, and stream protection and rehabilitation measures. On-site standards are usually the primary mechanism to protect streams from the impacts of increased high flows in future conditions. Regional flow control facilities are used primarily to correct existing stream erosion problems. Basin plans can evaluate retrofitting opportunities, such as modified outlets for, and expansion of existing stormwater detention facilities.

In-stream protection and rehabilitation measures may be applied where stream channel erosion problems exist that will not be corrected by on-site or regional facilities. However, caution is urged in the application of such measures. If the causes of the stream channel erosion problems still exist, repairs to the physical expression of those problems may be short-lived. In some instances, it may be prudent to apply in-stream measures to reduce impacts until the basin hydrology is improved.

Another potential outcome of basin planning is the identification of a different flow control standard. Ecology's flow duration standard is based upon a generalization that the threshold of significant bedload movement in Western Washington streams occurs at 50% of the 2-year return stream flow. Through field observations and measurements, a local government may estimate a more appropriate threshold – higher or lower- for a specific stream. The alternative threshold can become the lower limit for the range of flows over which the duration standard applies. For instance, if the threshold is established at 70% of a 2-year return flow, the alternative standard would be to match the discharge durations of flows from the developed site to the range of pre-developed discharge rates from 70% of the 2-year peak flow up to the full 50-year peak flow. An alternative flow control standard must be compatible with maintaining and restoring the designated beneficial uses for that stream. If the existing stream condition is not compatible with the beneficial uses, it should not be used to determine an alternative flow control standard.

Basin Planning Applied to Wetlands and other Sensitive Areas

(Minimum Requirement #8)

Basin planning can be used to develop alternative protection standards for wetlands and other sensitive areas, such as landslide hazard areas, wellhead protection areas, and ground water quality management areas. These standards can include source control, runoff treatment, flow control, stage levels, and frequency and duration of inundations.

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Appendix I-B

Water Quality Treatment Design Storm, Volume, and Flow Rate

~~—— **Water Quality Design Storm:** A 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). The 6-month, 24-hour storm can be estimated as 72% of the 2-year, 24-hour rainfall amount for areas in western Washington.~~

~~**Water Quality Design Storm Volume:** The volume of runoff predicted from a 6-month, 24-hour storm. **Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.**~~

~~—— Facilities such as wetpools are sized based upon either: 1) the volume of runoff produced by the water quality design storm, or 2) the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model. They are the same size whether they precede, follow, or are incorporated (i.e., combined detention and wetpool facilities) into detention facilities for flow control. The water quality design storm volume can be computed using the SCS (NRCS) curve number equations in Volume III, Chapter 2.~~

~~Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in this appendix. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Volume III.~~

~~—— **Background for the Water Quality Design Storm and Volume:**~~

~~**The 6-month, 24-hour storm was the water quality design storm in the 1992 Stormwater Management Manual for the Puget Sound Basin. It was originally chosen when developing the Puget Sound manual based upon a judgement of when the incremental costs of additional treatment capacity exceed the incremental benefits. In particular, the cost of**~~

~~providing the increased detention volume for a wet pond was not seen as cost-effective when compared with the incremental amount of annual stormwater volume that would be effectively treated. Rainfall data from Sea-Tac was used in the original analysis.~~
Amounts and Statistics

Table B.1.24 Hour Rainfall Amounts and Comparisons for Selected USGS Stations

	Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip. Inches
1	Aberdeen	2.47	92.58%	3.43	72.0%	2.25	2.81	83.12
2	Anacortes	0.93	90.45%	1.37	67.9%	0.91	1.22	25.92
3	Appleton	1.39	89.04%	1.96	70.9%	1.45	1.80	32.71
4	Arlington	1.28	93.42%	1.74	73.6%	1.11	1.40	46.46
5	Bellingham	1.27	90.78%	1.79	70.9%	1.23	1.63	35.82
6	Bremerton	1.87	90.75%	2.61	71.6%	1.83	2.22	49.97
7	Cathlamet	2.13	92.52%	3.47	61.4%	1.89	2.59	78.97
8	Centralia	1.49	91.81%	2.09	71.3%	1.40	1.78	45.94
9	Chelan	0.62	84.50%	0.96	64.6%	0.76	1.00	10.44
10	Chimacum	1.20	89.63%	1.73	69.4%	1.22	1.52	29.45
11	Clearwater	3.46	92.88%	4.75	72.8%	3.04	3.94	125.25
12	CleElum	1.06	86.85%	1.66	63.9%	1.20	1.64	22.17
13	Colfax	0.80	90.52%	1.07	74.8%	0.80	0.99	19.78
14	Colville	0.71	90.46%	0.97	73.2%	0.69	0.86	18.31
15	Cushman Dam	3.31	91.26%	5.29	62.6%	3.18	4.25	100.82
16	Cushman PwrH	3.17	90.81%	4.42	71.7%	3.08	4.00	85.71
17	Darrington	2.90	91.19%	4.01	72.3%	2.73	3.42	82.90
18	Ellensburg	0.50	84.63%	0.79	63.3%	0.62	0.81	8.75
19	Elwha RS	2.14	90.49%	2.80	76.4%	2.11	2.53	55.87
20	Everett	1.10	93.14%	1.46	75.3%	1.00	1.22	36.80
21	Forks	3.47	92.50%	5.07	68.4%	3.13	4.00	117.83
22	Goldendale	0.84	86.92%	1.29	65.1%	0.98	1.25	17.57
23	Hartline	0.61	84.85%	0.96	63.5%	0.77	0.97	10.67
24	Kennewick	0.46	84.10%	0.71	64.8%	0.55	0.72	7.57
25	Lk. Wenatchee	2.20	85.87%	3.16	69.6%	2.58	3.16	42.72
26	Long Beach	2.32	93.09%	3.08	75.3%	2.04	2.55	80.89
27	Longview	1.41	92.02%	1.97	71.6%	1.29	1.67	45.62

Table B.1.24 Hour Rainfall Amounts and Comparisons for Selected USGS Stations

	Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip. Inches
28	Mc Millin	1.31	92.24%	1.82	72.0%	1.21	1.49	40.66
29	Monroe	1.38	92.90%	1.86	74.2%	1.26	1.53	48.16
30	Moses Lake	0.47	85.32%	0.70	67.1%	0.54	0.68	7.89
31	Oakville	1.81	92.86%	2.28	79.4%	1.62	1.98	57.35
32	Odessa	0.52	87.23%	0.76	68.4%	0.56	0.72	10.09
33	Olga	1.02	90.82%	1.52	67.1%	0.99	1.30	28.96
34	Olympia	1.74	91.13%	2.51	69.3%	1.65	2.19	50.68
35	Omak	0.66	85.89%	0.98	67.3%	0.79	0.98	11.97
36	Packwood	2.41	88.70%	3.52	68.5%	2.51	3.20	55.20
37	Pomeroy	0.75	89.29%	1.02	73.5%	0.78	0.98	16.04
38	Port Angeles	1.12	88.39%	1.66	67.5%	1.19	1.56	25.46
39	Port Townsend	0.77	90.56%	1.14	67.5%	0.76	0.95	19.13
40	Prosser	0.48	83.82%	0.74	64.9%	0.61	0.78	7.90
41	Quilcene	2.53	88.81%	3.40	74.4%	2.61	3.15	54.88
42	Quincy	0.53	82.12%	0.81	65.4%	0.68	0.90	8.07
43	Sea-Tac	1.32	91.13%	1.83	72.1%	1.27	1.63	38.10
44	Seattle JP	1.30	92.05%	1.74	74.7%	1.20	1.49	38.60
45	Sedro Woolley	1.50	92.07%	2.01	74.6%	1.41	1.80	46.97
46	Shelton	2.15	91.49%	3.13	68.7%	2.05	2.55	64.63
47	Smyrna	0.52	83.16%	0.76	68.4%	0.63	0.75	7.96
48	Spokane	0.68	89.54%	0.96	70.8%	0.70	0.88	16.04
49	Sunnyside	0.45	82.22%	0.73	61.6%	0.63	0.76	6.80
50	Tacoma	1.21	92.18%	1.61	75.2%	1.12	1.37	36.92
51	Toledo	1.36	92.73%	2.10	64.8%	1.25	1.68	50.18
52	Vancouver	1.35	91.32%	1.93	69.9%	1.28	1.62	38.87
53	Walla Walla	0.90	88.60%	1.23	73.2%	0.94	1.18	19.50
54	Waterville	0.67	84.43%	1.04	64.4%	0.81	1.05	11.47
55	Wauna	1.82	91.37%	2.50	72.8%	1.72	2.18	51.61
56	Wenatchee	0.58	81.97%	0.92	63.0%	0.80	1.04	8.93
57	Winthrop	0.75	85.36%	1.13	66.4%	0.94	1.13	14.28
58	Yakima	0.53	81.44%	0.85	62.4%	0.72	1.03	8.16

Table B.2 24 - Hour Rainfall Amounts and Statistics

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Aberdeen	3.32	2.53	2.81		83.1
Anacortes	1.33	0.99	1.20		25.9
Appleton	1.97	1.47	1.80		32.7
Arlington	1.79	1.35	1.40		46.5
Auburn	2.00	1.51		0.54	44.9
Battle Ground	2.12	1.60			52.0
Bellingham 3SSW -- F	1.70	1.27			35.0
Bellingham CAA AP	1.56	1.17	1.63		35.8
Benton City 2NW	0.79	0.53			8.0
Blaine 1ENE	1.89	1.42		0.46	39.9
Bremerton	2.31	1.74	2.22		50.0
Buckley 1NE	2.09	1.58			49.0
Burlington	1.75	1.31		0.40	35.0
Carnation 4NW	1.91	1.44		0.49	47.5
Cathlamet 6NE	3.84	2.93	2.59		79.0
Centralia 1W	2.10	1.59	1.78	0.44	47.6
Chelan	0.94	0.65	1.00		10.4
Colfax 1NW	1.18	0.86	0.99		19.8
Colville	1.02	0.74	0.86		18.3
Colville WB AP	1.01	0.73		0.35	17.4
Coupsville 1S	1.08	0.79			21.0
Cushman Dam	4.61	3.52	4.25	1.23	99.7
Darrington RS	3.32	2.53	3.42	0.84	79.8
Duvall 3NE	1.99	1.50			50.0
Ellensburg	0.70	0.48	0.80	0.25	9.2
Ellensburg WB AP	0.72	0.51			12.0
Elwha RS	2.74	2.07	2.53		55.9
Everett Jr. Col.	1.48	1.11	1.22	0.41	34.4
Forks 1E	4.90	3.76	3.99		117.8
Goldendale	1.12	0.81	1.25		17.6
Goldendale 2E	1.31	0.95			18.0
Hartline	0.89	0.62	0.98		10.7
Hoquiam AP	2.85	2.17			71.0
Kennewick	0.71	0.48	0.71		7.6
Kent	1.87	1.40			36.0

Table B.2 24 - Hour Rainfall Amounts and Statistics

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Leavenworth	1.64	1.21			26.0
Long Beach Exp	2.99	2.28	2.54		80.0
Longview	2.20	1.66	1.67	0.48	48.1
Mazama 2W	1.59	1.17		0.41	22.7
Mc Millin Reservoir	1.81	1.36	1.49	0.46	40.0
Mill Creek	2.04	1.53			35.0
Monroe	1.91	1.44	1.52		48.2
Montesano 3NW	3.30	2.52		0.81	81.5
Moses Lake Devil Far	0.74	0.50	0.68		7.9
Mount Vernon 3WNW	1.60	1.20			32.0
Newport	1.41	1.05			29.0
Oakville	2.46	1.86	1.99		57.4
Odessa	0.80	0.55	0.72		10.1
Okanogan	0.90	0.63			12.0
Olga 2se	1.52	1.13	1.29		29.0
Olympia WB AP	2.62	1.98	2.18	0.62	51.1
Omak 2nw	0.99	0.70	0.98		12.0
Othello 5e	0.70	0.47			8.0
Packwood	2.92	2.21	3.16		55.2
Pomeroy	1.10	0.79	0.97		16.0
Port Angeles	1.69	1.26	1.56	0.42	24.2
Port Townsend	1.11	0.81	0.95	0.35	17.6
Prosser	0.74	0.49	0.78		7.9
Prosser 4NE	0.72	0.48			8.0
Pullman 2NW	1.17	0.86		0.41	22.3
Puyallup 2w Exp Stn	1.85	1.40			41.0
Quilcene 2SW	3.42	2.59	3.14		54.9
Quilcene Dam 5SW	3.84	2.92		0.77	69.4
Quincy 1S	0.77	0.52	0.90		8.1
Republic	1.04	0.76			17.0
Seattle Jackson Park	1.49	1.12	1.49		38.6
Seattle Tac WB AP	1.90	1.42	1.62	0.49	37.4
Seattle U. of W.	1.72	1.29			36.0
Sedro Wolley 1E	2.05	1.55	1.80		47.0
Sequim	1.11	0.80			16.0

Table B.2 24 - Hour Rainfall Amounts and Statistics

Station Name	Return 2-yr.	Freq 6-month	Knee-of- curve 24 hr. (in)	Mean Annual Storm (in)	Mean Annual Precip (in)
Shelton	3.15	2.39	2.54		64.6
Smyrna	0.79	0.53	0.75		8.0
Spokane	1.11	0.80	0.88		16.0
Spokane WB AP	0.97	0.70		0.35	17.0
Sunnyside	0.76	0.50	0.76	0.30	7.4
Tacoma City Hall	1.70	1.28	1.37		36.9
Toledo	1.99	1.51	1.68		50.2
Vancouver 4NNE	2.01	1.51	1.62		38.9
Walla Walla CAA AP	1.19	0.87	1.17		19.5
Waterville	1.00	0.70	1.05		11.5
Wauna	2.15	1.63	2.18		51.6
Wenatchee	0.95	0.65	1.04		8.9
Winthrop IWSW	1.19	0.85	1.13		14.3
Yakima WB AP	0.81	0.54	1.03	0.33	8.2

— *Estimation of the 6-month, 24-hour rainfall amount for rain gauge sites:* There are at least two ways to estimate the rainfall amount of a 6-month, 24-hour storm. One way is to analyze the 24-hour rainfall records for each rainfall station. The more extensive the record is, the more confidence there is in the estimate. The rainfall amount which has a probability of being equaled or exceeded twice a year is the 6-month, 24-hour storm. The 6-month, 24-hour rainfall amounts shown for 58 stations in Table B.1 have been estimated by analyzing the daily rain-gauge data obtained from CD-ROM Hydrodata, USGS Daily and Peak Values, published by Hydrosphere Data Products, Inc.⁽¹⁾

— The way in which the 6-month, 24-hour estimates in Table B.2 are calculated is as follows. A data set containing the annual maxima series for 24-hour durations for rainfall stations throughout the state was used to determine the 2-year, 24-hour return frequency in the first column of Table B.2. The data set was collected by Dr. Schaefer of the Washington State Department of Ecology and is more fully described in “Regional Analyses of Precipitation Annual Maxima in Washington State”^(1,2). An algorithm was applied to convert the series to a partial duration series. Dr. Schaefer describes the conversion as follows: “A return period of 1.16 years (annual exceedance probability of 0.862) in the annual maxima data series is equivalent to a 6-month return period in the partial duration data series. The 6-month values were computed using at-site 24-hour station mean values, regional coefficients of variation (Cv) and L-skewness (tau3), and a frequency factor (K) of 0.94 which corresponds to a return

period of 1.16 years. This K value of 0.94 yields 6 month estimates that are correct within 3% +/- for various Kappa distribution parameter sets for climates from arid to rainforest in Washington State.” (The reader is referred to Volume I References #13 and #14.) Note that the 2 year storm values in Table B.2 differ slightly from those in Table B.1 because they are a different data set and have undergone additional statistical analysis. Where a single site is listed in both tables, the value listed in Table B.2 should be used.

~~————— Estimation of 6 month, 24 hour amounts for any project site: —————~~

~~————— A disadvantage to using the 6 month, 24 hour storm as the design storm is that all isopluvials identifying 6 month, 24 hour storms statewide do not exist. A map would need to be produced, or a method developed to estimate the volume for projects at sites not listed in a reference table of 6 month, 24 hour storms. One method to do the latter is described below.~~

~~————— The first step is to look for a consistent relationship between the 6 month, 24 hour rainfall amount and a rainfall amount for which we have isopluvials. Based upon an analysis of the rainfall record of 58 stations across the state, the 6 month, and 2 year, 24 hour rainfall amounts were calculated and compared. Those results are shown in Table B.1. The arithmetic average of the ratio of the 6 month to the 2 year totals for 35 stations in western Washington (expressed as a percentage) was 71%. The median was 72%. With the exception of a few stations, the percentages vary within a range of 67% to 76%.~~

~~————— Updated statewide isopluvial maps for the 2 year, 24 hour rainfall amounts are expected to be available soon. By interpolation, the 2 year rainfall amount for a project site can be easily identified. Multiplying the 2 year amount by 72% yields an estimate of the 6 month, 24 hour rainfall amount.~~

~~————— Justification for use of the 6 month, 24 hour storm: —————~~

~~————— In the manual update, it is consistently proposed to retain the 6 month, 24 hour storm (hereafter referred to as the 6/24 storm) as the “Water Quality Design Storm.” The 1992 manual noted that 24 hour storms up through the 6/24 storm produced 91% of the historic runoff volume (Sea Tac Airport rain data). That is probably an overestimate because many smaller storms do not produce measurable runoff and the statement ignores the fact of variability in soil absorption capacity preceding each event. However, it is the presumption made in 1992, and it is not fatally incorrect.~~

~~The original basis for the 6 month, 24 hour rainfall amount was a cost-effectiveness analysis referred to in Appendix AI 2.1 of the '92 manual. The assumption in these comparisons is that storm sizes crudely track relative runoff quantities. The cost analysis simply compared the incremental cost increase in wet ponds sized to treat the 91st percentile~~

storm versus the 95th percentile storm. For a 4% increase in annual treated volume, the pond had to be increased by 34% in volume. That was seen as being not cost effective and therefore not cost reasonable. (The costs to treat the runoff from the 91st percentile storm were further supported by an analysis for three example developments (Herrera, 1993)).

——— The percentage of the 24 hour rainfall volumes that the 6 month, 24 hour storm and smaller 24 hour rainfall amounts represent changes across the state. For the 34 western Washington stations computed, the 6 month storm and smaller storms represent from 88.4% to 93.4% of the total rainfall volume. See Table B.1, column entitled, “6 month, % Rainfall Volume.” Therefore, the cost effectiveness analysis is not exactly the same for other areas. However, because the 91% value for Sea-Tac is a mid-range figure for a data set with small variation, the cost analysis is a reasonable basis for setting the 6 month, 24 hour storm as the water quality design storm.

——— Citing a particular percentage of the 2-year, 24 hour rainfall amount (or a 6 month, 24 hour event) means that different areas of the state will be effectively sizing treatment facilities for the runoff from storms of different sizes. However, those size differences are based upon actual differences in rainfall amounts among the sites.

Water Quality Design Flow Rate:

Preceding detention facilities or when detention facilities are not required: The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80% TSS removal).

——— *Downstream of detention facilities:* The full 2-year release rate from the detention facility.

Background for the Water Quality Design Flow Rate:

Basis for Water Quality Design Flow Rate in 1992 Manual:

The cost effectiveness analysis performed for the 1992 manual seems to assumed that BMPs sized by flow rate (bioswales, filter strips, oil/water separators), using the 10 minute peak flow predicted by SBUH for a 6/24 storm, and a Type 1A storm distribution would result in treating roughly 91 percent of the annual runoff volume. That appears to be an incorrect assumption. The error is caused by the size of the 10 minute peak increment of the 6/24 storm when compared to the actual rainfall intensities experienced in western Washington. The Olympia, Lacey, Tumwater, Thurston Co. stormwater managers provided some actual 2-hour rainfall intensity statistics for Olympia, and compared these to the

intensity predicted by a 6/24, type 1A storm for Olympia. The statistics seem to confirm the conservativeness of the original assumption.

————Basis for a new Water Quality Design Flow Rate:

The use of continuous runoff modeling techniques provides another perspective on flow rates. Continuous runoff modeling takes a long, uninterrupted record of observed rainfall data and transforms it into a record (a.k.a., time series) of runoff data. This is done by use of a set of mathematical algorithms that represent the rainfall-runoff processes. The model's algorithms are adjusted to simulate the rainfall/runoff relationships of a particular watershed. HSPF, Hydrological Simulation Program—Fortran, is one type of continuous runoff model. The Department of Ecology has funded the development of an HSPF-based continuous runoff model for Western Washington using the best available precipitation and mathematical algorithms. It is referred to as the Western Washington Hydrology Model (WWHM). King County has already employed an HSPF-based model (King County Runoff Time Series, KCRTS) to estimate runoff flow rates and volumes in their jurisdiction.

Runoff flow rates for a number of different development scenarios have been estimated and compared using KCRTS and the Santa Barbara Urban Hydrograph Method (SBUH). KCRTS was used for this comparison because it provides flow rates in 15 minute time increments. At the time of this analysis the WWHM only provided 1 hour increments. A 15-minute increment data set is more comparable to the 10 minute time step of the SBUH analysis. It is expected that a comparison between the WWHM and SBUH would provide similar results as the KCRTS vs. SBUH comparison.

A spreadsheet can be used to statistically analyze the long time series of runoff predicted by KCRTS. That analysis shows that only 2.5 to 3% of the annual runoff volume is discharged at a rate that equals or exceeds the peak 10 minute runoff predicted by SBUH for the water quality design storm. This is a second indicator that the 1992 manual water quality design flow rate is too conservative if the intent is to provide effective treatment for 91% of the runoff volume.

Using the same spreadsheet, a flow rate can be identified above which only 9% of the annual runoff volume is discharged. However, that flow rate is still too conservative if the intent is to provide effective treatment for 91% of the annual runoff volume. An off-line facility that is designed to receive and effectively treat a flow rate at or below which 91% of the annual volume is discharged, will actually treat 97 to 98% of the annual runoff volume. This occurs because a flow splitter continues to send a portion (in this instance, the flow rate above which only 9% of the runoff volume is discharged) of the higher flow rates to the treatment facility. To treat 91% of the annual runoff volume, a flow splitter should start to

bypass incremental portions of flow rates above a rate at which 72 to 80% of the runoff volume is discharged. The above percentage changes with project characteristics, most notably the percent imperviousness of a project.

This flow rate, which a flow splitter must route to the treatment facility in an off-line mode, becomes the water quality design flow rate. This rate is sometimes referred to as the 91% flow rate in the manual. At the time of publication of the 2001 manual, the WWHM did not identify this water quality design flow rate directly for the user. The user would have to take the output of the WWHM and perform a statistical analysis of the data set to determine the flow rate associated with treating 91% of the runoff volume. However, the WWHM only provides flow rates in 1-hour time increments. Further, it is more appropriate to use 15-minute time increments for facilities that perform their treatment function with short hydraulic residence times. Therefore, that flow rate would have to be increased by a factor to convert the hourly flow rate to an equivalent 15-minute flow rate.

WWHM2 now provides an estimate of the water quality design flow rate in 1-hour and 15-minute time steps, and for off-line and on-line facilities.

Water Quality Design Flow Rate Downstream of Detention Facilities:

The 91% flow rate downstream of detention will be significantly smaller than upstream of detention. The detention facilities, which are fitted with flow-restricting orifices, significantly change the distribution of flow rates. The flow-duration standard requires that the total amount of time that flows are discharged above $\frac{1}{2}$ of the 2-year flow not increase. There is a much greater volume of surface runoff post-development than pre-development. Therefore, an extra volume of water must be discharged at rates below $\frac{1}{2}$ the 2-year rate for extended periods of time.

The result of this redistribution is that downstream treatment facilities will operate for extended periods of time at flow rates at or near their design flow rate. For downstream facilities sized for the 91% flow rate this will achieve less annual treatment removal efficiency than that achieved by facilities located upstream. Upstream treatment facilities see more variable flow rates, and presumably, operate more efficiently at lower flow rates than the design flow rate. In addition, downstream detention facilities would have a hard time meeting the annual TSS removal performance goal of 80% removal. They also would need intensive maintenance as they are treating the same volume of water through substantially less treatment area and volume.

In order to compensate for this, the water quality design flow rate, downstream of detention facilities is the 2-year return frequency flow from

a detention facility that is designed to meet the flow duration standard. The 2-year frequency flow rate represents a flow rate that will effectively treat a greater percentage of the annual runoff volume than 91%. In addition, flow rate-based treatment facilities downstream of detention should only be designed to be on-line facilities. These downstream water quality design flow rates are 3.5 times smaller than upstream, off-line flow rates, and 6.5 times smaller than upstream, on-line flow rates.

This requirement applies to treatment facilities that are sized based upon a short hydraulic residence time or velocity. This would include biofiltration swales, oil/water separators, and sand/media filters that are not preceded by a significant storage reservoir (i.e., above the filtration unit). Where a sand/media filter is preceded by a significant equalization/storage reservoir, it may be sized using a continuous runoff model and a volume-based approach to achieve the 91% or 95% volume targets (whichever is applicable).

Impact on Design Criteria:

The 1992 design criteria for some public domain treatment facilities had been intended to apply to the water quality design flow rate in the 1992 manual. The new water quality design flow rate is a fraction of that old rate. If the 1992 design criteria were retained and applied at the new water quality design flow rate, new treatment facilities would be that same fraction of the size of existing treatment facilities. This would not be a prudent action since it is not known whether existing treatment facilities can meet the proposed performance goals. Until more reliable monitoring information to judge the performance of existing treatment facilities exist, the prudent action is to adjust their design criteria such that they continue to be built to approximately the same size as they should have been built using the 1992 design criteria and design flow rates.

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Appendix I-C Basic Treatment Receiving Waters

1. All Salt Waterbodies

2. Rivers Basic Treatment Applies Below This Location

Baker	Anderson Creek
Bogachiel	Bear Creek
Cascade	Marblemount
Chehalis	Bunker Creek
Clearwater	Town of Clearwater
Columbia	Canadian Border
Cowlitz	Skate Creek
Elwha	Lake Mills
Green	Howard Hanson Dam
Hoh	South Fork Hoh River
Humptulips	West and East Fork Confluence
Kalama	Italian Creek
Lewis	Swift Reservoir
Muddy	Clear Creek
Nisqually	Alder Lake
Nooksack	Glacier Creek
South Fork Nooksack	Hutchinson Creek
North River	Raymond
Puyallup	Carbon River
Queets	Clearwater River
Quillayute	Bogachiel River
Quinault	Lake Quinault
Sauk	Clear Creek
Satsop	Middle and East Fork Confluence
Skagit	Cascade River
Skokomish	Vance Creek
Skykomish	Beckler River
Snohomish	Snoqualmie River
Snoqualmie	Middle and North Fork Confluence
Sol Duc	Beaver Creek
Stillaguamish	North and South Fork Confluence
North Fork Stillaguamish	Boulder River
South Fork Stillaguamish	Canyon Creek
Suiattle	Darrington
Tilton	Bear Canyon Creek
Toutle	North and South Fork Confluence
North Fork Toutle	Green River
Washougal	Washougal
White	Greenwater River
Wind	Carson
Wynoochee	Wishkah River Road Bridge

3. <u>Lakes</u>	<u>County</u>
Washington	King
Sammamish	King
Union	King
Whatcom	Whatcom
Silver	Cowlitz

Note: Local governments may petition for the addition of more waters to this list. The initial criteria for this list are rivers whose mean annual flow exceeds 1,000 cfs, and lakes whose surface area exceeds 300 acres. Additional waters do not have to meet these criteria, but should have sufficient background dilution capacity to accommodate dissolved metals additions from build-out conditions in the watershed under the latest Comprehensive Land Use Plan and zoning regulations.

Appendix I-D Guidelines for Wetlands and when Managing Stormwater Management Guidelines

~~As Amended from Chapter 14 of “Wetlands and Urbanization, Implications for the Future,” by Richard R. Horner, Amanda A. Azous, Klaus O. Richter, Sarah S. Cooke, Lorin E. Reinelt and Kern Ewing~~

~~If you are unfamiliar with these~~ This Appendix provides guidelines, read the description of the approach and organization that follows. If you are familiar, proceed directly to the appropriate guide sheet(s) for guidelines covering your issue(s) or objective(s):

~~Guide Sheet 1: Comprehensive Landscape Planning for Wetlands and Stormwater Management—page D-4~~

~~Guide Sheet 2: Wetlands Protection Guidelines—page D-12~~

Approach and Organization of the Management Guidelines

Introduction

~~The Puget Sound Wetlands and Stormwater Management Research Program performed comprehensive research with the goal of deriving strategies that protect wetland resources in urban and urbanizing areas, while also benefiting the~~ on the management of urban stormwater ~~runoff that can affect those resources. The research primarily involved long-term comparisons of wetland ecosystem characteristics before and after their watersheds urbanized, and between a set of wetlands that became affected by urbanization (treatment sites) and a set whose watersheds did not change (control sites). This work was supplemented by shorter term and more intensive studies of pollutant transport and fate in wetlands, several laboratory experiments, and ongoing review of relevant work being performed elsewhere. These research efforts were aimed at defining the types of impacts that urbanization can cause and the degree, from development and redevelopment projects, to avoid or minimize changes to which they develop under different conditions, in order to identify means of avoiding or minimizing impacts that impair wetland structure and functioning. The program's scope embraced both situations where urban drainage incidentally affects wetlands in its path, as well as those in which direct stormwater management actions change wetlands' hydrology, water quality or both, wetland functions and values.~~

This appendix consists of seven sections:

[Scope and Principles](#)

[Guide Sheet 1: Criteria for Excluding Wetlands from Serving as a Treatment or Flow Control BMP/Facility](#)

[Guide Sheet 2: Criteria for Including Wetlands as a Treatment or Flow Control BMP/Facility](#)

[Guide Sheet 3: Wetland Protection Guidelines](#)

[Guide Sheet 4: Jurisdictional Planning for Wetlands and Stormwater Management](#)

[Information Needed to Apply the Guidelines](#)—This section contains a list of basic data needed for each of the guide sheets to perform basic analyses.

[Definitions](#)—document presents preliminary — Refer to this section for the meaning of terms throughout this appendix.

Scope and Principles

Purpose

[Wetlands are important features in the landscape that provide numerous beneficial functions and values for people, fish, and wildlife. Some of these include protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods.](#)

[Development, redevelopment, and stormwater management guidelines for urban projects may decrease the functions and values of wetlands and their stormwater discharges based on the research results. The set of guidelines by:](#)

- [Increasing the amount of water flow discharged to wetlands.](#)
- [Decreasing the amount of water flow discharged to wetland.](#)
- [Increasing the amount of pollutants discharged to wetland.](#)

[This can happen even if the wetland is the principal vehicle to implement the research findings in environmental planning and not formally used for stormwater management practice purposes.](#)

~~—— ***Guidelines Scope and Underlying Principles.*** Note: For terms in boldface type see item 1 under Support Materials below.~~

~~These provisions currently have the status of guidelines rather than requirements. Application of~~[These guidelines intend to prevent decreasing the functions and values of wetlands by avoiding alterations to the structural, hydrologic, and water quality characteristics of existing wetlands to the extent possible during development, redevelopment and stormwater management projects.](#)

Regulatory Requirements

Following these guidelines does not fulfill requirements for assessment and permitting ~~requirements that may be associated with a~~. Every development and redevelopment project. ~~It is, in general, necessary to should~~ follow the stipulations of the State Environmental Policy Act and ~~to contact~~ contact the local permitting authority. Other state and federal agencies may also have jurisdiction over projects affecting wetlands such as the local planning agency; the Washington State Departments of Ecology, Fisheries, and Wildlife; the U.S. Environmental Protection Agency; and the U.S. Army Corps of Engineers.

- ~~1. Using the guidelines should be approached from a problem-solving viewpoint. The “problem” is regarded to be accomplishing one or more particular planning or management objectives involving a wetland potentially or presently affected by stormwater drainage from an urban or urbanizing area. The objectives can be broad, specific, or both. Broad objectives involve comprehensive planning and subsequent management of a drainage catchment or other landscape unit containing one or more wetlands. Specific objectives pertain to managing a wetland having particular attributes to be sustained. Of course, the prospect for success is greater with ability to manage the whole landscape influencing the wetland, rather than just the wetland itself.~~
- ~~2. The guidelines are framed from the standpoint that some change in the landscape has the potential to modify the physical and chemical structure of the wetland environment, which in turn could alter biological communities and the wetland’s ecological functions. The general objective in this framework would be to avoid or minimize negative ecological change. This view is in contrast to one in which a wetland has at some time in the past experienced negative change, and consequent ecological degradation, and where the general objective would be to recover some or all of the lost structure and functioning through enhancement or restoration actions. Direct attention to this problem was outside the scope of the Puget Sound Wetlands and Stormwater Management Research Program. However, the guidelines do give information that applies to enhancement and restoration. For example, attempted restoration of a diverse amphibian community would not be successful if the water level fluctuation limits consistent with high amphibian species richness are not observed.~~
- ~~3. The guidelines can be applied with whatever information concerning the problem is available. Of course, the comprehensiveness and certainty of the outcome will vary with the amount and quality of information employed. The guidelines can be applied in an iterative fashion to improve management understanding as the information improves. Wetlands Guidance Appendix 1 lists the information~~

~~needed to perform basic analyses, followed by other information that can improve the understanding and analysis.~~

These guidelines do not address actions needed to enhance or restore degraded wetlands.

Guideline Basis

- ~~4. These guidelines emphasize avoiding structural, hydrologic, and water quality **modifications** of existing wetlands to the extent possible in the process of urbanization and the management of urban stormwater runoff.~~
- ~~5. In pursuit of this goal, the guidelines take a systematic approach to management problems that potentially involve both urban stormwater (quantity, quality, or both) and wetlands. The consideration of wetlands involves their areal extent, **values**, and functions. This approach emphasizes a comprehensive analysis of alternatives to solve the identified problem. The guidelines encourage conducting the analysis on a landscape scale and considering all of the possible stormwater management alternatives, which may or may not involve a wetland. They favor **source control best management practices** (BMPs) and **pre-treatment** of stormwater runoff prior to release to wetlands.~~
- ~~6. Furthermore, the guidelines take a holistic view of managing wetland resources in an urban setting. Thus, they recognize that urban wetlands have the potential to be affected structurally and functionally whether or not they are formally designated for stormwater management purposes. Even if an urban wetland is not structurally or hydrologically engineered for such purposes, it may experience altered hydrology (more or less water), reduced water quality, and a host of other impacts related to urban conditions. It is the objective of the guidelines to avoid or reduce the negative effects on wetland resources from both specific stormwater management actions and incidental urban impacts.~~

~~Support Material~~

- ~~1. The guidelines use certain terms that require definition to ensure that the intended meaning is conveyed to all users. Such terms are printed in **boldface** the first time that they appear in each guide sheet, and are defined in *Wetlands Guidance Appendix B*.~~

~~The guideline provisions were drawn principally from the **available** results of the Puget Sound Wetlands and Stormwater Management Research Program, as set forth in Sections 2 and 3 of the program's summary publication, *Wetlands and Urbanization, Implications for the Future*~~

(Horner et al. 1996). Where the results in this publication are the basis for a numerical provision, a separate reference is not given. Numerical provisions based on other sources are referenced. See Wetlands Guidance References at the end of this appendix. 1997).

2. Appendix 3 presents a list of plant species native to wetlands in the Puget Sound Region. This appendix is intended for reference by guideline users who are not specialists in wetland botany. However, non-specialists should obtain expert advice when making decisions involving vegetation.
3. Appendix 4 compares the water chemistry characteristics of *Sphagnum* bog and fen wetlands (termed **priority peat wetlands** in these guidelines) with more common wetland communities. These bogs and fens appear to be the most sensitive among the Puget Sound lowland wetlands to alteration of water chemistry, and require special water quality management to avoid losses of their relatively rare communities.

Guide Sheet 1: Comprehensive Landscape Planning for Wetlands and Stormwater Management

Wetlands in newly developing areas will receive urban effects even if not specifically "used" in stormwater management. Therefore, the task is proper overall management of the resources and protection of their general **functioning**, including their role in storm drainage systems. Stormwater management in newly developing areas is distinguished from management in already developed locations by the existence of many more feasible stormwater control options prior to development. The guidelines emphasize appropriate selection among the options to achieve optimum overall resource protection benefits, extending to downstream receiving waters and ground water aquifers, as well as to wetlands.

The comprehensive planning guidelines are based on two principles that are recognized to create the most effective environmental management: (1) the best management policies for the protection of wetlands and other natural resources are those that prevent or minimize the development of impacts at potential sources; and (2) **The best management strategies are self-perpetuating, that is they do not require periodic infusions of capital and labor.** To apply these principles in managing wetlands in a newly developing area, carry out the following steps.

Guide Sheet 1A: Comprehensive Planning Steps

1. Define the **landscape unit** subject to comprehensive planning. Refer to the definition of landscape unit in Appendix 2 for assistance in defining it.
2. Begin the development of a plan for the landscape unit with attention to the following general principles:
 - a. Formulate the plan on the basis of clearly articulated community goals. ~~Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.~~
 - Map and assess land suitability for urban uses. Include the following landscape features in the assessment: forested land, open unforested land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a fish run, scenic area, recreational area, threatened species habitat, farmland). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.
 - ~~Maximize natural water storage and infiltration opportunities within the landscape unit and outside of existing wetlands, especially. Promote the conservation of forest cover.~~ Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.
 - ~~Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams.~~ Develop and implement policies and regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.
 - In evaluating infiltration opportunities refer to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination and poor soils and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments

with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas. Relatively dense developments on glacial outwash soils may require additional runoff treatment to protect groundwater quality.

1. Establish and maintain **buffers** surrounding wetlands and in riparian zones as required by local regulations or recommended by the Puget Sound Water Quality Authority's wetland guidelines. ~~Also, maintain interconnections among wetlands and other natural habitats to allow for wildlife movements.~~
3. ~~Determine whether the wetland has a breeding, native amphibian population. A survey should be conducted in the spring.~~
2. Take specific management measures to avoid general urban impacts on wetlands and other water bodies (e.g., ~~littering, vegetation destruction, human and pet intrusion harmful to wildlife~~).
4. ~~To support management of runoff water quantity, perform a hydrologic analysis of the contributing drainage catchment to define the type and extent of flooding and stream channel erosion problems associated with existing development, redevelopment, or new development that require control to protect the beneficial uses of receiving waters, including wetlands. This analysis should include assembly of existing flow data and hydrologic modeling as necessary to establish conditions limiting to attainment of beneficial uses. Modeling should be performed as directed by the stormwater management manual in effect in the jurisdiction.~~
5. In wetlands previously relatively unaffected by human activities, ~~manage stormwater quantity to attempt to match the pre-development hydroperiod and hydrodynamics.~~ In wetlands whose hydrology has been disturbed, consider ways of reducing hydrologic impacts. This provision involves not only management of high runoff volumes and rates of flow during the wet season, but also prevention of water supply depletion during the dry season. The latter guideline may require flow augmentation if urbanization reduces existing surface or groundwater inflows. Refer to Guide Sheet 2, Wetland Protection Guidelines, for detail on implementing these guidelines.
6. ~~Assess alternatives for the control of runoff water quantities as follows:~~
 - a. ~~Define the runoff quantity problem subject to management by analyzing the proposed land development action.~~

- ~~— b. —~~ For existing development or **redevelopment**, assess possible alternative solutions that are applicable at the site of the problem occurrence, including:
 - ~~—~~ Protect health, safety, and property from flooding by removing habitation from the flood plain.
 - ~~—~~ Prevent stream channel erosion by stabilizing the eroding bed and/or bank area with **bioengineering** techniques, preferably, or by structurally reinforcing it, if this solution would be consistent with the protection of aquatic habitats and beneficial uses of the stream (refer to Chapter 173-201A of the Washington Administrative Code (WAC) for the definition of beneficial uses).
- ~~e.~~ For new development or redevelopment, assess possible regulatory and incentive land use control alternatives, such as density controls, clearing limits, impervious surface limits, transfer of development rights, purchase of conservation areas, etc.
- ~~d.c.~~ If the alternatives considered in Steps 9a or 9b cannot solve an existing or potential problem, perform an analysis of the contributing drainage catchment to assess possible alternative solutions that can be applied **on-site** or on a **regional** scale. **The most appropriate solution or combination of alternatives should be selected with regard to the specific opportunities and constraints existing in the drainage catchment. For new development or redevelopment, on-site facilities that should be assessed include, in approximate order of preference:**
 - ~~—~~ Infiltration basins or trenches;
 - ~~—~~ Retention/detention ponds;
 - ~~—~~ Below-ground vault or tank storage;

~~Parking lot detention.~~ **Washington State Wetland Rating System**

The wetlands in Washington State differ widely in their functions and values. Washington State's wetland rating systems categorizes wetlands into four categories based on their sensitivity to disturbance, their rarity, our ability to replace them, and the functions they provide.

The rating system, however, does not replace a full assessment of wetland functions that may be necessary to plan and monitor a project of compensatory mitigation.

For more information on the wetlands rating system go to:
<http://www.ecy.wa.gov/programs/sea/wetlands/ratingsystems/index.html>.

Guide Sheet 1: Criteria that excludes wetlands from serving as a treatment or flow control BMP/facility

~~—The following types of wetlands are not suitable as a treatment or flow control BMPs/facilities. Engineering structural or hydrologic changes within the wetland itself to improve stormwater flows and water quality are not allowed. Do not increase or decrease the water regime in these wetlands beyond the limits set in Guide Sheet 3. Provide these wetlands with the maximum protection from urban impacts (see [Guide Sheet 3](#)~~

~~—Regional facilities that should be assessed for solving problems associated with new development, redevelopment, or existing development include:~~

- ~~—Infiltration basins or trenches;~~
- ~~—Detention ponds;~~

Constructed, Wetland Protection Guidelines):

1. The wetland is currently a Category I wetland because of special conditions (forested, bog, estuarine, Natural Heritage, coastal lagoon).

~~—The wetland provides a high level of many functions. These are Category I and II wetlands;~~

- ~~(1) Bypassing a portion of the flow to an acceptable receiving water body, with treatment as required to protect water quality and other special precautions as necessary to prevent downstream impacts;~~

- ~~e. Consider structurally or hydrologically engineering an existing wetland for water quantity control only if upland alternatives are~~

~~inadequate to solve the existing or potential problem. To evaluate the possibility, refer to the Storm-water Wetland Assessment Criteria in Guide Sheet 1B.~~

- ~~7. Place strong emphasis on water resource protection during construction of new development, as determined by the Washington State Wetland Rating System of Establish effective erosion control programs to reduce the sediment loadings to receiving waters to the maximum extent possible. No preexisting wetland or other water body should ever be used for the sedimentation of solids in construction-phase runoff;~~

- ~~8. In wetlands previously relatively unaffected by human activities, manage stormwater quality to attempt to match pre-development water quality conditions. To support management of runoff water quality, perform an analysis of the contributing drainage catchment to define the type and extent of runoff water quality problems associated with existing development, redevelopment, or new development that~~

require control to protect the beneficial uses of receiving waters, including wetlands. This analysis should incorporate the hydrologic assessment performed under step 7 and include identification of key water pollutants, which may include solids, oxygen-demanding substances, nutrients, metals, oils, trace organics, and bacteria, and evaluation of the potential effects of water pollutants throughout the drainage system.

9. Assess alternatives for the control of runoff water quality as follows:

a. Perform an analysis of the contributing drainage catchment to assess possible alternative solutions that can be applied on-site or on a regional scale. The most appropriate solution or combination of alternatives should be selected with regard to the specific opportunities and constraints existing in the drainage catchment. Consider both **source control BMPs** and **treatment BMPs** as alternative solutions before considering use of existing wetlands for quality improvement according to the following considerations:

— Implementation of **source control BMPs** prevent the generation or release of water pollutants at potential sources. These alternatives are generally both more effective and less expensive than treatment controls. They should be applied to the maximum extent possible to new development, redevelopment, and existing development.

1.2. Treatment BMPs capture water pollutants after their release. This alternative often has limited application in existing developments because of space limitations, although it can be employed in new development and when redevelopment occurs in already developed areas. Refer to Minimum Requirement #6 in Volume 1 of the Stormwater Management Manual for Western Washington to determine whether a treatment facility is necessary for your site. If a facility is required, refer to Chapter 4 of Volume 1, or Chapter 2 of Volume 5 to determine which treatment requirement—basic, enhanced, phosphorus, or oil control—applies to your site. Then refer to the corresponding BMP menu for that requirement in Chapter 3 of Volume V. From the menu select a BMP that fits with your project site.

b. Consider structurally or hydrologically engineering an existing wetland for water quality control only if upland alternatives are inadequate to solve the existing or potential problem. Use of Waters of the State and Waters of the United States, including wetlands, for the treatment or conveyance of wastewater, including stormwater, is prohibited under state and federal law. Discussions with federal and state regulators during the research program led to development of a statement concerning the use of existing

wetlands for improving stormwater quality (**polishing**), as follows. Such use is subject to analysis on a case-by-case basis and may be allowed only if the following conditions are met:

- If ~~restoration or enhancement~~ of a previously ~~degraded~~ wetland is required, and if the upgrading of other wetland functions can be accomplished along with benefiting runoff quality control, and
- If appropriate source control and treatment BMPs are applied in the contributing catchment on the basis of the analysis in Step 12a, and any legally adopted water quality standards for wetlands are observed.
- If these circumstances apply, refer to the Stormwater Wetland Assessment Criteria in Guide Sheet 1B to evaluate further.

10. ~~Stimulate public awareness of and interest in wetlands and other water resources in order to establish protective attitudes in the community. This program should include:~~

- ~~Education regarding the use of fertilizers and pesticides, automobile maintenance, the care of animals to prevent water pollution, and the importance of retaining buffers;~~
- ~~Descriptive signboards adjacent to wetlands informing residents of the wetland type, its functions, the protective measures being taken, etc.~~
- ~~If beavers are present in a wetland, educate residents about their ecological role and value and take steps to avoid human interference with beavers.~~

Guide Sheet 1B: Stormwater Wetland Assessment Criteria

— This guide sheet gives criteria that disqualify a natural wetland from being structurally or hydrologically engineered for control of stormwater quantity, quality, or both. These criteria should be applied only after performing the alternatives analysis outlined in Guide Sheet 1A.

1. ~~A wetland should not be structurally or hydrologically engineered for runoff quantity or quality control and should be given maximum protection from overall urban impacts (see Guide Sheet 2, Wetland Protection Guidelines) under any of the following circumstances:~~

- ~~In its present state it is primarily an **estuarine or forested wetland** or a **priority peat system**.~~

- It is a rare or irreplaceable wetland type, as identified by the Washington Natural Heritage Program, the Puget Sound Water Quality Preservation Program, or local government.

~~2.3. It provides rare, threatened.~~ The wetland provides habitat for threatened or endangered species ~~habitat that could be impaired by the proposed action.~~ Determining whether or not the conserved species will be affected by the proposed project requires a careful analysis of its requirements in relation to the anticipated habitat changes. Consult with the appropriate agencies with jurisdiction over the specific threatened or endangered species on the site.

- It provides a high level of many functions

— In general, the wetlands in these groups are classified in Categories I and II in the “Washington State Wetland Rating System of Western Washington.” That publication is available on-line at <http://www.ecy.wa.gov/biblio/sea.htm#es>.

If a wetland type listed above needs to be included in a stormwater system then this activity is considered an impact. It will be treated as any other impact, and will need to be mitigated according to the rules for wetland mitigation. Project proponents will have to demonstrate that they have done everything to avoid and minimize impacts before proceeding to compensatory mitigation.

The wetlands listed above cannot receive flows from a stormwater system unless the criteria in Guide Sheets 3B and 3C are met.

Guide Sheet 2: Criteria for including wetlands as a treatment or flow control BMP/facility

A wetland can be ~~considered~~ for structural or hydrological modification for runoff quantity ~~physically~~ or quality control ~~hydrologically~~ altered to meet the requirements of a treatment or flow control BMP/facility if ~~most~~ ALL of the following ~~circumstances exist~~ criteria are met:

Modifications that alter the structure of a wetland or its soils will require permits. Existing functions and values that are lost would have to be compensated/replaced.

~~1. It is classified in Category IV in the “Washington State Wetland Rating System of Western Washington.” In general,~~ or a Category IV wetlands have monotypic vegetation of similar age and class, lack special-III wetland with a habitat features, and are isolated from other aquatic systems. ~~Any score of 19 points or less.~~

~~1-2. You can demonstrate that there will be “no net loss” of functions lost through hydrologic or structural modification in a Category IV wetland would have to be compensated/replaced. and values of the~~

wetland as a result of the structural or hydrologic modifications done to provide control of runoff and water quality. This includes the impacts from the machinery used for the construction. Heavy equipment can often damage the soil structure of a wetland. However, the functions and values of degraded wetlands may sometimes be increased by such alterations and thus would be self-mitigating. Functions and values that are not replaced on site will have to be mitigated elsewhere.

- ~~The wetland has been previously **disturbed** by human activity, as evidenced by agriculture, fill, ditching, and/or introduced or **invasive weedy plant species**.~~
- ~~The wetland has been deprived of a significant amount of its water supply by draining or previous urbanization (e.g., by loss of groundwater supply), and stormwater runoff is sufficient to augment the water supply. A particular candidate is a wetland that has experienced an increased summer dry period, especially if the drought has been extended by more than two weeks.~~
- ~~Construction for structural or hydrologic modification in order to provide runoff quantity or quality control will disturb relatively little of the wetland.~~
- a. The wetland can provide the Modifications that alter the structure of a wetland or its soils will require permits. Check with the agency(ies) issuing the permits for the modification(s) to determine which method to use to establish “no net loss.”
- a.b. ~~A wetland will usually sustain fewer impacts if the required storage capacity ~~for quantity or quality control~~ can be met through ~~ana modification of the outlet orifice~~ modification to increase storage of water, rather than through raising the existing overflow. Orifice modification is likely to require less construction activity and consequent negative impacts.~~
- ~~Under existing conditions the wetland's experiences a relatively high degree of water level fluctuation and a range of velocities (i.e., a wetland associated with substantially flowing water, rather than one in the headwaters or entirely isolated from flowing water).~~
- 3. The wetland does not ~~exhibit~~ contain a breeding population of any native amphibian species.
- The hydrologic functions of the wetland can be improved as outlined in questions 3.4.5 of Chart 4 and questions 2.3.4 of Chart 5 in the “Guide for Selecting Mitigation Sites Using a Watershed Approach.” (available [here](#);

<http://www.ecy.wa.gov/biblio/0906032.html>); or the following features:

- Significant wetland is part of a priority peat system or forested zones that will experience substantially altered hydroperiod as a result of the proposed action;
 - Regionally **unusual biological community types**;
 - Animal habitat features of relatively high value in the region (e.g., a protected, undisturbed area connected through undisturbed corridors to restoration plan that achieves restoration goals identified in a Shoreline Master Program or other valuable habitats, an important breeding site for protected species);
 - The presence of protected commercial or sport fish;
 - Configuration and topography that will require significant modification that may threaten fish stranding;
 - A relatively high degree of public interest as a result of, for example, offering valued local open space or educational, scientific, or recreational opportunities, unless the proposed action would enhance these opportunities;
 - The wetland is threatened by potential impacts exclusive of stormwater management, and could receive greater protection if acquired for a stormwater management project rather than left in existing ownership;
 - There is good evidence that the wetland actually can be restored or enhanced to perform other functions in addition to runoff quantity or quality control;
- 2.4. ~~There is good evidence that the wetland lends itself to the effective application of the Wetland Protection Guidelines in Guide Sheet 2 or regional watershed plan.~~
- The wetland lies in the natural routing of the runoff. ~~Local regulations often prohibit drainage diversion from one basin to another.~~

3.5. ~~The wetland allows runoff, and the~~ discharge at follows the natural location routing.

Guide Sheet ~~2~~ 3: Wetland protection guidelines

This guide sheet provides information ~~about likely on ways to protect wetlands from~~ changes to ~~the their~~ ecological structure and **functioning of wetlands** that are incidentally subject to the effects of an urban or urbanizing watershed or are **modified** to supply runoff water quantity or quality control benefits. ~~The guide sheet functions that result from human~~

alterations of the landscape. It also recommends management actions that can avoid or minimize deleterious changes ~~in these~~to wetlands.

Guide Sheet 2A: General Wetland Protection Guidelines

Although, this guide sheet is intended primarily for the protection of the wetlands listed in Guide Sheet 1; this guidance still should be applied, as practical, for wetlands listed in Guide Sheet 2 when they are modified to meet stormwater requirements.

Guide Sheet 3A: General guidelines for protecting functions and values of wetlands

1. Consult regulations issued under federal and state laws that govern the discharge of pollutants. Wetlands are classified as "Waters of the United States" and "Waters of the State" in Washington.
2. Maintain the wetland buffer required by local regulations ~~or recommended by the Puget Sound Water Quality Authority's draft wetland guidelines.~~
3. Retain areas of native vegetation connecting the wetland and its buffer with nearby wetlands and other contiguous areas of native vegetation.
4. Avoid compaction of soil and introduction of exotic plant species during any work in a wetland.
5. Take ~~specific site design and maintenance~~ measures to avoid general urban impacts (e. g., littering and vegetation destruction). Examples are protecting existing buffer zones; discouraging access, especially by vehicles, by plantings outside the wetland; and encouragement of stewardship by a homeowners' association.
6. Fences can be useful to restrict dogs and pedestrian access, but they also interfere with wildlife movements. Their use should be very carefully evaluated on the basis of the relative importance of intrusive impacts versus wildlife presence. Fences should generally not be installed when wildlife would be restricted and intrusion is relatively minor. They generally should be used when wildlife passage is not a major issue and the potential for intrusive impacts is high. When wildlife movements and intrusion are both issues, the circumstances will have to be weighed to make a decision about fencing.
7. If the wetland inlet will be modified for the stormwater management project, use a diffuse flow method, ~~such as a spreader swale,~~(e.g. BMPC206 Level Spreader Swale, Volume II, and BMP T5.10B Downspout Dispersion Systems, Volume III) to discharge water into the wetland in order to prevent flow channelization.

Guide Sheet 2B: Guidelines for Protection **3B: Protecting wetlands from Adverse impacts of Modified Runoff Quantity Discharged to Wetlands** **changes in water flows**

~~Protection of~~ Protecting wetland plant and animal communities depends on ~~controlling~~ maintaining the existing wetland's hydroperiod, ~~meaning. This means maintaining the pattern of fluctuation of annual fluctuations in~~ water depth and ~~the frequency~~ its timing as closely as possible. The risk of impacts to functions and duration of exceeding certain levels, including the length and onset of drying in the summer. A hydrologic assessment values increases as the changes in water regime deviate more from the existing conditions. These changes often result from development.

Hydrologic modeling is useful to measure or estimate ~~elements~~ the aspects of the hydroperiod under existing pre-~~development~~ project and anticipated post-~~development~~ conditions. This assessment should be performed with the aid of a qualified hydrologist. project conditions. Post-~~development~~ project estimates of the water regime in a watershed hydrology and wetland hydroperiod must include the cumulative effect of all anticipated watershed and wetland modifications. Perform this assessment with the aid of a qualified hydrologist.

Provisions in these guidelines pertain to the full anticipated build-out of the wetland's watershed: as well as changes resulting from an individual development.

— ~~This analysis hypothesizes a fluctuating water stage over time before development that could fluctuate more, both higher and lower after development; these greater use the standard hydrologic models for describing the flow and fluctuations are termed stage excursions. The guidelines set limits on the frequency and duration of excursions, as well as on overall water level fluctuation, after development.~~

— ~~To determine existing hydroperiod use one of the following methods, listed in order of preference:~~

- ~~Estimation by a continuous simulation computer stormwater pond have failed to adequately model —The model should be calibrated with at least one year of data taken using a continuously recording level gage under existing conditions and should be run for the historical rainfall period. The resulting data can be used to express the magnitudes of depth fluctuation, as well as the frequencies and durations of surpassing given depths. [Note: Modeling that yields high quality information of the type needed for wetland hydroperiod analysis hydrodynamics in wetlands. It is a complex subject. Providing guidance on selecting and applying modeling options is beyond the scope of these guidelines but is being difficult, to estimate if stormwater discharges to a wetland will meet the criteria for protection developed by King County Surface Water Management Division and other local jurisdictions. An alternative possibility to modeling depths, frequencies, and~~

duration within the wetland is to model durations above given discharge levels entering the wetland over various time periods (e.g., seasonal, monthly, weekly). This option requires further development.]

- ~~Measurement during a series of time intervals (no longer than one month in length) over a period of at least one year of the maximum water stage, using a crest stage gage, and instantaneous water stage, using a staff gage. The resulting data can be used to express water level fluctuation (WLF) during the interval as follows:~~

~~———— Average base stage = (Instantaneous stage at beginning of interval + Instantaneous stage at end of interval)/2~~

~~———— WLF = Crest stage — Average base stage~~

~~———— Compute mean annual and mean monthly WLF as the arithmetic averages for each year and month for which data are available.~~

- ~~— To forecast future hydroperiod use one of the following methods, listed in order of preference:~~

- ~~Estimation by the continuous simulation computer model calibrated during pre-development analysis and run for the historical rainfall period. The resulting data can be used to express the magnitudes of depth fluctuation, as well as the frequencies and durations of surpassing given depths. [Note: Post development modeling results should generally be compared with pre-development modeling results, rather than directly with field measurements, because different sets of assumptions underlie modeling and monitoring. Making pre- and post-development comparisons on the basis of common assumptions allows cancellation of errors inherent in the assumptions.]~~

- ~~Estimation according to general relationships developed from the Puget Sound Wetlands Wetland and Stormwater Management Program Research Program, as follows (in part adapted from Chin 1996):~~

Mean annual WLF is very likely (100% of cases measured). The criteria developed by that program apply only to depressional wetlands. They are not applicable to riverine, slope, or lake-fringe wetlands. Ecology does not have any hydrologic models available to be < 20 cm (8 inches or 0.7 ft) if total impervious area (TIA) cover in the watershed is < 6% (roughly corresponding to no more than 15% of the watershed converted to urban land use). Characterize the hydrodynamics in these types of wetlands.

Mean annual WLFAs a result, it is difficult to predict the direct impacts of changes in water flows resulting from a development. In the absence of hydrologic models that characterize all types of wetlands, criteria have to be set using information that is readily available. These criteria are based on risk to the resource rather than an actual understanding of impacts.

The following criteria will provide some protection for the valuable wetland types listed in Guide Sheet 1, but we cannot determine if they result in the complete protection of a wetland's functions and values. The risk to wetland functions will increase as the water volumes into the wetland diverge from the pre-project conditions. The risk will be decreased if the divergence is smaller.

Use the Western Washington Hydrology Model (WWHM), or other models approved by Ecology, for estimating the increases or decreases in total flows (volume) into a wetland that can result from the development project. These total flows can be modeled for individual days or on a monthly basis. Compare the results from this modeling to the criterion below. WWHM 2012 will have the capability to compare these results with the criterion.

Criterion 1: total volume of water into a wetland during a single precipitation event should not be more than 20% higher or lower than the pre-project volumes.

Modeling algorithm for Criterion 1

1. Daily Volumes can be calculated for each day over 50 years for Pre- and Post-project scenarios. Volumes are to be calculated at the inflow to the wetland or the upslope edge where surface runoff, interflow, and ground water are assumed to enter.
2. Calculate the average of Daily Volume for each day for Pre- and Post-project scenarios. There will be 365 values for the Pre-project scenario and 365 for the Post-project.

Example calc for each day in a year (e.g., April 1):

- If you use 50 years of precipitation data, there will be 50 values for April 1. Calculate the average of the 50, April 1, Daily Volumes for Pre- and Post-project scenarios.
 - Compare the average Daily Volumes for Pre- versus Post-project scenarios for each day. The average Post-project Daily Volume for April 1 must be within +/- 20% of the Pre-project Daily Volume for April 1.
3. Check compliance with the 20% criterion for each day of year. Criterion 1 is met/passed if none of the 365 post-project daily volumes varies by more than 20% from the pre-project daily volume for that day.

Criterion 2: Total volume of water into a wetland on a monthly basis should not be more than 15% higher or lower than the pre-project volumes.

This needs to be calculated based on the average precipitation for each month of the year. This criterion is especially important for the summer months when a development may reduce the monthly flows rather than increase them because of reduced infiltration and recharging of ground water.

Modeling algorithm for Criterion 2

1. Monthly Volumes can be calculated for each calendar month over 50 years for Pre- and Post-project scenarios. Volumes are to be calculated at the inflow to the wetland or the upslope edge where surface runoff, interflow, and ground water are assumed to enter.
2. Calculate the average of Monthly Volume for each calendar month for Pre- and Post-project scenarios.

Example calc for each calendar month in a year (e.g., April):

- If you use 50 years of precipitation data, there will be 50 values for the month of April. Calculate the average of the 50, April, Monthly Volumes for Pre- and Post-project scenarios.
- Compare the Monthly Volumes for Pre- versus Post-project scenarios. Post- project Monthly Volume for April must be within +/- 15% of the Pre- project Monthly Volume for April.
 - Check compliance with the 15% criterion for each calendar month of year. Criterion 2 is very likely (89% of cases measured) to be > 20 cm if TIA in the watershed is $> 21\%$ (roughly corresponding to more than 30% of the watershed converted to urban land use).
 - Mean annual WLF is somewhat likely (50% of cases measured) to be > 30 cm (1.0 ft) if TIA in the watershed is $> 21\%$ (roughly corresponding to more than 30% of the watershed converted to urban land use).
 - Mean annual WLF is likely (75% of cases measured) to be > 30 cm, and somewhat likely (50% of cases measured) to be 50 cm (20 inches or 1.6 ft) or higher, if TIA in the watershed is $> 40\%$ (roughly corresponding to met/passed if none of the post-project Monthly Volume varies by more than 70% of the watershed converted to urban land use).
 - The frequency of stage excursions greater than 15 cm (6 inches or 0.5 ft) above or below pre-development levels is somewhat likely (54% of cases measured) to be more than six per year if

~~the mean annual WLF increases to > 24 cm (9.5 inches or 0.8 ft).~~

- ~~—The average duration of stage excursions greater than 15 cm above or below 15% from the pre-development levels is likely (69% of cases measured) to be more than 72 hours if the mean annual WLF increases to > 20 cm.~~

~~1. The following hydroperiod limits characterize wetlands with relatively high vegetation species richness and apply to all zones within all wetlands over the entire year. If these limits are exceeded, then species richness is likely to decline. If the analysis described above forecasts exceedences, one or more of the management strategies listed in step 5 should be employed to attempt to stay within the limits.~~

~~1.3. Mean annual WLF (and mean monthly WLF project Monthly Volume for every month of the year) does not exceed 20 cm. Vegetation species richness decrease is likely with: (1) a mean annual (and mean monthly) WLF increase of more than 5 cm (2 inches or 0.16 ft) if pre-development mean annual (and mean monthly) WLF is greater than 15 cm, or (2) a mean annual (and mean monthly) WLF increase to 20 cm or more if pre-development mean annual (and mean monthly) WLF is 15 cm or less.~~

- ~~• The frequency of stage excursions of 15 cm above or below pre-development stage does not exceed an annual average of six. Note: A short term lagging or advancement of the continuous record of water levels is acceptable. The 15 cm limit applies to the temporary increase in maximum water surface elevations (hydrograph peaks) after storm events and the maximum decrease in water surface elevations (hydrograph valley bottoms) between events and during the dry season.~~
- ~~• The duration of stage excursions of 15 cm above or below pre-development stage does not exceed 72 hours per excursion. Note: A short term lagging or advancement of the continuous record of water levels is acceptable. However, the 15 cm limit applies throughout the entire hydrograph, not just the peaks and valleys.~~
- ~~• The total dry period (when pools dry down to the soil surface everywhere in the wetland) does not increase or decrease by more than two weeks in any year.~~
- ~~• Alterations to watershed and wetland hydrology that may cause perennial wetlands to become **vernal** are avoided.~~

~~2. The following hydroperiod limit characterizes priority peat wetlands (bogs and fens as more specifically defined by the Washington~~

Department of Ecology) and applies to all zones over the entire year. If this limit is exceeded, then characteristic bog or fen wetland vegetation is likely to decline. If the analysis described above forecasts exceedence, one or more of the management strategies listed in step 5 should be employed to attempt to stay within the limit.

- ~~The duration of stage excursions above the pre-development stage does not exceed 24 hours in any year.~~
- ~~Note: This guideline is in addition to the guidelines in #2 directly above. To apply this guideline a continuous simulation computer model needs to be employed. The model should be calibrated with data taken under existing conditions at the wetland being analyzed and then used to forecast post-development duration of excursions.~~

3. ~~The following hydroperiod limits characterize wetlands inhabited by breeding native amphibians and apply to breeding zones during the period 1 February through 31 May. If these limits are exceeded, then amphibian breeding success is likely to decline. If the analysis described above forecasts exceedences, one or more of the management strategies listed in step 5 should be employed to attempt to stay within the limits.~~

- ~~The magnitude of stage excursions above or below the pre-development stage should not exceed 8 cm for more than 24 hours in any 30-day period.~~
- ~~Note: To apply this guideline a continuous simulation computer model needs to be employed. The model should be calibrated with data taken under existing conditions at the wetland being analyzed and then used to forecast post-development magnitude and duration of excursions.~~

WWHM Modeling Assumption and Approach

Assumption - Flow components feeding the wetland under both Pre- and Post-project scenarios are assumed to be the sum of the surface, interflow, and ground water flows from the project site.

Approach - Assign the wetland a point of compliance #1 (POC) number such as POC1 downstream of the project area.

- Pre-project scenario - Connect all flow components to the wetland/POC1
 - **Pre-project Total Flows to POC1 = Surface + Interflow + Ground water**
- Post-project scenario - Identify flows to the wetland/POC1.
 - a) Impervious surfaces send flows to wetland via (1)- surface flow.

✓ WWHM sub-flows to POC1 = Surface flow (+ Interflow default set in WWHM)

b) Pervious surfaces send flows to wetland via (1)- surface, (2)- interflow, and (3)- ground.

✓ WWHM sub-flows to POC1 = Surface + Interflow + Ground water

c) Infiltrating facilities send flows to wetland via ground water, and surface overflows.

(1) Ground water - Connect infiltrated water (Outlet 2) to ground water component of the area between facility and wetland. Use Lateral Basin downstream of the infiltrating facility and connect Outlet 2 to the ground water component of the Lateral Basin. If this area is the same area modeled in Step (b) above, use the Lateral Basin element in Step (b).

✓ WWHM sub-flows to POC1 = infiltrated flows

(2) Surface Overflow – Connect the surface flow (Outlet 1) to wetland/POC1

✓ WWHM sub-flows to POC1 = facility surface flows (Outlet 1)

➤ Post-project Total Flows to POC1 = Sum of flows in (a), (b), and (c).

If it is expected that the ~~hydroperiod~~ limits stated above could be exceeded, consider the following strategies such as to reduce the volume of surface flows:

- ~~Reduction~~ Reducing of the level of development; by reducing the amount of impervious surface and/or increasing the retention of natural forest cover.
- ~~Increasing runoff infiltration~~ [Note: Infiltration is prone to failure in many Puget Sound Basin locations with glacial till soils and generally requires **pretreatment** to avoid clogging. In other situations infiltrating urban runoff may contaminate groundwater. Consult the stormwater management manual adopted by the jurisdiction and carefully analyze infiltration according to its prescriptions.]
- Increasing infiltration through the use of LID BMPs and LID principles.
- Increasing ~~runoff~~ storage capacity; and for surface runoff.
 - ~~Using~~ selective runoff bypass.
- After development, monitor hydroperiod with a continuously recording level gauge or staff and crest stage gauges. If the ~~around the~~

wetland. Bypassed flow must still comply with other applicable limits are exceeded, consider additional applications of the strategies in step 5 that may still be available. It is also recommended that goals be established to maintain key vegetation species, amphibians, or both, and that these species be monitored to determine if the goals are being met stormwater requirements.

Monitoring – Modifications that alter the structure of a wetland or its soils will require permits. Conduct monitoring as required by local, state, or federal permits.

Guide Sheet 2C3C: Guidelines for ~~Protection~~protecting wetlands from Adverse Impacts of Modified Runoff Quality Discharged to Wetlands~~pollutants~~

~~Require~~Protecting a wetland from pollutants generated by a development should include the following measures:

1. ~~Use~~ effective erosion control at ~~any~~ construction sites in the wetland's drainage catchment. ~~Refer to Volume II this manual and local jurisdiction requirements.~~
2. Institute a program of source control BMPs ~~to~~and minimize the ~~generation of~~ pollutants that will enter storm runoff that drains to the wetland.
3. ~~For wetlands the meet the criteria in Guide Sheet 1,~~ provide a water quality control facility consisting of one or more treatment BMPs to treat ~~all urban~~ runoff entering the wetland. ~~Refer to Chapter 4 of Volume 1 or Chapter 2 of Volume V of the Stormwater Management Manual for Western Washington to determine treatment requirements. Then refer to the corresponding BMP menu for that requirement in Chapter 3 of Volume V. From the menu select a BMP that fits with the project site.~~

If the wetland is a ~~priority peat~~Category I wetland (~~bogs and fens as more specifically defined by the Washington Department of Ecology because of special conditions (forested, bog, estuarine, Natural Heritage, costal lagoon)~~), the facility should include a BMP with the most advanced ability to control nutrients (~~e. g., an infiltration device, a wet pond or constructed wetland with residence time in the pooled storage of at least two weeks~~). [Note: Infiltration is prone to failure in many Puget Sound Basin locations with glacial till soils and generally requires ~~pretreatment~~ to avoid clogging. In other situations infiltrating urban runoff may contaminate groundwater. Consult the

Guide Sheet 4: Jurisdictional planning for wetlands and stormwater management ~~manual adopted by the jurisdiction and carefully analyze infiltration according to its prescriptions.~~ Refer to Appendix 4 for a comparison of water

chemistry conditions in priority peat versus more typical wetlands.

Refer to the Local jurisdictions should plan and manage their resources to protect the overall function and values of wetlands, including their role in storm drainage systems.

Advanced planning can help local jurisdictions to take advantage of the most options for managing stormwater in newly developing areas.

The comprehensive planning steps, below, are based on two principles for effective environmental management:

1. The best management policies for the protection of wetlands are those that prevent or minimize impacts at their point of origin.
2. The best management strategies are self-perpetuating, that is they do not require periodic infusions of capital and labor.

The Department of Ecology, the Puget Sound Partnership, and other groups are actively developing new tools for watershed planning that will address many of the steps outlined below. We suggest you review information that has already been developed in the region of your concern. This may significantly reduce your efforts. A good place to start is: <http://www.ecy.wa.gov/watershed/index.html> manual to select and design the facility. Generally,

Comprehensive Planning Steps

3. Define the facility should landscape unit you will be located outside and upstream of using for your planning effort. See the definition of landscape unit in the Definitions section.
4. Begin the plan for the landscape unit with attention to the following general principles:
 - b. Formulate the plan based on clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.
 - c. Map and assess the suitability of different areas for urban uses.
 - d. There are several tools available for identifying such areas. For more information visit <http://www.ecy.wa.gov/mitigation/landscapeplan.html>. When appropriate, the assessment can also highlight outstanding local or regional resources that the community determines should be protected. For example, a fish run, scenic area, recreational area, threatened species habitat, farmland.
- 3-5. Maximize natural water storage and infiltration opportunities within the landscape unit and outside of existing wetlands, especially:

- a. Promote the conservation of forest cover. Develop on deforested land. This affects the water flows in a basin less than building on land that requires removing forest cover. Loss of forest cover increases peak runoff requiring expensive structural solutions.
 - b. Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Implement policies and regulations to discourage the clearing, filling, and channelization of these features. Use existing drainage networks in preference to pipes, culverts, and engineered ditches as long as the flows and volumes of water in them are not increased.
- 4-6. Establish and maintain buffers surrounding wetlands and in riparian zones. Also, maintain interconnections among wetlands and other natural habitats to allow for wildlife movements.
- 5-7. Implement measures to avoid general impacts on wetlands and other water bodies (e. g., littering, vegetation destruction, human and pet intrusion harmful to wildlife).
- In wetlands that are relatively unaffected by human activities, plan so the quantity or stormwater flows match the pre-project hydroperiod and hydrodynamics. In wetlands whose water flows have been disturbed, consider ways of reducing the existing changes to flows. This involves not only management of high volumes and rates of flow during the wet season, but also preventing water supply depletion during the dry season. The latter may require augmenting flows if urbanization reduces existing surface or ground water inflows. Refer to [Guide Sheet 3: Wetland Protection Guidelines](#), for details on implementing these guidelines.
8. Assess alternatives for controlling the quantities of runoff as follows:
- a. Analyze proposed development actions in terms of changes to quantity of runoff.
 - b. For existing development or redevelopment, assess possible alternative solutions to adding flow controls by:
 - (1) Protecting health, safety, and property from flooding by removing buildings from the flood plain.
 - (2) Preventing stream channel erosion by stabilizing the eroding bed and/or bank area with bioengineering techniques, preferably, by using structural reinforcements that are consistent with the protection of aquatic habitats and beneficial uses of the stream (refer to [Chapter 173-201A](#) of the Washington Administrative Code (WAC) for the definition of beneficial uses).

- d. For new development or redevelopment, assess different regulatory alternatives or incentives for changing common practices in land use including: density controls, clearing limits, impervious surface limits, transfer of development rights, purchase of conservation areas, etc.
- ~~f.~~e. If the alternatives considered in Step 6 above cannot solve an existing or potential problem, perform an analysis of the contributing drainage catchment to assess possible alternative solutions that can be applied on-site or on a regional scale. The most appropriate solution or combination of alternatives should be selected with regard to the specific opportunities and constraints existing in the drainage catchment. For new development or redevelopment, on-site facilities that should be assessed include, in approximate order of preference:
- (1) LID BMPs and LID principles
 - (2) Infiltration basins or trenches.
 - (3) Detention ponds.
 - (4) Below-ground vault or tank storage.
 - (5) Parking lot detention.
- Regional facilities that should be assessed for solving problems associated with new development, redevelopment, or existing development include:
- (2) LID BMPs and LID principles
 - (3) Infiltration basins or trenches.
 - (4) Detention ponds.
 - (5) Constructed wetlands.
 - (2)(6) Bypassing a portion of the flow to an acceptable receiving water body, with treatment as required to protect water quality and other special precautions as necessary to prevent downstream impacts.
- f. Consider physically altering an existing wetland for controlling water quantities only if upland alternatives are inadequate to solve the existing or potential problem. Refer to the criteria in Guide Sheet 1 and 2 to evaluate if wetlands can be altered.
- ~~6-9.~~Place strong emphasis on water resource protection during construction of new development. Establish effective erosion control programs to reduce the sediment loadings to receiving waters to the maximum extent possible. No preexisting wetland and its buffer or other water body should ever be used for the sedimentation of solids in construction-phase runoff.

10. Characterize alternatives for the control of runoff water quality as follows:

- a. Analyze the contributing drainage catchment basin to assess possible alternative solutions that can be applied on-site or on a regional scale. The best alternatives are those that minimize changes to water quality resulting from development. Consider both source control BMPs, treatment BMPs, and LID BMPs as alternative solutions before considering use of existing wetlands.
- b. Consider altering an existing wetland for water quality control only if upland alternatives are inadequate to solve the existing or potential problem.

Using wetlands for polishing is subject to analysis on a case-by-case basis and may be allowed only if the following conditions are met:

- (1) The restoration or enhancement of a previously degraded wetland is required.
- (2) Both improving water quality and the upgrading of other wetland functions need to be accomplished.
- (3) All legally adopted water quality standards for wetlands are observed.
- (4) Appropriate source control and treatment BMPs are applied in the contributing catchment on the basis of the analysis in Step 9a.

If these circumstances apply, refer to *Guide Sheet 2: Criteria for Including Wetlands as a Treatment or Flow Control BMP/Facility*

11. Stimulate public awareness of and interest in wetlands and other water resources in order to encourage protective attitudes in the community. This program should include:

- a. Education regarding the use of fertilizers and pesticides, automobile maintenance, the care of animals and the importance of retaining buffers to prevent water pollution.
- b. Descriptive signboards adjacent to wetlands informing residents of the wetland type, its functions, the protective measures taken, etc.
- c. If beavers are present in a wetland, educate residents about their ecological role and value and take steps to avoid human interference with beavers.

Monitoring

Design and ~~perform~~carry out a program to monitor water quality monitoring program for priority peat bogs and other Category I wetlands ~~and for other wetlands~~will be subject to ~~relatively high water~~ pollutant loadings. ~~The research results (Horner 1989) identified from new developments.~~ Such wetlands ~~as having~~are at risk if they have contributing catchments ~~exhibiting~~with either of the following characteristics:

1. More than 20 percent of the catchment area is committed to commercial, industrial, and/or multiple family residential land uses ~~or~~.
2. The combination of all urban land uses (including single family residential) exceeds 30 percent of the catchment area.

~~A recommended~~The monitoring program, ~~consistent with monitoring during~~ should include the ~~research program, is~~following tasks:

1. Perform pre-~~development~~project baseline sampling by collecting water quality grab samples in an open water pool of the wetland for at least one year, allocated through the year as follows:

- November 1-March 31--4 samples
- ~~April~~ April 1- May 31--1 sample
- ~~June~~ June 1- August 31--2 samples
- ~~and~~ September 1- October 31--1 sample

~~(If the wetland is dry during any period, reallocate the sample(s) scheduled then to another time)~~when the wetland is no longer dry.

Analyze samples for pH; dissolved oxygen (DO); conductivity (Cond); total suspended solids (TSS); total phosphorus (TP); nitrate + nitrite-nitrogen (N); fecal coliforms (FC); and total copper (Cu), lead (Pb), and zinc (Zn). Find the median and range of each water quality variable.

2. Considering the baseline results, set water quality goals to be maintained in the post-~~development~~project period. Example goals are:

- ~~(1)~~ pH--no more than "x" percent (e. g., 10%) increase (relative to baseline) in annual median and maximum or decrease in annual minimum ~~(2)~~.
- ~~Do~~--no more than "x" percent decrease in annual median and minimum concentrations ~~(3)~~.
- ~~Other~~ variables--no more than "x" percent increase in annual median and maximum concentrations ~~(4)~~.
- No increase in violations of the Washington Administrative Code (WAC) water quality criteria.

Repeat the sampling on the same schedule for at least one year after all development is complete. Compare the results to the set goals.

—— If the water quality goals are not met, consider additional applications of the source and treatment controls described in steps 2 and 3. Continue monitoring until the goals are met at least two years in succession.

—— Note: Wetland water quality was found to be highly variable during the research, a fact that should be reflected in goals. Using the maximum (or minimum), as well as a measure of central tendency like the median, and allowing some change from pre-development levels are ways of incorporating an allowance for variability. Table D-1 presents data from the wetlands studied during the research program to give an approximate idea of magnitudes and degree of variability to be expected. Nonurbanized watersheds (N) are those that have both < 15% urbanization and < 6% impervious cover. Highly urbanized watersheds (H) are those that have both lost all forest cover and have > 20% impervious cover. Moderately urbanized watersheds (M) are those that fit neither the N nor H category.

^a Std. Dev. = standard deviation; n = number of observations.

^b Values do not apply to priority peat wetlands. The program did not specifically study these wetlands but measured pH in three wetlands with “bog-like” characteristics. The minimum value measured in these wetlands was 4.5, and the lowest median was 4.8; but pH can be approximately 1 unit lower in wetlands of this type.

Guide Sheet 2D: Guidelines for the Protection of Specific Biological Communities

1. For wetlands inhabited by breeding native amphibians:

- Refer to step 4 of Guide Sheet 2B for hydroperiod limit.
- Avoid decreasing the sizes of the open water and aquatic bed zones.
- Avoid increasing the channelization of flow. Do not form channels where none exist, and take care that inflows to the wetland do not become more concentrated and do not enter at higher velocities than accustomed. If necessary, concentrated flows can be uniformly distributed with a flow-spreading device such as a shallow weir, stilling basin, or perforated pipe. Velocity dissipation can be accomplished with a stilling basin or rip-rap pad.
- Limit the post-development flow velocity to < 5 cm/s (0.16 ft/second) in any location that had a velocity in the range 0–5 cm/s in the pre-development condition.
- Avoid increasing the gradient of wetland side slopes.

2. For wetlands inhabited by forest bird species:

- Retain areas of coniferous forest in and around the wetland as habitat for forest species.
- Retain shrub or woody debris as nesting sites for ground-nesting birds and downed logs and stumps for winter wren habitat.
- Retain snags as habitat for cavity-nesting species, such as woodpeckers.
- Retain shrubs in and around the wetland for protective cover. If cover is insufficient to protect against domestic pet predation, consider planting native bushes such as rose species in the buffer.

3. For wetlands inhabited by wetland-obligate bird species:

- Retain **forested zones**, sedge and rush meadows, and deep open water zones, both without vegetation and with submerged and floating plants.
- Retain shrubs in and around the wetland for protective cover. If cover is insufficient to protect against domestic pet predation, consider planting native bushes such as rose species in the buffer.
- Avoid introducing **invasive weedy plant species**, such as purple loosestrife and reed canary grass.
- Retain the buffer zone. If it has lost width or forest cover, consider re-establishing forested buffer area at least 30 meters (100 ft) wide.
- If human entry is desired, establish paths that permit people to observe the wetland with minimum disturbance to the birds.

4. For wetlands inhabited by fish:

- Protect fish habitats by avoiding water velocities above tolerated levels (selected with the aid of a qualified fishery biologist to protect fish in each life stage when they are present), siltation of spawning beds, etc. Habitat requirements vary substantially among fish species. If the wetland is associated with a larger water body, contact the Department of Fisheries and Wildlife to determine the species of concern and the acceptable ranges of habitat variables.
- If stranding of protected commercial or sport fish could result from a structural or hydrologic modification for runoff quantity or quality control, develop a strategy to avoid stranding that minimizes disturbance in the wetland (e.g., by making provisions for fish return to the stream as the wetland drains, or avoiding use of the facility for quantity or quality control during fish presence).

Wetlands Guidance Appendix 1:
Information Needed to Apply the Guidelines

~~The following information listed for Each guide sheet is most essential~~ requires collecting specific information. The following sections list the basic data needed for applying the ~~Wetlands and Stormwater Management Guidelines- Guide Sheets~~. As a start, obtain the relevant soil survey; the National Wetland Inventory for the watershed, topographic and land use maps, and the results of any local wetland inventory.

Data Needed for Guide Sheet 1: Criteria for Excluding Wetlands as Part of a Stormwater System

~~Wetland category Ecology's "Washington State Wetland Rating System for Western Washington," available on-line at <http://www.ecy.wa.gov/biblio/sea.html>~~ **Guide Sheet 1**

1. Boundary and
2. Rare, threatened, or endangered species inhabiting the wetland.
3. Presence or absence of a breeding population of native amphibians. If amphibians are found in the wetland assume they are native unless you can demonstrate the only species present are non-native.

Data Needed for Guide Sheet 2: Criteria for Including Wetlands as Part of a Stormwater System

1. Hydrologic modeling of the existing flows and predicted flows into the wetland.
2. A characterization of the changes to water quality coming into the wetland from the development.
3. Presence of breeding populations of native amphibian species.
4. Presence of fish species.

Data Needed for Guide Sheet 3B: Protecting wetlands from impacts of changes in water flows

The WWHM user manual will have a modeling procedure for estimating water flows to wetlands. Follow the modeling procedure in WWHM user manual to estimate flows and determine compliance with the wetland Criteria 1 and 2. The information needed to model water flows to a wetland in WWHM includes the following:

1. Location of the development project
2. Land use characteristics before and after development.
 - a) Soil Type
 - b) Surface Vegetation
 - c) Land slope
 - d) Land area (acres)
3. Land use characteristics between the development project area and the wetland.

Data Needed for Guide Sheet 4: Jurisdictional Planning for Wetlands and Stormwater Management

1. Wetland boundary delineated using the latest Federal Manuals
<http://www.ecy.wa.gov/programs/sea/wetlands/delineation.html>
- ~~1-2.~~ A map of the contributing watershed ~~of~~ the wetland or other landscape unit, and an estimate of its area.
- ~~2-3.~~ A ~~complete~~ definition of ~~environmental and development~~ goals for the ~~wetland and~~ landscape unit subject to planning and management.
- ~~3-4.~~ Existing management and monitoring plans.
- ~~4-5.~~ Existing and projected land use in the landscape unit in the categories commercial, industrial, multi-family residential, single-family residential, agricultural, various categories of undeveloped, and areas subject to active logging or construction (expressed as percentages of the total watershed area).
- ~~5-6.~~ Surface drainage network throughout the landscape unit.
- ~~6-7.~~ Soil conditions, including soil types, infiltration rates, and ~~positions~~ elevation of ~~seasonal~~ water table ~~(as it changes~~ seasonally), and the presence of any restrictive layers.
- ~~7-8.~~ Groundwater ~~Ground water~~ recharge and discharge points.
- ~~8.~~ Wetland category (I– IV in the Dept. of Ecology’s “Washington State Wetland Rating System for Western Washington,” available on-line at <http://www.ecy.wa.gov/biblio/sea.html>); designation as rare or irreplaceable. Refer to the Washington Natural Heritage Program database. If the needed information is not available, a biological assessment will be necessary.
- ~~9.~~ Watershed hydrologic assessment
- ~~10.~~ Watershed water quality assessment
- ~~11.~~ Wetland type and zones present, with special note of estuarine, priority peat system, forested, sensitive scrub shrub zone, sensitive emergent zone and other sensitive or critical areas designated by state or local government (with dominant plant species)
- ~~12.~~ Rare, threatened, or endangered species inhabiting the wetland
- ~~13.~~ History of wetland changes
- ~~14.~~ Relationship of wetland to other water bodies in the landscape unit and the drainage network
- ~~15.~~ Flow pattern through the wetland
- ~~16.~~ Fish and wildlife inhabiting the wetland
- ~~17.~~ Relationship of wetland to other wildlife habitats in the landscape unit and the corridors between them

Guide Sheet 2

- ~~1. Existing and potential stormwater pollution sources~~
- ~~2. Existing and projected landscape unit land use (see number 4 under Guide Sheet 1)~~
- ~~3. Existing and projected wetland hydroperiod characteristics~~
- ~~4. Wetland bathymetry~~
- ~~5. Inlet and outlet locations and hydraulics~~
- ~~6. Landscape unit soils, geologic and hydrogeologic conditions~~
- ~~7. Wetland type and zones present (see number 11 under Guide Sheet 1)~~
- ~~8. Presence of breeding populations of native amphibian species~~
- ~~9. Presence of forest and wetland obligate bird species~~
- ~~10. Presence of fish species~~

Wetlands Guidance Appendix 2: Definitions

The following terms are applicable only to this appendix (Appendix I-D).

Baseline sampling	Sampling performed to define an <u>the</u> existing state <u>environmental and biological conditions present</u> before any modification occurs that could change the state.
Bioengineering	Restoration or reinforcement of slopes and stream banks with living plant materials <u>Bioengineering for streams and wetlands --The use of living and nonliving plant materials in combination with natura and synthetic support materials for slope stabilization, erosion reduction, and vegetative establishment.</u>
Buffer	The area <u>(either upland, open water, or another wetland)</u> that surrounds a wetland and that reduces adverse impacts to it from adjacent development.
Constructed wetland	A wetland intentionally created from a non-wetland site for the sole purpose of wastewater or stormwater treatment. These wetlands are not normally considered Waters of the United States or Waters of the State.
Degraded wetland	A wetland whose functions and values have been reduced as a result of human activities
Enhancement	Actions performed to improve the condition of an existing degraded wetland, so that functions it provides are of a higher quality.
Estuarine wetland	Generally, an eelgrass bed; salt marsh; or rocky, sandflat, or mudflat intertidal area. <u>Enhancement</u> The manipulat <u>undertaken for specified purposes such as water quality improvement, flood water retention or wildlife habitat. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these. Enhancement results in a change in some wetland functions and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres.</u>
Estuarine wetland	Generally, a vegetated wetland where fresh and salt water mix. (Specifically, a tidal wetland with the salinity of the surface or port waters is greater than 0.5 parts per thousand, usually semi-enclosed by land but with partly obstructed or sporadic access to the open ocean).

Functions	The ecological (physical, chemical, and biological) processes or attributes of a wetland without regard for their importance. Functions are often defined in terms of the processes that provide value to society (see also Values)-, but they can be defined on processes that are not value based. Wetland functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, flood flow alteration, groundwater <u>ground water</u> recharge and discharge, water quality improvement, and soil stabilization.
Hydrodynamics	The science involving the energy and forces acting on water <u>or other liquids</u> and its <u>the</u> resulting <u>impact on the motion of the liquid.</u>
Hydroperiod	The seasonal occurrence of flooding and/or soil saturation; encompasses the depth, frequency, duration, and seasonal pattern of inundation.
Invasive plant species	Opportunistic plant species (either native or non-native) that colonize disturbed ecosystems and come to dominate the plant community in ways that are seen by us as reducing the values provided by the previous plant community. Most often, opportunistic plants are considered invasive if they reduce the value of an area as habitat for valuable species.
Landscape unit	An area of land that has a specified boundary and is the <u>used for planning purposes that defines an area</u> of interrelated physical, chemical, and biological processes. <u>A watershed or drainage basin is a common type of landscape unit. A ground water aquifer is another type of landscape unit.</u>

Modification, Modified (wetland)	A wetland whose physical, hydrological, or water quality characteristics have been purposefully altered for a management purpose, such as by dredging, filling, forebay construction, and inlet or outlet control.
On-site	An action (here, for stormwater management purposes) taken within the property boundaries of the site to which the action applies.
Polishing	Advanced Additional treatment of a waste stream that has already received one or more stages of treatment by other means. <u>This is also called advance treatment. The conditions present across a landscape after a specific stormwater management project (e.g. raising the outlet, building and outlet control structure) are placed in the wetland or a land use change that occurs in the landscape unit that will potentially affect the wetland.</u>
Post-project	The conditions present across a landscape after a specific stormwater management project (e. g., raising the outlet, building an outlet control structure) are placed in the wetland or a land use change that occurs in the landscape unit that will potentially affect the wetland.
Pre-project	The conditions present across a landscape before a specific stormwater management project (e. g., raising the outlet, building an outlet control structure) are placed in the wetland or a land use change occurs in the landscape unit that will potentially affect the wetland.
Rare, threatened, or endangered species	Plant or animal species that are regional relatively uncommon, are nearing endangered status, or whose existence is in immediate jeopardy and is usually restricted to highly specific habitats. Threatened and endangered species are officially listed by federal and state authorities, whereas rare species are unofficial species of concern that fit the above definitions.
Pre-treatment	An action taken to remove pollutants from runoff before it is discharged into another system for additional treatment.
Priority peat systems	Unique, irreplaceable fens that can exhibit water pH in a wide range from highly acidic to alkaline, including fens typified by <i>Sphagnum</i> species, <i>Rhododendron groenlandicum</i> (Labrador tea), <i>Drosera rotundifolia</i> (sundew), and <i>Vaccinium oxycoccos</i> (bog cranberry); marl fens; estuarine peat deposits; and other moss peat systems with relatively diverse, undisturbed flora and fauna. Bog is

~~the common name for peat systems having the *Sphagnum* association described, but this term applies strictly only to systems that receive water income from precipitation exclusively.~~

Redevelopment	Conversion of an existing development to another land use, or addition of a material improvement to an existing development.
Regional	An action (here, for stormwater management purposes) that involves more than one discrete property.
RestorationRe-establishment	Actions performed to reestablish wetland functional characteristics and processes that have been lost by alterations, activities, or catastrophic events in an area that no longer meets the definition of a wetland.
Stage excursion	A post-development departure, either higher or lower, from the water depth existing under a given set of conditions in the pre-development state.
Structure	The <u>physical</u> components of an ecosystem, both the abiotic (physical and chemical) and biotic (living).
Values	Wetland processes or attributes that are valuable or beneficial to society (also see <u>Functions</u> Functions); Wetland values include support of commercial and sport fish and wildlife species, protection of life and property from flooding, recreation, education, and aesthetic enhancement of human communities.
Vernal wetland	A wetland that has water above the soil surface for a period of time during and/or after the wettest season but always dries to or below the soil surface in warmer, drier weather.
Wetland obligate	A biological organism that absolutely requires a wetland habitat for at least some stage of its life cycle.
Wetlands	Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. <u>Wetlands</u>

may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. ~~Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands.~~ (Waterbodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)

Wetlands Guidance Appendix 3: Native and Recommended Noninvasive Plant Species for Wetlands in the Puget Sound Basin

~~Caution: Extracting plants from an existing wetland donor site can cause a significant negative effect on that site. It is recommended that plants be obtained from native plant nursery stocks whenever possible. Collections from existing wetlands should be limited in scale and undertaken with care to avoid disturbing the wetland outside of the actual point of collection. Plant selection is a complex task, involving matching plant requirements with environmental conditions. It should be performed by a qualified wetlands botanist. Refer to Restoring Wetlands in Washington by the Washington Department of Ecology for more information.~~

~~Nymphaea odorata (pond lily)~~

~~Brasenia schreberi (watershield)~~

~~Nuphar luteum (yellow pond lily)~~

~~Polygonum hydropiper (smartweed)~~

~~Alisma plantago-aquatica (broadleaf water plantain)~~

~~Ludwigia palustris (water purslane)~~

~~Menyanthes trifoliata (bogbean)~~

~~Utricularia minor, U. vulgaris (bladderwort)~~

~~Emergent zone:~~

~~Carex obnupta, C. utriculata, C. areta, C. stipata, C. vesicaria, C. aquatilis, C. comosa, C. lenticularis (sedge)~~

~~Scirpus atricinctus (woolly bulrush)~~

~~Scirpus microcarpus (small fruited bulrush)~~

~~Eleocharis palustris, E. ovata (spike rush)~~

~~Epilobium watsonii (Watson's willow herb)~~

~~Typha latifolia (common cattail) (Note: This native plant can be aggressive but has been found to offer certain wildlife habitat and water quality improvement benefits; use with care.)~~

~~Veronica americana, V. scutellata (American brookline, marsh speedwell)~~

~~Mentha arvensis (field mint)~~

~~Lycopus americanus, L. uniflora (bugleweed or horehound)~~

~~Angelica species (angelica)~~

~~Oenanthe sarmentosa (water parsley)~~

~~Heracleum lanatum (cow parsnip)~~
~~Glyceria grandis, G. elata (manna grass)~~
~~Juncus acuminatus (tapertip rush)~~
~~Juncus ensifolius (daggerleaf rush)~~
~~Juncus bufonius (toad rush)~~
~~Mimulus guttatus (common monkey flower)~~
Scrub-shrub zone
~~Salix lucida, S. rigida, S. sitchensis, S. scouleriana, S. pedicellaris (willow)~~
~~Lysichiton americanus (skunk cabbage)~~
~~Athyrium filix-femina (lady fern)~~
~~Cornus sericea (redstem dogwood)~~
~~Rubus spectabilis (salmonberry)~~
~~Physocarpus capitatus (ninebark)~~
~~Ribes species (gooseberry)~~
~~Rhamnus purshiana (cascara)~~
~~Sambucus racemosa (red elderberry) (occurs in wetland-upland transition)~~
~~Lonicera involucrata (black twinberry)~~
~~Oemleria cerasiformis (Indian plum)~~
~~Stachys cooleyae (Stachy's horsemint)~~
~~Prunus emarginata (bitter cherry)~~
Forested zone:
~~Populus balsamifera, ssp. trichocarpa (black cottonwood)~~
~~Fraxinus latifolia (Oregon ash)~~
~~Thuja plicata (western red cedar)~~
~~Picea sitchensis (Sitka spruce)~~
~~Alnus rubra (red alder)~~
~~Tsuga heterophylla (hemlock)~~
~~Acer circinatum (vine maple)~~
~~Maianthemum dilatatum (wild lily of the valley)~~
~~Izula parviflora (small flower wood rush)~~
~~Torreyochloa pauciflora (weak alkaligrass)~~

~~— *Ribes* species (currants)~~

~~— **Bog:**~~

~~— *Sphagnum* species (sphagnum mosses)~~

~~— *Rhododendron groenlandicum* (Labrador tea)~~

~~— *Vaccinium oxycoccos* (bog cranberry)~~

~~— *Kalmia microphylla*, ssp. *occidentalis* (bog laurel)~~

~~— *Ilex aquifolia* (holly)~~

~~— *Impatiens glandulifera* (policeman's helmet)~~

~~— *Lotus corniculatus* (birdsfoot trefoil)~~

~~— *Lysimachia thyrsiflora* (tufted loosestrife)~~

~~— *Myriophyllum* species (water milfoil, parrot's feather)~~

~~— *Polygonum cuspidatum* (Japanese knotweed)~~

~~— *Polygonum sachalinense* (giant knotweed)~~

~~— *Rubus discolor* (Himalayan blackberry)~~

~~— *Tanacetum vulgare* (common tansy)~~

~~— *Ranunculus repens* (creeping buttercup)~~

**~~Wetlands Guidance Appendix 4: Comparison of Water
Chemistry Characteristics In *Sphagnum* Bog And Fen
Versus More Typical Wetlands~~**

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Appendix I-E Flow Control-Exempt Surface Waters

Stormwater discharges, that are otherwise subject to Minimum Requirement #7 – Flow Control, to waters on this list must meet the following restrictions to be exempt from Minimum Requirement #7.

- Direct discharge to the exempt receiving water does not result in the diversion of drainage from any perennial stream classified as Types 1, 2, 3, or 4 in the State of Washington Interim Water Typing System, or Types “S”, “F”, or “Np” in the Permanent Water Typing System, or from any category I, II, or III wetland; and
- Flow splitting devices or drainage BMP’s are applied to route natural runoff volumes from the project site to any downstream Type 5 stream or category IV wetland:
 - Design of flow splitting devices or drainage BMP’s will be based on continuous hydrologic modeling analysis. ~~Design of flow splitting devices or drainage BMP’s will be based on continuous hydrologic modeling analysis.~~ The design will assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50% of the 2-year to the 50-year peak flow.
 - Flow splitting devices or drainage BMP’s that deliver flow to category IV wetlands will also be designed using continuous hydrologic modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction; and
- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection, etc.) and extends to the ordinary high water ~~line~~mark of the exempt receiving water; and
- The conveyance system between the project site and the exempt receiving water shall have a hydraulic capacity sufficient to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Exempt Surface Waters List.

Water Body	Upstream Point/Reach for Exemption (if applicable)
Alder Lake	
Baker Lake	
Baker River	Baker River/Baker Lake downstream of the confluence with Noisy Creek
Bogachiel River	0.4 miles downstream of Dowans Creek
Calawah River	Downstream of confluence with South Fork Calawah River
Capital Lake / Deschutes River	Downstream of Tumwater Falls
Carbon River	Downstream of confluence with South Prairie Creek
Cascade River	Downstream of Found Creek
Cedar River	Downstream of confluence with Taylor Creek
Chehalis River	1,500 feet downstream of confluence with Stowe Creek
Chehalis River, South Fork	1,000 feet upstream of confluence with Lake Creek
Cispus River	Downstream of confluence with Cat Creek
Clearwater River	Downstream of confluence with Christmas Creek
Coal Creek Slough	Boundary of Consolidated Diking and Irrigation District #1 to confluence with the Columbia River.
Columbia River	Downstream of Canadian border
Consolidated Diking and Irrigations District #1	Waters that lie within the area bounded by the Columbia River on the south, the Cowlitz River on the east, Ditch No. 10 to the west, and Ditch No. 6 to the north.
Consolidated Diking and Irrigation District #3	Ditches served by these pump stations: Tam O'Shanter #1 and #2, Coweeman, Baker Way, Elk's
Coweman River	Downstream of confluence with Gobble Creek
Cowlitz River	Downstream of confluence of Ohanapecosh River and Clear Fork Cowlitz River
Crescent Lake	
Dickey River	Downstream of confluence with Coal Creek
Dosewallips River	Downstream of confluence with Rocky Brook
Dungeness River	Downstream of confluence with Gray Wolf River
Duwamish / Green River	Downstream River Mile 6 (S. Boeing Access Road)
Elwha River	Downstream of confluence with Goldie River
Erdahl Ditch in Fife	Downstream of pump station
First Creek in Tacoma	
Grays River	Downstream of confluence with Hull Creek
Green River (WRIA 26 – Cowlitz)	3.5 miles upstream of Devils Creek
Hoh River	1.2 miles downstream of Jackson Creek
Humptulips River	Downstream of confluence with West and East Forks
Johns Creek	Downstream of Interstate-405 East Right-of-way
Kalama River	2.0 miles downstream of Jacks Creek
Lacamas Lake	
Lake Cushman	
Lake Quinault	
Lake River (Clark County)	
Lake Shannon	
Lake Sammamish	
Lake Union & Union Bay	King County
Lake Washington, Montlake Cut, Ship Canal, & Salmon Bay	

Water Body	Upstream Point/Reach for Exemption (if applicable)
Lake Whatcom	
Lewis River	Downstream of confluence with Quartz Creek
Lewis River, East Fork	Downstream of confluence with Big Tree Creek
Lightning Creek	Downstream of confluence with Three Fools Creek
Little White Salmon River	Downstream of confluence with Lava Creek
Mayfield Lake	
Mercer Slough	
Muddy River	Downstream of confluence with Clear Creek
Naselle River	Downstream of confluence with Johnson Creek
Newaukum River	Downstream of confluence with South Fork Newaukum River
Nisqually River	Downstream of confluence with Big Creek
Nooksack River	Downstream of confluence of North Fork and Middle Forks
Nooksack River, North Fork	Downstream of confluence with Glacier Creek, at USGS gauge 12205000
Nooksack River, South Fork	0.1 miles upstream of confluence with Skookum Creek
North River	Downstream of confluence with Vesta Creek
Ohanapecosh River	Downstream of confluence with Summit Creek
Puyallup River	Half-mile downstream of confluence with Kellog Creek
Queets River	Downstream of confluence with Tshletshy Creek
Quillayute River	Downstream of Bogachiel River
Quinalt River	Downstream of confluence with North Fork Quinalt River
Riffe Lake	
Round Lake	
Ruby Creek	Ruby Creek at SR-20 crossing downstream of Granite and Canyon Creeks
Sammamish River	Downstream of Lake Sammamish
Satsop River	Downstream of confluence of Middle and East Forks
Satsop River, East Fork	Downstream of confluence with Decker Creek
Sauk River	Downstream of confluence of South Fork and North Fork
Sauk River, North Fork	North Fork Sauk River at Bedal Campground
Silver Lake	Cowlitz County
Skagit River	Downstream of Canadian border
Skokomish River	Downstream of confluence of North and South Fork
Skokomish River, South Fork	Downstream of confluence with Vance Creek
Skokomish River, North Fork	Downstream of confluence with McTaggart Creek
Skookumchuck River	1 mile upstream of Bucoda at SR 507 mile post 11.0
Skykomish River	Downstream of South Fork
Skykomish River, South Fork	Downstream of confluence of Tye and Foss Rivers
Snohomish River	Down stream of confluence of Snoqualmie and Skykomish Rivers
Snohomish River Estuary	
Snoqualmie River	Downstream of confluence of the Middle Fork
Snoqualmie River, Middle Fork	Downstream of confluence with Rainy Creek
Sol Duc River	Downstream of confluence of North and South Fork Soleduck River
Stillaguamish River	Downstream of confluence of North and South Fork
Stillaguamish River, North Fork	7.7 highway miles west of Darrington on SR530, downstream of confluence with French Creek.
Stillaguamish River, South Fork	Downstream of confluence of Cranberry Creek and South Fork
Suiattle River	Downstream of confluence with Milk Creek
Sultan River	0.4 miles upstream of SR2
Swift Creek Reservoir	
Thunder Creek	Downstream of the confluence with Neve Creek

Water Body	Upstream Point/Reach for Exemption (if applicable)
Tilton River	Downstream of confluence with North Fork Tilton River
Toutle River	North and South Fork Confluence
Toutle River, North Fork	Downstream of confluence with Hoffstadt Creek
Toutle River, South Fork	Downstream of confluence with Thirteen Creek
Union Bay	
Vancouver Lake	
White River	Downstream of confluence with Huckleberry Creek
Willapa River	Downstream of confluence with Mill Creek
Wind River	Downstream of confluence with Cold Creek
Wynoochee Lake	
Wynoochee River	Downstream of confluence with Schafer Creek

Appendix I-F Basins with 40% or more total impervious area as of 1985

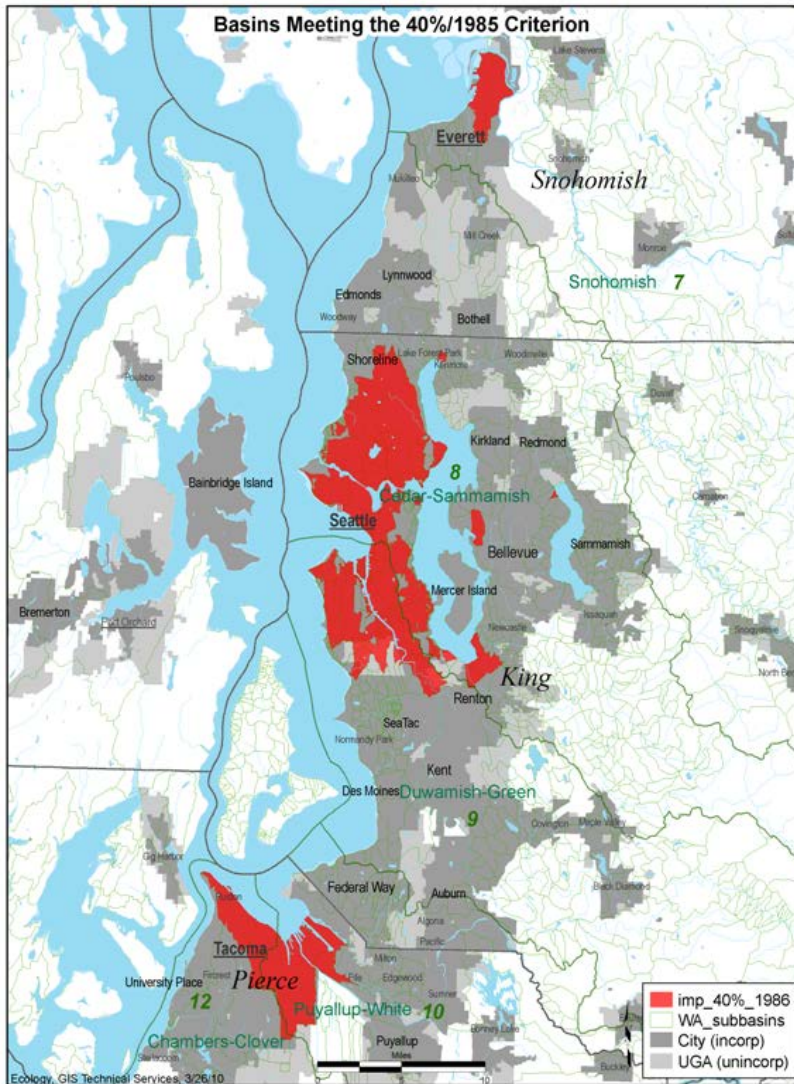


Figure F.1 – Basins with 40% total impervious area as of 1985

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Glossary and Notations

The following terms are provided for reference and use with this manual. They shall be superseded by any other definitions for these terms adopted by ordinance, unless they are defined in a Washington State WAC or RCW, or are used and defined as part of the Minimum Requirements for all new development and redevelopment.

AASHTO classification	The official classification of soil materials and soil aggregate mixtures for highway construction, used by the American Association of State Highway and Transportation Officials.
Absorption	The penetration of a substance into or through another, such as the dissolving of a soluble gas in a liquid.
Adjacent steep slope	A slope with a gradient of 15 percent or steeper within five hundred feet of the site.
Adjustment	A variation in the application of a Minimum Requirement to a particular project. Adjustments provide substantially equivalent environmental protection.
<u>Administrator</u>	<u>The local government official(s) authorized to make decisions in regard to Adjustments and Exceptions/Variances.</u>
Adsorption	The adhesion of a substance to the surface of a solid or liquid; often used to extract pollutants by causing them to be attached to such adsorbents as activated carbon or silica gel. Hydrophobic, or water-repulsing adsorbents, are used to extract oil from waterways when oil spills occur. Heavy metals such as zinc and lead often adsorb onto sediment particles.
Aeration	The process of being supplied or impregnated with air. In waste treatment, the process used to foster biological and chemical purification. In soils, the process by which air in the soil is replenished by air from the atmosphere. In a well aerated soil, the soil air is similar in composition to the atmosphere above the soil. Poorly aerated soils usually contain a much higher percentage of carbon dioxide and a correspondingly lower percentage of oxygen.
Aerobic	Living or active only in the presence of free (dissolved or molecular) oxygen.
Aerobic bacteria	Bacteria that require the presence of free oxygen for their metabolic processes.

Aggressive plant species	Opportunistic species of inferior biological value that tend to out-compete more desirable forms and become dominant; applied to native species in this manual.
Algae	Primitive plants, many microscopic, containing chlorophyll and forming the base of the food chain in aquatic environments. Some species may create a nuisance when environmental conditions are suitable for prolific growth.
Algal bloom	Proliferation of living algae on the surface of lakes, streams or ponds; often stimulated by phosphate over-enrichment. Algal blooms reduce the oxygen available to other aquatic organisms.
American Public Works Association (APWA)	The Washington State Chapter of the American Public Works Association.
Anadromous	Fish that grow to maturity in the ocean and return to rivers for spawning.
Anaerobic	Living or active in the absence of oxygen.
Anaerobic bacteria	Bacteria that do not require the presence of free or dissolved oxygen for metabolism.
Annual flood	The highest peak discharge on average which can be expected in any given year.
Antecedent moisture conditions	The degree of wetness of a watershed or within the soil at the beginning of a storm.
Anti-seep collar	A device constructed around a pipe or other conduit and placed through a dam, levee, or dike for the purpose of reducing seepage losses and piping failures.
Anti-vortex device	A facility placed at the entrance to a pipe conduit structure such as a drop inlet spillway or hood inlet spillway to prevent air from entering the structure when the pipe is flowing full.
Applicable BMPs	As used in Volume IV, applicable BMPs are those source control BMPs that are expected to be required by local governments at new development and redevelopment sites. Applicable BMPs will also be required if they are incorporated into NPDES permits, or they are included by local governments in a stormwater program for existing facilities.
Applicant	The person who has applied for a development permit or approval.
Appurtenances	Machinery, appliances, or auxiliary structures attached to a main structure, but not considered an integral part thereof, for the purpose of enabling it to function.
Aquifer	A geologic stratum containing ground water that can be withdrawn and used for human purposes.

Arterial	A road or street primarily for through traffic. <u>The term generally includes roads or streets considered collectors. It does not include local access roads which are generally limited to providing access to abutting property. See also RCW 35.78.010, RCW 36.86.070, and RCW 47.05.021.</u> A major arterial connects an Interstate Highway to cities and counties. A minor arterial connects major arterials to collectors. A collector connects an arterial to a neighborhood. A collector is not an arterial. A local access road connects individual homes to a collector.
As-built drawings	Engineering plans which have been revised to reflect all changes to the plans which occurred during construction.
As-graded	The extent of surface conditions on completion of grading.
BSBL	See <u>Building set back line</u> Building set back line.
Background	A description of pollutant levels arising from natural sources, and not because of man's immediate activities.
Backwater	Water upstream from an obstruction which is deeper than it would normally be without the obstruction.
Baffle	A device to check, deflect, or regulate flow.
Bankfull discharge	A flow condition where streamflow completely fills the stream channel up to the top of the bank. In undisturbed watersheds, the discharge conditions occur on average every 1.5 to 2 years and controls the shape and form of natural channels.
Base flood	A flood having a one percent chance of being equaled or exceeded in any given year. This is also referred to as the 100-year flood.
Base flood elevation	The water surface elevation of the base flood. It shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD).
Baseline sample	A sample collected during dry-weather flow (i.e., it does not consist of runoff from a specific precipitation event).
Basin plan	<p>A plan that assesses, evaluates, and proposes solutions to existing and potential future impacts to the beneficial uses of, and the physical, chemical, and biological properties of waters of the state within a basin. Basins typically range in size from 1 to 50 square miles. A plan should include but not be limited to recommendations for:</p> <ul style="list-style-type: none"> • Stormwater requirements for new development and redevelopment; • Capital improvement projects; • Land Use management through identification and protection of critical areas, comprehensive land use and transportation plans, zoning regulations, site development standards, and conservation areas;

- Source control activities including public education and involvement, and business programs;
- Other targeted stormwater programs and activities, such as maintenance, inspections and enforcement;
- Monitoring; and
- An implementation schedule and funding strategy.

A plan that is “adopted and implemented” must have the following characteristics:

- It must be adopted by legislative or regulatory action of jurisdictions with responsibilities under the plan;
- Ordinances, regulations, programs, and procedures recommended by the plan should be in effect or on schedule to be in effect; and,
- An implementation schedule and funding strategy that are in progress.

Bearing capacity	The maximum load that a material can support before failing.
Bedrock	The more or less solid rock in place either on or beneath the surface of the earth. It may be soft, medium, or hard and have a smooth or irregular surface.
Bench	A relatively level step excavated into earth material on which fill is to be placed.
Berm	A constructed barrier of compacted earth, rock, or gravel. In a stormwater facility, a berm may serve as a vertical divider typically built up from the bottom.
Best management practice (BMP)	The schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State.
Biochemical oxygen demand (BOD)	An indirect measure of the concentration of biologically degradable materials present in organic wastes. The amount of free oxygen utilized by aerobic organisms when allowed to attack the organic material in an aerobically maintained environment at a specified temperature (20°C) for a specific time period (5 days), and thus stated as BOD5. It is expressed in milligrams of oxygen utilized per liter of liquid waste volume (mg/l) or in milligrams of oxygen per kilogram of waste solution (mg/kg = ppm = parts per million parts). Also called biological oxygen demand.
Biodegradable	Capable of being readily broken down by biological means, especially by microbial action. Microbial action includes the combined effect of bacteria, fungus, flagellates, amoebae, ciliates, and nematodes.

	Degradation can be rapid or may take many years depending upon such factors as available oxygen and moisture.
Bioengineering	The combination of biological, mechanical, and ecological concepts (and methods) to control erosion and stabilize soil through the use of vegetation or in combination with construction materials.
Biofilter	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. The former mechanism is probably the most important in western Washington where the period of major runoff coincides with the period of lowest biological activity.
Biofiltration	The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.
Biological control	A method of controlling pest organisms by means of introduced or naturally occurring predatory organisms, sterilization, the use of inhibiting hormones, or other means, rather than by mechanical or chemical means.
Biological magnification	The increasing concentration of a substance along succeeding steps in a food chain. Also called biomagnification.
Bioretention BMP	<u>Engineered facilities that store and treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for flow attenuation. Refer to Chapter 7 of Volume V for Bioretention BMP types and design specifications.</u>
Bollard	A post (may or may not be removable) used to prevent vehicular access.
Bond	A surety bond, cash deposit or escrow account, assignment of savings, irrevocable letter of credit or other means acceptable to or required by the manager to guarantee that work is completed in compliance with the project's drainage plan and in compliance with all local government requirements.
Borrow area	A source of earth fill material used in the construction of embankments or other earth fill structures.
Buffer	The zone contiguous with a sensitive area that is required for the continued maintenance, function, and structural stability of the sensitive area. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals,

maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from stormwater runoff and precipitation, and erosion control.

Building setback line (BSBL) A line measured parallel to a property, easement, drainage facility, or buffer boundary, that delineates the area (defined by the distance of separation) where buildings or other obstructions are prohibited (including decks, patios, outbuildings, or overhangs beyond 18 inches). Wooden or chain link fences and landscaping are allowable within a building setback line. In this manual the minimum building setback line shall be 5 feet.

CIP See Capital Improvement Project.

Capital Improvement Project or Program (CIP) A project prioritized and scheduled as a part of an overall construction program or, the actual construction program.

Catch basin A chamber or well, usually built at the curb line of a street, for the admission of surface water to a sewer or subdrain, having at its base a sediment sump designed to retain grit and detritus below the point of overflow.

Catchline The point where a severe slope intercepts a different, more gentle slope.

Catchment Surface drainage area.

Cation Exchange Capacity (CEC) The amount of exchangeable cations that a soil can adsorb. Units are milli-equivalents per 100 g of soil, typically abbreviated simply as meq. Soil found to have a CEC of 5 meq at pH 7 will have CEC < 5 meq when pH < 7..

CESCL See Certified Erosion and Sediment Control Lead

Certified Erosion and Sediment Control Lead An individual who has current certification through an approved erosion and sediment control training program that meets the minimum training standards established by Ecology (see BMP C160 of Volume II). A CESCL is knowledgeable in the principles and practices of erosion and sediment control. The CESCL must have the skills to assess site conditions and construction activities that could impact the quality of stormwater and, the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges. Certification is obtained through an Ecology approved erosion and sediment control course. Course listings are provided online at Ecology's website.

Commercial Agriculture Those activities conducted on lands defined in [RCW 84.34.020\(2\)](#) and activities involved in the production of crops or livestock for commercial trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for

conversion to a nonagricultural use or has lain idle for more than five years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

Converted Vegetation (areas)	The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation (e.g., Himalayan blackberry, scotch broom) are converted to lawn or landscaped areas, or where native vegetation is converted to pasture.
Channel	A feature that conveys surface water and is open to the air.
Channel, constructed	Channels or ditches constructed (or reconstructed natural channels) to convey surface water.
Channel, natural	Streams, creeks, or swales that convey surface/ground water and have existed long enough to establish a stable route and/or biological community.
Channel stabilization	Erosion prevention and stabilization of velocity distribution in a channel using vegetation, jetties, drops, revetments, and/or other measures.
Channel storage	Water temporarily stored in channels while enroute to an outlet.
Channelization	Alteration of a stream channel by widening, deepening, straightening, cleaning, or paving certain areas to change flow characteristics.
Check dam	Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.
Chemical oxygen demand (COD)	A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water. The COD test, like the BOD test, is used to determine the degree of pollution in water.
Civil engineer	A professional engineer licensed in the State of Washington in Civil Engineering.
Civil engineering	The application of the knowledge of the forces of nature, principles of mechanics and the properties of materials to the evaluation, design and construction of civil works for the beneficial uses of mankind.
Clay lens	A naturally occurring, localized area of clay which acts as an impermeable layer to runoff infiltration.
Clearing	The destruction and removal of vegetation by manual, mechanical, or chemical methods.
Closed depression	An area which is low-lying and either has no, or such a limited, surface water outlet that during storm events the area acts as a retention basin.
Cohesion	The capacity of a soil to resist shearing stress, exclusive of functional resistance.
Coliform bacteria	Microorganisms common in the intestinal tracts of man and other warm-blooded animals; all the aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria which ferment

lactose with gas formation within 48 hours at 35°C. Used as an indicator of bacterial pollution.

Commercial agriculture

Those activities conducted on lands defined in [RCW 84.34.020\(2\)](#), and activities involved in the production of crops or livestock for wholesale trade. An activity ceases to be considered commercial agriculture when the area on which it is conducted is proposed for conversion to a nonagricultural use or has lain idle for more than five (5) years, unless the idle land is registered in a federal or state soils conservation program, or unless the activity is maintenance of irrigation ditches, laterals, canals, or drainage ditches related to an existing and ongoing agricultural activity.

Common Plan of Development or Sale

A site where multiple separate and distinct construction activities may be taking place at different times on different schedules and/or by different contractors, but still under a single plan. Examples include: 1) phase projects and projects with multiple filings or lots, even if the separate phases or filings/lots will be constructed under separate contract or by separate owners (e.g., a development where lots are sold to separate builders); 2) a development plan that may be phased over multiple years, but is still under a consistent plan for long-term development; 3) projects in a contiguous area that may be unrelated but still under the same contract, such as construction of a building extension and a new parking lot at the same facility; and 4) linear projects such as roads, pipelines, or utilities. If the project is part of a common plan of development or sale, the disturbed area of the entire plan must be used in determine permit requirements.

Compaction

The densification, settlement, or packing of soil in such a way that permeability of the soil is reduced. Compaction effectively shifts the performance of a hydrologic group to a lower permeability hydrologic group. For example, a group B hydrologic soil can be compacted and be effectively converted to a group C hydrologic soil in the way it performs in regard to runoff.

Compaction may also refer to the densification of a fill by mechanical means.

Compensatory storage

New excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe. Equivalent shall mean that the storage removed shall be replaced by equal volume between corresponding one-foot contour intervals that are hydraulically connected to the floodway through their entire depth.

Compost

Organic ~~residue or a mixture of organic residues and soil~~, solid waste that has undergone biological degradation and transformation under controlled conditions designed to promote aerobic decomposition ~~until it has become relatively stable humus.~~

~~Reference note: The Department of Ecology Interim Guidelines for Compost Quality (1994) defines compost as “at a solid waste facility in compliance with the requirements of Chapter 173-350 WAC product of composting; it has undergone an initial, rapid stage of decomposition and is in the process of humification (curing).” Compost used should meet specifications for grade A or AA compost. Natural decay of organic solid waste under uncontrolled conditions does not result in Ecology publication 94-038-composted material.~~

Composted Mulch Mulch prepared from decomposed organic materials that have undergone a controlled process to minimize weed seeds. Acceptable feedstocks include, but are not limited to, yard debris, wood waste, land clearing debris, brush, and branches.

~~**Composting** A controlled process of degrading organic matter by microorganisms. Present day composting is the aerobic, thermophilic decomposing of organic waste to relatively stable humus. Composting is the process of making usable, organic matter that is beneficial to plants and has converted nutrients into slow release forms (versus mineralized water-soluble forms found in fertilizer).~~

Composting The biological degradation and transformation of organic solid waste under controlled conditions designed to promote aerobic decomposition. Natural decay of organic solid waste under uncontrolled conditions is not composting.

Comprehensive planning Planning that takes into account all aspects of water, air, and land resources and their uses and limits.

Conservation district A public organization created under state enabling law as a special-purpose district to develop and carry out a program of soil, water, and related resource conservation, use, and development within its boundaries, usually a subdivision of state government with a local governing body and always with limited authority. Often called a soil conservation district or a soil and water conservation district.

Constructed wetland Those wetlands intentionally ~~created on~~created on sites that are not wetlands for the primary purpose of wastewater or stormwater treatment and managed as such. Constructed wetlands are normally considered as part of the stormwater collection and treatment system.

Construction Stormwater Pollution Prevention Plan A document that describes the potential for pollution problems on a construction project and explains and illustrates the measures to be taken on the construction site to control those problems.

Contour An imaginary line on the surface of the earth connecting points of the same elevation.

Converted Vegetation (Areas) The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained non-native vegetation (e.g., himalayan blackberry, scotch broom) are converted to lawn or landscaped areas,

or where native vegetation is converted to pasture.

Conveyance	A mechanism for transporting water from one point to another, including pipes, ditches, and channels.
Conveyance system	The drainage facilities, both natural and man-made, which collect, contain, and provide for the flow of surface and stormwater from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The human-made elements of the conveyance system include gutters, ditches, pipes, channels, and most retention/detention facilities.
Cover crop	A close-growing crop grown primarily for the purpose of protecting and improving soil between periods of permanent vegetation.
Created wetland	Means those wetlands intentionally created from nonwetland sites to produce or replace natural wetland habitat (e.g., compensatory mitigation projects).
Critical Areas	At a minimum, areas which include wetlands, areas with a critical recharging effect on aquifers used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, including unstable slopes, and associated areas and ecosystems.
Critical Drainage Area	An area with such severe flooding, drainage and/or erosion/sedimentation conditions that the area has been formally adopted as a Critical Drainage Area by rule under the procedures specified in an ordinance.
Critical reach	The point in a receiving stream below a discharge point at which the lowest dissolved oxygen level is reached and stream recovery begins.
Culvert	Pipe or concrete box structure that drains open channels, swales or ditches under a roadway or embankment. Typically with no catchbasins or manholes along its length.
Cut	Portion of land surface or area from which earth has been removed or will be removed by excavating; the depth below original ground surface to excavated surface.
Cut-and-fill	Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.
Cut slope	A slope formed by excavating overlying material to connect the original ground surface with a lower ground surface created by the excavation. A cut slope is distinguished from a bermed slope, which is constructed by importing soil to create the slope.
DNS	See Determination of Nonsignificance Determination of Nonsignificance.

Dead storage	The volume available in a depression in the ground below any conveyance system, or surface drainage pathway, or outlet invert elevation that could allow the discharge of surface and stormwater runoff.
Dedication of land	Refers to setting aside a portion of a property for a specific use or function.
Degradation	(Biological or chemical) The breakdown of complex organic or other chemical compounds into simpler substances, usually less harmful than the original compound, as with the degradation of a persistent pesticide. (Geological) Wearing down by erosion. (Water) The lowering of the water quality of a watercourse by an increase in the pollutant loading.
Degraded (disturbed) wetland (community)	A wetland (community) in which the vegetation, soils, and/or hydrology have been adversely altered, resulting in lost or reduced functions and values; generally, implies topographic isolation; hydrologic alterations such as hydroperiod alteration (increased or decreased quantity of water), diking, channelization, and/or outlet modification; soils alterations such as presence of fill, soil removal, and/or compaction; accumulation of toxicants in the biotic or abiotic components of the wetland; and/or low plant species richness with dominance by invasive weedy species.
Denitrification	The biochemical reduction of nitrates or nitrites in the soil or organic deposits to ammonia or free nitrogen.
Depression storage	The amount of precipitation that is trapped in depressions on the surface of the ground.
Design engineer	The professional civil engineer licensed in the State of Washington who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.
Design storm	A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) used to estimate runoff for a hypothetical storm of interest or concern for the purposes of analyzing existing drainage, designing new drainage facilities or assessing other impacts of a proposed project on the flow of surface water. (A hyetograph is a graph of percentages of total precipitation for a series of time steps representing the total time during which the precipitation occurs.)
Detention	The release of stormwater runoff from the site at a slower rate than it is collected by the stormwater facility system, the difference being held in temporary storage.
Detention facility	An above or below ground facility, such as a pond or tank, that temporarily stores stormwater runoff and subsequently releases it at a

	slower rate than it is collected by the drainage facility system. There is little or no infiltration of stored stormwater.
Detention time	The theoretical time required to displace the contents of a stormwater treatment facility at a given rate of discharge (volume divided by rate of discharge).
Determination of Nonsignificance (DNS)	The written decision by the responsible official of the lead agency that a proposal is not likely to have a significant adverse environmental impact, and therefore an EIS is not required.
Development	Means new development, redevelopment new development, redevelopment, or both. See definitions for each.
Discharge	Runoff leaving a new development or redevelopment via overland flow, built conveyance systems, or infiltration facilities. A hydraulic rate of flow, specifically fluid flow; a volume of fluid passing a point
	per ⁷ per unit of time, commonly expressed as cubic feet per second, cubic meters per second, gallons per minute, gallons per day, or millions of gallons per day.
Dispersion	Release of surface and stormwater runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils.
Ditch	A long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.
Divide, Drainage	The boundary between one drainage basin and another.
Drain	A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or ground water.
(To) Drain	To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or by internal flow. To lose water (from the soil) by percolation.
Drainage	Refers to the collection, conveyance, containment, and/or discharge of surface and stormwater runoff.
Drainage basin	A geographic and hydrologic subunit of a watershed.
Drainage channel	A drainage pathway with a well-defined bed and banks indicating frequent conveyance of surface and stormwater runoff.
Drainage course	A pathway for watershed drainage characterized by wet soil vegetation; often intermittent in flow.
Drainage easement	A legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.

Drainage pathway	The route that surface and stormwater runoff follows downslope as it leaves any part of the site.
Drainage review	An evaluation by Plan Approving Authority staff of a proposed project's compliance with the drainage requirements in this manual or its technical equivalent.
Drainage, Soil	<p>As a natural condition of the soil, soil drainage refers to the frequency and duration of periods when the soil is free of saturation; for example, in well-drained soils the water is removed readily but not rapidly; in poorly drained soils the root zone is waterlogged for long periods unless artificially drained, and the roots of ordinary crop plants cannot get enough oxygen; in excessively drained soils the water is removed so completely that most crop plants suffer from lack of water. Strictly speaking, excessively drained soils are a result of excessive runoff due to steep slopes or low available water-holding capacity due to small amounts of silt and clay in the soil material. The following classes are used to express soil drainage:</p> <p>Well drained - Excess water drains away rapidly and no mottling occurs within 36 inches of the surface.</p> <ul style="list-style-type: none"> • Moderately well drained - Water is removed from the soil somewhat slowly, resulting in small but significant periods of wetness. Mottling occurs between 18 and 36 inches. • Somewhat poorly drained - Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Mottling occurs between 8 and 18 inches. • Poorly drained - Water is removed so slowly that the soil is wet for a large part of the time. Mottling occurs between 0 and 8 inches. • Very poorly drained - Water is removed so slowly that the water table remains at or near the surface for the greater part of the time. There may also be periods of surface ponding. The soil has a black to gray surface layer with mottles up to the surface.
Drawdown	Lowering of the water surface (in open channel flow), water table or piezometric surface (in ground water flow) resulting from a withdrawal of water.
Drop-inlet spillway	Overall structure in which the water drops through a vertical riser connected to a discharge conduit.
Drop spillway	Overall structure in which the water drops over a vertical wall onto an apron at a lower elevation.
Drop structure	A structure for dropping water to a lower level and dissipating its surplus energy; a fall. A drop may be vertical or inclined.

Dry weather flow	The combination of groundwater <u>ground water</u> seepage and allowed non-stormwater flows found in storm sewers during dry weather --- . Also that flow in streams during the dry season.
EIS	See Environmental Impact Statement Environmental Impact Statement .
ESC	Erosion and Sediment Control (Plan).
Earth material	Any rock, natural soil or fill and/or any combination thereof. Earth material shall not be considered topsoil used for landscape purposes. Topsoil used for landscaped purposes shall comply with ASTM D 5268 specifications. Engineered soil/landscape systems are also defined independently.
Easement	The legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owners use of the land.
Effective Impervious Surface	Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. Impervious surfaces are considered ineffective if: 1) the runoff is dispersed through at least one hundred feet of native vegetation in accordance with BMP T5.30 – “Full Dispersion” as described in Chapter 5 of Volume V; 2) residential roof runoff is infiltrated in accordance with Downspout Full Infiltration Systems in BMP 5.10A Volume III; or 3) approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.
Embankment	A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.
Emergent plants	Aquatic plants that are rooted in the sediment but whose leaves are at or above the water surface. These wetland plants often have high habitat value for wildlife and waterfowl, and can aid in pollutant uptake.
Emergency spillway	A vegetated earth channel used to safely convey flood discharges in excess of the capacity of the principal spillway.
Emerging technology	Treatment technologies that have not been evaluated with approved protocols, but for which preliminary data indicate that they may provide a necessary function(s) in a stormwater treatment system. Emerging technologies need additional evaluation to define design criteria to achieve, or to contribute to achieving, state performance goals, and to define the limits of their use.
Energy dissipator<u>dissipater</u>	Any means by which the total energy of flowing water is reduced. In stormwater design, they are usually mechanisms that reduce velocity prior to, or at, discharge from an outfall in order to prevent erosion. They include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.
Energy gradient	The slope of the specific energy line (i.e., the sum of the potential and velocity heads).

Engineered soil/landscape system	<p>This is a self-sustaining soil and plant system that simultaneously supports plant growth, soil microbes, water infiltration, nutrient and pollutant adsorption, sediment and pollutant biofiltration, water interflow, and pollution decomposition. The system shall be protected from compaction and erosion. The system shall be planted and/or mulched as part of the installation.</p> <p>The engineered soil/plant system shall have the following characteristics:</p> <ol style="list-style-type: none"> a. Be protected from compaction and erosion. b. Have a plant system to support a sustained soil quality. c. Possess permeability characteristics of not less than 6.0, 2.0, and 0.6 inches/hour for hydrologic soil groups A, B, and C, respectively (per ASTM D 3385). D is less than 0.6 inches/hour. d. Possess minimum percent organic matter of 12, 14, 16, and 18 percent (dry-weight basis) for hydrologic soil groups A, B, C, and D, respectively (per ASTM D 2974).
Engineering geology	The application of geologic knowledge and principles in the investigation and evaluation of naturally occurring rock and soil for use in the design of civil works.
Engineering plan	A plan prepared and stamped by a professional civil engineer.
Enhancement	To raise value, desirability, or attractiveness of an environment associated with surface water.
Environmental Impact Statement (EIS)	A document that discusses the likely significant adverse impacts of a proposal, ways to lessen the impacts, and alternatives to the proposal. They are required by the national and state environmental policy acts when projects are determined to have significant environmental impact.
Erodible granular soils	Soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.
Erodible or leachable materials	Wastes, or chemicals, or other substances that measurably alter the physical or chemical characteristics of runoff when exposed to rainfall. Examples include erodible soils that are stockpiled, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, and garbage dumpster leakage.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational

creep. Also, detachment and movement of soil or rock fragments by water, wind, ice, or gravity. The following terms are used to describe different types of water erosion:

Accelerated erosion - Erosion much more rapid than normal or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of the animals or natural catastrophes that expose bare surfaces (e.g., fires).

- Geological erosion - The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plains, etc. Synonymous with natural erosion.
- Gully erosion - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.
- Natural erosion - Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man. Synonymous with geological erosion.
- Normal erosion - The gradual erosion of land used by man which does not greatly exceed natural erosion.
- Rill erosion - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently disturbed and exposed soils. See Rill.
- Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by runoff.
- Splash erosion - The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surface runoff.

Erosion classes (soil survey)

A grouping of erosion conditions based on the degree of erosion or on characteristic patterns. Applied to accelerated erosion, not to normal, natural, or geological erosion. Four erosion classes are recognized for water erosion and three for wind erosion.

Erosion and sedimentation control

Any temporary or permanent measures taken to reduce erosion; control siltation and sedimentation; and ensure that sediment-laden water does not leave the site.

Erosion and sediment control facility

A type of drainage facility designed to hold water for a period of time to allow sediment contained in the surface and stormwater runoff directed to the facility to settle out so as to improve the quality of the runoff.

Escarpment	A steep face or a ridge of high land.
Estuarine wetland	Generally, an eelgrass bed; salt marsh; or rocky, sandflat, or mudflat intertidal area where fresh and salt water mix. (Specifically, a tidal wetland with salinity greater than 0.5 parts per thousand, usually semi-enclosed by land but with partially obstructed or sporadic access to the open ocean).
Estuary	An area where fresh water meets salt water, or where the tide meets the river current (e.g., bays, mouths of rivers, salt marshes and lagoons). Estuaries serve as nurseries and spawning and feeding grounds for large groups of marine life and provide shelter and food for birds and wildlife.
Eutrophication	Refers to the process where nutrient over-enrichment of water leads to excessive growth of aquatic plants, especially algae.
Evapotranspiration	The collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere.
Excavation	The mechanical removal of earth material.
Exception	Relief from the application of a Minimum Requirement to a project.
Exfiltration	The downward movement of runoff through the bottom of an infiltration BMP into the soil layer or the downward movement of water through soil.
FIRM	See Flood Insurance Rate Map Flood Insurance Rate Map.
Fertilizer	Any material or mixture used to supply one or more of the essential plant nutrient elements.
Fill	A deposit of earth material placed by artificial means.
Filter fabric	A woven or nonwoven, water-permeable material generally made of synthetic products such as polypropylene and used in stormwater management and erosion and sediment control applications to trap sediment or prevent the clogging of aggregates by fine soil particles.
Filter fabric fence	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. Also commonly referred to in the Washington Department of Transportation standard specifications as “construction geotextile for temporary silt fences.”
Filter strip	A grassy area with gentle slopes that treats stormwater runoff from adjacent paved areas before it concentrates into a discrete channel.
Flocculation	The process by which suspended colloidal or very fine particles are assembled into larger masses or floccules which eventually settle out of suspension. This process occurs naturally but can also be caused through the use of such chemicals as alum.

Flood	An overflow or inundation that comes from a river or any other source, including (but not limited to) streams, tides, wave action, storm drains, or excess rainfall. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream.
Flood control	Methods or facilities for reducing flood flows and the extent of flooding.
Flood control project	A structural system installed to protect land and improvements from floods by the construction of dikes, river embankments, channels, or dams.
Flood frequency	The frequency with which the flood of interest may be expected to occur at a site in any average interval of years. Frequency analysis defines the "n-year flood" as being the flood that will, over a long period of time, be equaled or exceeded on the average once every "n" years.
Flood fringe	That portion of the floodplain outside of the floodway which is covered by floodwaters during the base flood; it is generally associated with slower moving or standing water rather than rapidly flowing water.
Flood hazard areas	Those areas subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions.
Flood Insurance Rate Map (FIRM)	The official map on which the Federal Emergency Management Agency has delineated many areas of flood hazard, floodway, and the risk premium zones.
Flood Insurance Study	The official report provided by the Federal Emergency Management Agency that includes flood profiles and the FIRM.
Flood peak	The highest value of the stage or discharge attained by a flood; thus, peak stage or peak discharge.
Floodplain	The total area subject to inundation by a flood including the flood fringe and floodway.
Flood-proofing	Adaptations that ensure a structure is substantially impermeable to the passage of water below the flood protection elevation that resists hydrostatic and hydrodynamic loads and effects of buoyancy.
Flood protection elevation	The base flood elevation or higher as defined by the local government.
Flood protection facility	Any levee, berm, wall, enclosure, raise bank, revetment, constructed bank stabilization, or armoring, that is commonly recognized by the community as providing significant protection to a property from inundation by flood waters.
Flood routing	An analytical technique used to compute the effects of system storage dynamics on the shape and movement of flow represented by a hydrograph.

Flood stage	The stage at which overflow of the natural banks of a stream begins.
Floodway	The channel of the river or stream and those portions of the adjoining floodplains that are reasonably required to carry and discharge the base flood flow. The portions of the adjoining floodplains which are considered to be "reasonably required" is defined by flood hazard regulations.
Flow control BMP (or facility)	A drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.
Flow control facility	A drainage facility designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff for a short period of time, releasing it to the conveyance system at a controlled rate.
Flow duration	The aggregate time that peak flows are at or above a particular flow rate of interest. For example, the amount of time that peak flows are at or above 50% of the 2-year peak flow rate for a period of record.
Flow frequency	The inverse of the probability that the flow will be equaled or exceeded in any given year (the exceedance probability). For example, if the exceedance probability is 0.01 or 1 in 100, that flow is referred to as the 100-year flow.
Flow path	The route that stormwater runoff follows between two points of interest.
Forebay	An easily maintained, extra storage area provided near an inlet of a BMP to trap incoming sediments before they accumulate in a pond or wetland BMP.
Forest practice	Any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing timber, including but not limited to: <ul style="list-style-type: none"> a. a. Road and trail construction. b. b. Harvesting, final and intermediate. c. c. Precommercial thinning. d. d. Reforestation. e. e. Fertilization. f. f. Prevention and suppression of diseases and insects.

	g. g. —Salvage of trees.
	h. h. —Brush control.
Forested communities (wetlands)	In general terms, communities (wetlands) characterized by woody vegetation that is greater than or equal to 6 meters in height; in this manual the term applies to such communities (wetlands) that represent a significant amount of tree cover consisting of species that offer wildlife habitat and other values and advance the performance of wetland functions overall.
Freeboard	The vertical distance between the design water surface elevation and the elevation of the barrier that contains the water.
Frequently flooded areas	The 100-year floodplain designations of the Federal Emergency Management Agency and the National Flood Insurance Program or as defined by the local government.
Frost-heave	The upward movement of soil surface due to the expansion of water stored between particles in the first few feet of the soil profile as it freezes. May cause surface fracturing of asphalt or concrete.
Frequency of storm (design storm frequency)	The anticipated period in years that will elapse, based on average probability of storms in the design region, before a storm of a given intensity and/or total volume will recur; thus a 10-year storm can be expected to occur on the average once every 10 years. Sewers designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.
Fully controlled limited access highway	A highway where the right of owner or occupants of abutting land or other persons to access, light, air, or view in connection with the highway is controlled to give preference to through traffic by providing access connections with selected public roads only, and by prohibiting crossings or direct private driveway connections at grade. (See WAC 468-58-010)
FunctionsFunction(s)	The ecological (physical, chemical, and biological) processes or attributes of a wetland without regard for their importance to society (see also values values). Wetland functions include food chain support, provision of ecosystem diversity and fish and wildlife habitat, floodflow alteration, ground water recharge and discharge, water quality improvement, and soil stabilization.
Gabion	A rectangular or cylindrical wire mesh cage (a chicken wire basket) filled with rock and used as a protecting agent, revetment, etc., against erosion. Soft gabions, often used in streambank stabilization, are made of geotextiles filled with dirt, in between which cuttings are placed.
Gage or gauge	Device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc. Also, a measure of the thickness of metal; e.g., diameter of wire, wall thickness of steel pipe.

Gaging station	A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.
Geologist	A person who has earned a degree in geology from an accredited college or university or who has equivalent educational training and has at least five years of experience as a practicing geologist or four years of experience and at least two years post-graduate study, research or teaching. The practical experience shall include at least three years work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers.
Geologically hazardous areas	Areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.
Geometrics	The mathematical relationships between points, lines, angles, and surfaces used to measure and identify areas of land.
Geotechnical professional civil engineer	A practicing, geotechnical/civil engineer licensed as a professional Civil Engineer with the State of Washington who has at least four years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.
Grade	The slope of a road, channel, or natural ground. The finished surface of a canal bed, roadbed, top of embankment, or bottom of excavation; any surface prepared for the support of construction such as paving or the laying of a conduit.
(To) Grade	To finish the surface of a canal bed, roadbed, top of embankment or bottom of excavation.
Gradient terrace	An earth embankment or a ridge-and-channel constructed with suitable spacing and an acceptable grade to reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a stable nonerosive velocity.
Grassed waterway	A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, used to conduct surface water from an area at a reduced flow rate. See also biofilter biofilter.
Ground water	Water in a saturated zone or stratum beneath the land surface or a surface waterbody.
Ground water recharge	Inflow to a ground water reservoir.
Ground water table	The free surface of the ground water, that surface subject to atmospheric pressure under the ground, generally rising and falling with the season, the rate of withdrawal, the rate of restoration, and other conditions. It is seldom static.

Gully	A channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.
Habitat	The specific area or environment in which a particular type of plant or animal lives. An organism's habitat must provide all of the basic requirements for life and should be protected from harmful biological, chemical, and physical alterations.
Hardpan	A cemented or compacted and often clay-like layer of soil that is impenetrable by roots. Also known as glacial till.
Hard Surface	<u>An impervious surface, a permeable pavement, or a vegetated roof.</u>
Harmful pollutant	A substance that has adverse effects to an organism including immediate death, chronic poisoning, impaired reproduction, cancer or other effects.
Head (hydraulics)	The height of water above any plane of reference. The energy, either kinetic or potential, possessed by each unit weight of a liquid, expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head, velocity head, and head loss.
Head loss	Energy loss due to friction, eddies, changes in velocity, or direction of flow.
Heavy metals	Metals of high specific gravity, present in municipal and industrial wastes, that pose long-term environmental hazards. Such metals include cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc.
High-use site	<p>High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:</p> <ul style="list-style-type: none"> • An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area; • An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil; • An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);<u>An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);</u> • A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any

intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Highway

A main public road connecting towns and cities.

Hog fuel

~~See~~ Wood-based mulch.

Horton overland flow

A runoff process whereby the rainfall rate exceeds the infiltration rate, so that the precipitation that does not infiltrate flows downhill over the soil surface.

HSPF

Hydrological Simulation Program-Fortran. A continuous simulation hydrologic model that transforms an uninterrupted rainfall record into a concurrent series of runoff or flow data by means of a set of mathematical algorithms which represent the rainfall-runoff process at some conceptual level.

Humus

Organic matter in or on a soil, composed of partly or fully decomposed bits of plant tissue or from animal manure.

Hydraulic Conductivity

The quality of saturated soil that enables water or air to move through it. Also known as permeability coefficient

Hydraulic gradient

Slope of the potential head relative to a fixed datum.

Hydrodynamics

Means the dynamic energy, force, or motion of fluids as affected by the physical forces acting upon those fluids.

Hydrograph

A graph of runoff rate, inflow rate or discharge rate, past a specific point over time.

Hydrologic cycle

The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrologic Soil Groups

A soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties.

Type A: Low runoff potential. Soils having high infiltration rates, even when thoroughly wetted, and consisting chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Type B: Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted, and consisting chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Type C: Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted, and consisting chiefly of soils with a layer that impedes downward movement of water, or soils

with moderately fine to fine textures. These soils have a slow rate of water transmission.

Type D: High runoff potential. Soils having very slow infiltration rates when thoroughly wetted, and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan, till, or clay layer at or near the surface, soils with a compacted subgrade at or near the surface, and shallow soils or nearly impervious material. These soils have a very slow rate of water transmission.¹

¹ Vladimir Novotny and Harvey Olem. *Water Quality Prevention, Identification, and Management of Diffuse Pollution*, Van Nostrand Reinhold: New York, 1994, p. 109.

Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.
Hydroperiod	A seasonal occurrence of flooding and/or soil saturation; it encompasses depth, frequency, duration, and seasonal pattern of inundation.
Hyetograph	A graph of percentages of total precipitation for a series of time steps representing the total time in which precipitation occurs.
Illicit discharge	All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or ground water quality standards, including but not limited to sanitary sewer connections, industrial process water, interior floor drains, car washing, and greywater systems.
Impact basin	A device used to dissipate the energy of flowing water. Generally constructed of concrete in the form of a partially depressed or partially submerged vessel, it may utilize baffles to dissipate velocities.
Impervious	A surface which cannot be easily penetrated. For instance, rain does not readily penetrate paved surfaces.
Impervious surface	A hard non-vegetated surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. A hard non-vegetated surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, 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 runoff modeling.

Impoundment

A natural or man-made containment for surface water.

Improvement

Streets (with or without curbs or gutters), sidewalks, crosswalks, parking lots, water mains, sanitary and storm sewers, drainage facilities, street trees and other appropriate items.

Industrial activities

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

Means the downward movement of water from the surface to the subsoil.

**Infiltration facility
(or system)**

A drainage facility designed to use the hydrologic process of surface and stormwater runoff soaking into the ground, commonly referred to as a percolation, to dispose of surface and stormwater runoff.

Infiltration rate

The rate, usually expressed in inches/hour, at which water moves downward (percolates) through the soil profile. Short-term infiltration rates may be inferred from soil analysis or ~~texture or~~ derived from field measurements. Long-term infiltration rates are affected by variability in soils and subsurface conditions at the site, the effectiveness of pretreatment or influent control, and the degree of long-term maintenance of the infiltration facility.

Ingress/egress

The points of access to and from a property.

Inlet

A form of connection between surface of the ground and a drain or sewer for the admission of surface and stormwater runoff.

Insecticide

A substance, usually chemical, that is used to kill insects.

**Interception
(Hydraulics)**

The process by which precipitation is caught and held by foliage, twigs, and branches of trees, shrubs, and other vegetation. Often used for "interception loss" or the amount of water evaporated from the precipitation intercepted.

Interflow

That portion of rainfall that infiltrates into the soil and moves laterally through the upper soil horizons until intercepted by a stream channel or until it returns to the surface for example, in a roadside ditch,

	wetland, spring or seep. Interflow is a function of the soil system depth, permeability, and water-holding capacity.
Intermittent stream	A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. It is dry for a large part of the year, ordinarily more than three months.
Invasive weedy plant species	Opportunistic species of inferior biological value that tend to out-compete more desirable forms and become dominant; applied to non-native species in this manual.
Invert	The lowest point on the inside of a sewer or other conduit.
Invert elevation	The vertical elevation of a pipe or orifice in a pond that defines the water level.
Isopluvial map	A map with lines representing constant depth of total precipitation for a given return frequency.
Lag time	The interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff.
Lake	An area permanently inundated by water in excess of two meters deep and greater than 20 acres in size as measured at the ordinary high water marks.
Land disturbing activity	Any activity that results in a change in the existing soil cover (both vegetative and nonvegetative) and/or the existing soil topography. Land disturbing activities include, but are not limited to clearing, grading, filling, and excavation. Compaction that is associated with stabilization of structures and road construction shall also be considered a land disturbing activity. Vegetation maintenance practices, including landscape maintenance and gardening, are not considered land-disturbing activity. Stormwater facility maintenance is not considered land disturbing activity if conducted according to established standards and procedures.
Landslide	Episodic downslope movement of a mass of soil or rock that includes but is not limited to rockfalls, slumps, mudflows, and earthflows. For the purpose of these rules, snow avalanches are considered to be a special case of landsliding.
Landslide hazard areas	Those areas subject to a severe risk of landslide.
Leachable materials	Those substances that, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff. Examples include erodible soils, uncovered process wastes, manure, fertilizers, oil substances, ashes, kiln dust, and garbage dumpster leakage.
Leachate	Liquid that has percolated through soil and contains substances in solution or suspension.

Leaching	Removal of the more soluble materials from the soil by percolating waters.
Legume	A member of the legume or pulse family, <u>Leguminosae</u> , one of the most important and widely distributed plant families. The fruit is a "legume" or pod. Includes many valuable food and forage species, such as peas, beans, clovers, alfalfas, sweet clovers, and vetches. Practically all legumes are nitrogen-fixing plants.
Level pool routing	The basic technique of storage routing used for sizing and analyzing detention storage and determining water levels for ponding water bodies. The level pool routing technique is based on the continuity equation: Inflow – Outflow = Change in storage.
Level spreader	A temporary ESC device used to spread out stormwater runoff uniformly over the ground surface as sheet flow (i.e., not through channels). The purpose of level spreaders is to prevent concentrated, erosive flows from occurring, and to enhance infiltration.
LID	See Low Impact Development
Local government	Any county, city, town, or special purpose district having its own incorporated government for local affairs.
Low flow channel	An incised or paved channel from inlet to outlet in a dry basin which is designed to carry low runoff flows and/or baseflow, directly to the outlet without detention.
Low Impact Development (LID)	A stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.
Low Impact Development (LID) Best Management Practices	Distributed stormwater management practices, integrated into a project design, that emphasize pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration. LID BMPs include, but are not limited to, bioretention/rain gardens, permeable pavements, roof downspout controls, dispersion, soil quality and depth, minimal excavation foundations, vegetated roofs, and water re-use.
Low Impact Development (LID) Principles	Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff.
Low permeable liner	A layer of compacted till or clay, or a geomembrane.
Lowest floor	The lowest enclosed area (including basement) of a structure. An area used solely for parking of vehicles, building access, or storage, in an area other than a basement area, is not considered a building's lowest

floor, provided that the enclosed area meets all of the structural requirements of the flood hazard standards.

MDNS

A Mitigated Determination of Nonsignificance (See [DNS](#) and [Mitigation](#)).

Maintenance

Repair and maintenance includes activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and ~~resulting results~~ in no significant adverse hydrologic impact. It includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems ~~and includes~~. Those usual activities may include replacement of ~~dysfunctioning~~ facilities, including cases where environmental permits require replacing an existing structure with a different type structure, as long as the functioning characteristics of the original structure are not changed. For example, replacing is the replacement of a collapsed, fish blocking, round culvert with a new box culvert under the same span, or width, of roadway. For further details on the application of this manual in regard to various road management functions, please see Section 2.2 stormwater facilities, maintenance includes assessment to ensure ongoing proper operation, removal of built-up pollutants (i.e., sediments), replacement of failed or failing treatment media, and other actions taken to correct defects as identified in chapter 2 the maintenance standards of Chapter 4, Volume V. See also Pavement Maintenance exemptions in Section 2.2 of Volume I.

Manning's equation

An equation used to predict the velocity of water flow in an open channel or pipelines:

$$V = \frac{1.486R^{2/3}S^{1/2}}{n}$$

where:

V is the mean velocity of flow in feet per second

R is the hydraulic radius in feet

S is the slope of the energy gradient or, for assumed uniform flow, the slope of the channel in feet per foot; and

n is Manning's roughness coefficient or retardance factor of the channel lining.

Mass wasting

The movement of large volumes of earth material downslope.

Master drainage plan

A comprehensive drainage control plan intended to prevent significant adverse impacts to the natural and manmade drainage system, both on and off-site.

Mean annual water level fluctuation

Derived as follows:

- (1) Measure the maximum water level (e.g., with a crest stage

gage, Reinelt and Horner 1990) and the existing water level at the time of the site visit (e.g., with a staff gage) on at least eight occasions spread through a year.

- (2) Take the difference of the maximum and existing water level on each occasion and divide by the number of occasions.

Mean depth	Average depth; cross-sectional area of a stream or channel divided by its surface or top width.
Mean velocity	The average velocity of a stream flowing in a channel or conduit at a given cross-section or in a given reach. It is equal to the discharge divided by the cross-sectional area of the reach.
Measuring weir	A shaped notch through which water flows are measured. Common shapes are rectangular, trapezoidal, and triangular.
Mechanical analysis	The analytical procedure by which soil particles are separated to determine the particle size distribution.
Mechanical practices	Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion.
Metals	Elements, such as mercury, lead, nickel, zinc and cadmium, which are of environmental concern because they do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations. They are also referred to as heavy metals.
Microbes	The lower trophic levels of the soil food web. They are normally considered to include bacteria, fungi, flagellates, amoebae, ciliates, and nematodes. These in turn support the higher trophic levels, such as mites and earthworms. Together they are the basic life forms that are necessary for plant growth. Soil microbes also function to bioremediate pollutants such as petroleum, nutrients, and pathogens.
Mitigation	Means, in the following order of preference: <ol style="list-style-type: none"> a. Avoiding the impact altogether by not taking a certain action or part of an action; b. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts; c. Rectifying the impact by repairing, rehabilitating or restoring the affected environment; d. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and e. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.

Modification, modified (wetland)	A wetland whose physical, hydrological, or water quality characteristics have been purposefully altered for a management purpose, such as by dredging, filling, forebay construction, and inlet or outlet control.
Monitor	To systematically and repeatedly measure something in order to track changes.
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.
NGPE	See Native Growth Protection Easement Native Growth Protection Easement.
NGVD	National Geodetic Vertical Datum.
NPDES	The National Pollutant Discharge Elimination System as established by the Federal Clean Water Act.
National Pollutant Discharge Elimination System (NPDES)	The part of the federal Clean Water Act, which requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and, in Washington State, are administered by the Washington State Department of Ecology.
Native Growth Protection Easement (NGPE)	An easement granted for the protection of native vegetation within a sensitive area or its associated buffer. The NGPE shall be recorded on the appropriate documents of title and filed with the County Records Division.
Native vegetation	Vegetation comprised of plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and which reasonably could have been expected to naturally occur on the site. Examples include trees such as Douglas fir, Western Hemlock, Western Red Cedar, Alder, Big-leaf Maple, and Vine Maple; shrubs such as willow, elderberry, salmonberry and salal; and herbaceous plants such as sword fern, foam flower, and fireweed.
Natural location	Means the location of those channels, swales, and other non-manmade conveyance systems as defined by the first documented topographic contours existing for the subject property, either from maps or photographs, or such other means as appropriate. In the case of outwash soils with relatively flat terrain, no natural location of surface discharge may exist.
New development	Land disturbing activities, including Class IV -general forest practices that are conversions from timber land to other uses; structural development, including construction or installation of a building or other structure; creation of impervious <u>hard</u> surfaces; and subdivision, short subdivision and binding site plans, as defined and applied in

	Chapter 58.17 RCW Chapter 58.17 RCW . Projects meeting the definition of redevelopment shall not be considered new development.
Nitrate (NO₃)	A form of nitrogen which is an essential nutrient to plants. It can cause algal blooms in water if all other nutrients are present in sufficient quantities. It is a product of bacterial oxidation of other forms of nitrogen, from the atmosphere during electrical storms and from fertilizer manufacturing.
Nitrification	The biochemical oxidation process by which ammonia is changed first to nitrites and then to nitrates by bacterial action, consuming oxygen in the water.
Nitrogen, Available	Usually ammonium, nitrite, and nitrate ions, and certain simple amines available for plant growth. A small fraction of organic or total nitrogen in the soil is available at any time.
Nonpoint source pollution	Pollution that enters a waterbody from diffuse origins on the watershed and does not result from discernible, confined, or discrete conveyances.
Normal depth	The depth of uniform flow. This is a unique depth of flow for any combination of channel characteristics and flow conditions. Normal depth is calculated using Manning's Equation.
NRCS Method	A single-event hydrologic analysis technique for estimating runoff based on the Curve Number method. The Curve Numbers are published by NRCS in Technical Release No. 55: Urban Hydrology for Small Watersheds, 1986 See SCS. With the change in name to the Natural Resource Conservation Service, the method may be referred to as the NRCS Method.
Nutrients	Essential chemicals 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.
Off-line facilities	Water quality treatment facilities to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.
Off-site	Any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.
Off-system storage	Facilities for holding or retaining excess flows over and above the carrying capacity of the stormwater conveyance system, in chambers, tanks, lagoons, ponds, or other basins that are not a part of the subsurface sewer system.
Oil/water separator	A vault, usually underground, designed to provide a quiescent environment to separate oil from water.
On-line facilities	Water quality treatment facilities which receive all of the stormwater runoff from a drainage area. Flows above the water quality design flow

rate or volume are passed through at a lower percent removal efficiency.

On-site

The entire property that includes the proposed development.

On-site Stormwater Management BMPs

As used in this manual, a synonym for Low Impact Development BMPs.

Operational BMPs

Operational BMPs are a type of Source Control BMP. They are schedules of activities, prohibition of practices, and other managerial practices to prevent or reduce pollutants from entering stormwater. Operational BMPs include formation of a pollution prevention team, good housekeeping, preventive maintenance procedures, spill prevention and clean-up, employee training, inspections of pollutant sources and BMPs, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes.

Ordinary high water mark

The term ordinary high water mark means the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil destruction on terrestrial vegetation, or the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding area.

The ordinary high water mark will be found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water shall substitute. In any area where neither can be found, the channel bank shall be substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute shall be measured so as to include the entire stream feature.

Organic matter

Organic matter as decomposed animal or vegetable matter. It is measured by ASTM D 2974. Organic matter is an important reservoir of carbon and a dynamic component of soil and the carbon cycle. It improves soil and plant efficiency by improving soil physical properties including drainage, aeration, and other structural characteristics. It contains the nutrients, microbes, and higher-form soil food web organisms necessary for plant growth. The maturity of organic matter is a measure of its beneficial properties. Raw organic matter can release water-soluble nutrients (similar to chemical fertilizer). Beneficial organic matter has undergone a humification process either naturally in the environment or through a composting process.

Orifice	An opening with closed perimeter, usually sharp-edged, and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of water.
Outlet	Point of water disposal from a stream, river, lake, tidewater, or artificial drain.
Outlet channel	A waterway constructed or altered primarily to carry water from man-made structures, such as terraces, tile lines, and diversions.
Outwash soils	Soils formed from highly permeable sands and gravels.
Overflow	A pipeline or conduit device, together with an outlet pipe, that provides for the discharge of portions of combined sewer flows into receiving waters or other points of disposal, after a regular device has allowed the portion of the flow which can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.
Overflow rate	Detention basin release rate divided by the surface area of the basin. It can be thought of as an average flow rate through the basin.
Overtopping	To flow over the limits of a containment or conveyance element.
Partially controlled limited access highway	A highway where the right of owner or occupants of abutting land or other persons to access, light, air, or view in connection with the highway is controlled to give preference to through traffic to a degree that, in addition to access connections with selected public roads, there may be some crossings and some private driveway connections at grade. (See WAC 468-58-010)
Particle Size	The effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods.
Peak discharge	The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.
Peak-shaving	Controlling post-development peak discharge rates to pre-development levels by providing temporary detention in a BMP.
Percolation	The movement of water through soil.
Percolation rate	The rate, often expressed in minutes/inch, at which clear water, maintained at a relatively constant depth, will seep out of a standardized test hole that has been previously saturated. The term percolation rate is often used synonymously with infiltration rate (short-term infiltration rate).
Permanent Stormwater Control (PSC) Plan	A plan which includes permanent BMPs for the control of pollution from stormwater runoff after construction and/or land disturbing activity has been completed
Permeable pavement	<u>Pervious concrete, porous asphalt, permeable pavers or other forms of pervious or porous paving material intended to allow passage of water</u>

	<u>through the pavement section. It often includes an aggregate base that provides structural support and acts as a stormwater reservoir.</u>
Permeable soils	Soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as SCS hydrologic soil types A and B.
Person	Any individual, partnership, corporation, association, organization, cooperative, public or municipal corporation, agency of the state, or local government unit, however designated.
Perviousness	Related to the size and continuity of void spaces in soils; related to a soil's infiltration rate.
<u>Pervious Surface</u>	<u>A surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.</u>
Pesticide	A general term used to describe any substance - usually chemical - used to destroy or control organisms; includes herbicides, insecticides, algicides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins that are extracted from plants and animals.
pH	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 acid.
Physiographic	Characteristics of the natural physical environment (including hills).
Plan Approval Authority	The Plan Approval Authority is defined as that department within a local government that has been delegated authority to approve stormwater site plans.
Planned unit development (PUD)	A special classification authorized in some zoning ordinances, where a unit of land under control of a single developer may be used for a variety of uses and densities, subject to review and approval by the local governing body. The locations of the zones are usually decided on a case-by-case basis.
Plat	A map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.
Plunge pool	A device used to dissipate the energy of flowing water that may be constructed or made by the action of flowing. These facilities may be protected by various lining materials.
Point discharge	The release of collected and/or concentrated surface and stormwater runoff from a pipe, culvert, or channel.

Point of compliance	The location at which compliance with a discharge performance standard or a receiving water quality standard is measured.
Pollution	Contamination or other alteration of the physical, chemical, or biological properties, of waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental or injurious to the public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life.
Pollution-generating hard surface (PGHS)	Those hard surfaces considered to be a significant source of pollutants in stormwater runoff. See the listing of surfaces under pollution-generating impervious surface.
Pollution-generating impervious surface (PGIS)	Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to: vehicular use; industrial activities (as further defined in this glossary); or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall; metal roofs unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating); or roofs that are subject to venting significant amounts of dusts, mists, or fumes from manufacturing, commercial, or other indoor activities.
Pollution-generating pervious surface (PGPS)	Any non-impervious surface subject to vehicular use, industrial activities (as further defined in this glossary); or storage of erodible or leachable materials, wastes or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall, use of pesticides and fertilizers, or loss of soil. Typical PGPS include permeable pavement subject to vehicular use, lawns and landscaped areas including: golf courses, parks, cemeteries, and sports fields (natural and artificial turf).
Predeveloped Condition	The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The pre-developed condition shall be assumed to be forested land cover unless reasonable, historic information is provided that indicates the site was prairie prior to settlement.

~~— 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, 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.
Prediction	For the purposes of this document an expected outcome based on the results of hydrologic modelling and/or the judgment of a trained professional civil engineer or geologist.
Pretreatment	The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a Basic Treatment BMP prior to infiltration.
Priority peat systems	Unique, irreplaceable fens that can exhibit water pH in a wide range from highly acidic to alkaline, including fens typified by Sphagnum species, <u>Ledum groenlandicum</u> (Labrador tea), <u>Drosera rotundifolia</u> (sundew), and <u>Vaccinium oxycoccos</u> (bog cranberry); marl fens; estuarine peat deposits; and other moss peat systems with relatively diverse, undisturbed flora and fauna. Bog is the common name for peat systems having the Sphagnum association described, but this term applies strictly only to systems that receive water income from precipitation exclusively.
Professional civil engineer	A person registered with the state of Washington as a professional engineer in civil engineering.
Project	Any proposed action to alter or develop a site. The proposed action of a permit application or an approval, which requires drainage review.
Project site	That portion of a property, properties, or right of way subject to land disturbing activities, new impervious <u>hard</u> surfaces, or replaced impervious <u>hard</u> surfaces.
Properly Functioning Soil System (PFSS)	Equivalent to engineered soil/landscape system. This can also be a natural system that has not been disturbed or modified.
Puget Sound basin	Puget Sound south of Admiralty Inlet (including Hood Canal and Saratoga Passage); the waters north to the Canadian border, including portions of the Strait of Georgia; the Strait of Juan de Fuca south of the Canadian border; and all the lands draining into these waters as mapped in Water Resources Inventory Areas numbers 1 through 19, set forth in WAC 173-500-040 WAC 173-500-040.
R/D	See Retention/detention facility Retention/detention facility.
<u>Rain garden</u>	<u>A non-engineered shallow, landscaped depression, with compost-amended native soils and adapted plants. The depression is designed to pond and temporarily store stormwater runoff from adjacent areas, and to allow stormwater to pass through the amended soil profile. Refer to the Rain Garden Handbook for Western Washington Homeowners (WSU, 2007 or as revised) for rain garden specifications and construction guidance.</u>

Rare, threatened, or endangered species	Plant or animal species that are regional relatively uncommon, are nearing endangered status, or whose existence is in immediate jeopardy and is usually restricted to highly specific habitats. Threatened and endangered species are officially listed by federal and state authorities, whereas rare species are unofficial species of concern that fit the above definitions.
Rational method	A means of computing storm drainage flow rates (Q) by use of the formula $Q = CIA$, where C is a coefficient describing the physical drainage area, I is the rainfall intensity and A is the area. This method is no longer used in the technical manual.
Reach	A length of channel with uniform characteristics.
Receiving waters	Bodies of water or surface water systems to which surface runoff is discharged via a point source of stormwater or via sheet flow. <u>Ground water to which surface runoff is directed by infiltration.</u>
Recharge	The addition of water to the zone of saturation (i.e., an aquifer).
Recommended BMPs	As used in Volume IV, recommended BMPs are those BMPs that are not expected to be mandatory by local governments 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.
Redevelopment	On a site that is already substantially developed (i.e., has 35% or more of existing <u>impervioushard</u> surface coverage), the creation or addition of <u>impervioushard</u> surfaces; the expansion of a building footprint or addition or replacement of a structure; structural development including construction, installation or expansion of a building or other structure; replacement of <u>impervioushard</u> surface that is not part of a routine maintenance activity; and land disturbing activities.
Regional	An action (here, for stormwater management purposes) that involves more than one discrete property.
Regional detention facility	<p>A stormwater quantity control structure designed to correct existing surface water runoff problems of a basin or subbasin. The area downstream has been previously identified as having existing or predicted significant and regional flooding and/or erosion problems.</p> <p>This term is also used when a detention facility is sited to detain stormwater runoff from a number of new developments or areas within a catchment.</p>
Release rate	The computed peak rate of surface and stormwater runoff from a site.
Replaced hard surface	For structures, the removal and replacement of hard surfaces down to the foundation. For other hard surfaces, the removal down to bare soil or base course and replacement.
Replaced impervious	For structures, the removal and replacement of impervious surfaces

surface	down to the foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.
Residential density	The number of dwelling units per unit of surface area. Net density includes only occupied land. Gross density includes unoccupied portions of residential areas, such as roads and open space.
Restoration	Actions performed to reestablish wetland functional characteristics and processes that have been lost by alterations, activities, or catastrophic events in an area that no longer meets the definition of a wetland.
Retention	The process of collecting and holding surface and stormwater runoff with no surface outflow.
Retention/detention facility (R/D)	A type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground; or to hold surface and stormwater runoff for a short period of time and then release it to the surface and stormwater management system.
Retrofitting	The renovation of an existing structure or facility to meet changed conditions or to improve performance.
Return frequency	A statistical term for the average time of expected interval that an event of some kind will equal or exceed given conditions (e.g., a stormwater flow that occurs every 2 years).
Rhizome	A modified plant stem that grows horizontally underground.
Riffles	Fast sections of a stream where shallow water races over stones and gravel. Riffles usually support a wider variety of bottom organisms than other stream sections.
Rill	A small intermittent watercourse with steep sides, usually only a few inches deep. Often rills are caused by an increase in surface water flow when soil is cleared of vegetation.
Riprap	A facing layer or protective mound of rocks placed to prevent erosion or sloughing of a structure or embankment due to flow of surface and stormwater runoff.
Riparian	Pertaining to the banks of streams, wetlands, lakes, or tidewater.
Riser	A vertical pipe extending from the bottom of a pond BMP that is used to control the discharge rate from a BMP for a specified design storm.
Rodenticide	A substance used to destroy rodents.
Runoff	Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes and wetlands as well as shallow ground water. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.

SCS	Soil Conservation Service (now the Natural Resources Conservation Service), U.S. Department of Agriculture
SCS Method	See NRCS Method.
NRCS Method	A single-event hydrologic analysis technique for estimating runoff based on the Curve Number method. The Curve Numbers are published by NRCS in Technical Release No. 55: Urban Hydrology for Small Watersheds, 1986 Urban Hydrology for Small Watersheds, 55 TR, June 1976 . With the change in name to the Natural Resource Conservation Service, the method may be referred to as the NRCS Method.
SEPA	See State Environmental Policy Act State Environmental Policy Act .
Salmonid	A member of the fish family Salmonidae . Chinook, coho, chum, sockeye and pink salmon; cutthroat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.
Sand filter	A man-made depression or basin with a layer of sand that treats stormwater as it percolates through the sand and is discharged via a central collector pipe.
Saturation point	In soils, the point at which a soil or an aquifer will no longer absorb any amount of water without losing an equal amount.
Scour	Erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.
Sediment	Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.
Sedimentation	The depositing or formation of sediment.
Sensitive emergent vegetation communities	Assemblages of erect, rooted, herbaceous vegetation, excluding mosses and lichens, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as sundew and, as well as a number of species of <i>Carex</i> (sedges).
Sensitive life stages	Stages during which organisms have limited mobility or alternatives in securing the necessities of life, especially including reproduction, rearing, and migration periods.
Sensitive scrub-shrub vegetation communities	Assemblages of woody vegetation less than 6 meters in height, at least some of whose members have relatively narrow ranges of environmental requirements, such as hydroperiod, nutrition, temperature, and light. Examples include fen species such as Labrador tea, bog laurel, and cranberry.
Settleable solids	Those suspended solids in stormwater that separate by settling when the stormwater is held in a quiescent condition for a specified time.

Sheet erosion	The relatively uniform removal of soil from an area without the development of conspicuous water channels.
Sheet flow	Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.
Shoreline development	The proposed project as regulated by the Shoreline Management Act. Usually the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.
Short circuiting	The passage of runoff through a BMP in less than the design treatment time.
Siltation	The process by which a river, lake, or other waterbody becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.
Site	The area within defined by the legal boundaries of a parcel or parcels of land that is (are) subject to new development or redevelopment. For road projects, the length of the project site and the right-of-way boundaries define the site.
Slope	Degree of deviation of a surface from the horizontal; measured as a numerical ratio, percent, or in degrees. Expressed as a ratio, the first number is the horizontal distance (run) and the second is the vertical distance (rise), as 2:1. A 2:1 slope is a 50 percent slope. Expressed in degrees, the slope is the angle from the horizontal plane, with a 90° slope being vertical (maximum) and 45° being a 1:1 or 100 percent slope.
Sloughing	The sliding of overlying material. It is the same effect as caving, but it usually occurs when the bank or an underlying stratum is saturated or scoured. Soil The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. See also topsoil , engineered soil/landscape system topsoil, engineered soil/landscape system, and properly functioning soil system properly functioning soil system,
Soil group, hydrologic	A classification of soils by the Soil Conservation Service into four runoff potential groups. The groups range from A soils, which are very permeable and produce little or no runoff, to D soils, which are not very permeable and produce much more runoff.
Soil horizon	A layer of soil, approximately parallel to the surface, which has distinct characteristics produced by soil-forming factors.
Soil profile	A vertical section of the soil from the surface through all horizons, including C horizons.

Soil structure	The relation of particles or groups of particles which impart to the whole soil a characteristic manner of breaking; some types are crumb structure, block structure, platy structure, and columnar structure.
Soil permeability	The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.
Soil stabilization	The use of measures such as rock lining, vegetation or other engineering structures to prevent the movement of soil when loads are applied to the soil.
Soil Texture Class	The relative proportion, by weight, of particle sizes, based on the USDA system, of individual soil grains less than 2 mm equivalent diameter in a mass of soil. The basic texture classes in the approximate order of increasing proportions of fine particles include: sand, loamy sand, sandy loam, loam, silt loam, silt, clay loam, sandy clay, silty clay, and clay.
Sorption	The physical or chemical binding of pollutants to sediment or organic particles.
Source control BMP	A structure or operation that is intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This manual separates source control BMPs into two types. <i>Structural source control BMPs</i> are physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. <i>Operational BMPs</i> are non-structural practices that prevent or reduce pollutants from entering stormwater. See Volume IV for details.
Spill control device	A Tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze. Spill control devices are passive and must be cleaned-out for the spilled pollutant to actually be removed.
Spillway	A passage such as a paved apron or channel for surplus water over or around a dam or similar obstruction. An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.
State Environmental Policy Act (SEPA) RCW 43.21C	The Washington State law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size and comprehensive plans. As part of this process, environmental documents are prepared and opportunities for public comment are provided.
Steep slope	Slopes of 40 percent gradient or steeper within a vertical elevation change of at least ten feet. A slope is delineated by establishing its toe

and top, and is measured by averaging the inclination over at least ten feet of vertical relief. For the purpose of this definition:

The toe of a slope is a distinct topographic break in slope that separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the toe of a steep slope is the lowermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet; AND

The top of a slope is a distinct topographic break in slope that separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the top of a steep slope is the uppermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet.

Storage routing	A method to account for the attenuation of peak flows passing through a detention facility or other storage feature.
Storm drains	The enclosed conduits that transport surface and stormwater runoff toward points of discharge (sometimes called storm sewers).
Storm frequency	The time interval between major storms of predetermined intensity and volumes of runoff for which storm sewers and other structures are designed and constructed to handle hydraulically without surcharging and backflooding, e.g., a 2-year, 10-year or 100-year storm.
Storm sewer	A sewer that carries stormwater and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes. Also called a storm drain.
Stormwater	That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface waterbody, or a constructed infiltration facility.
Stormwater drainage system	Constructed and natural features which function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat or filter stormwater.
Stormwater facility	A constructed component of a stormwater drainage system, designed or constructed to perform a particular function, or multiple functions. Stormwater facilities include, but are not limited to, pipes, swales, ditches, culverts, street gutters, detention ponds, retention ponds, constructed wetlands, infiltration devices, catch basins, oil/water separators, and biofiltration swales.
Stormwater Management Manual for Western Washington (Stormwater Manual)	This manual, as prepared by Ecology, contains BMPs to prevent, control or treat pollution in stormwater and reduce other stormwater-related impacts to waters of the State. The Stormwater Manual is intended to provide guidance on measures necessary in western Washington to control the quantity and quality of stormwater runoff from new development and redevelopment.

Stormwater Program	Either the Basic Stormwater Program or the Comprehensive Stormwater Program (as appropriate to the context of the reference) called for under the Puget Sound Water Quality Management Plan.
Stormwater Site Plan	The comprehensive report containing all of the technical information and analysis necessary for regulatory agencies to evaluate a proposed new development or redevelopment project for compliance with stormwater requirements. Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics. <u>Contents of the Stormwater Site Plan will vary with the type and size of the project, and individual site characteristics.</u> It includes a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) and a Permanent Stormwater Control Plan (PSC Plan). Guidance on preparing a Stormwater Site Plan is contained in Chapter 3 Chapter 3 of Volume I.
Stream gaging	The quantitative determination of stream flow using gages, current meters, weirs, or other measuring instruments at selected locations. See Gaging station Gaging station.
Streambanks	The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.
Streams	Those areas where surface waters flow sufficiently to produce a defined channel or bed. A defined channel or bed is an area that demonstrates clear evidence of the passage of water and includes, but is not limited to, indicated by hydraulically sorted sediments or the removal of vegetative litter or loosely rooted vegetation by the action of moving water. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, stormwater runoff devices or other entirely artificial watercourses unless they are used to convey streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (i.e. swales) shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.
Structure	A catchbasin or manhole in reference to a storm drainage system.
Structural source control BMPs	Physical, structural, or mechanical devices or facilities that are intended to prevent pollutants from entering stormwater. Structural source control BMPs typically include: <ul style="list-style-type: none"> • Enclosing and/or covering the pollutant source (building or other enclosure, a roof over storage and working areas, temporary tarp, etc.). • Segregating the pollutant source to prevent run-on of stormwater, and to direct only contaminated stormwater to appropriate treatment BMPs.

Stub-out	A short length of pipe provided for future connection to a storm drainage system.
Subbasin	A drainage area that drains to a water-course or waterbody named and noted on common maps and which is contained within a basin.
Subcatchment	A subdivision of a drainage basin (generally determined by topography and pipe network configuration).
Subdrain	A pervious backfilled trench containing stone or a pipe for intercepting ground water or seepage.
Subgrade	A layer of stone or soil used as the underlying base for a BMP.
Subsoil	The B horizons of soils with distinct profiles. In soils with weak profile development, the subsoil can be defined as the soil below the plowed soil (or its equivalent of surface soil), in which roots normally grow. Although a common term, it cannot be defined accurately. It has been carried over from early days when "soil" was conceived only as the plowed soil and that under it as the "subsoil."
Substrate	The natural soil base underlying a BMP.
Surcharge	The flow condition occurring in closed conduits when the hydraulic grade line is above the crown of the sewer.
Surface and stormwater	Water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow ground water.
Surface and stormwater management system	Drainage facilities and any other natural features that collect, store, control, treat and/or convey surface and stormwater.
Suspended solids	Organic or inorganic particles that are suspended in and carried by the water. The term includes sand, mud, and clay particles (and associated pollutants) as well as solids in stormwater.
Swale	A shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.
Terrace	An embankment or combination of an embankment and channel across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope.
Threshold Discharge Area	An on-site area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter mile downstream (as determined by the shortest flowpath). The examples in Figure 2.3.1 of Volume I illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.

Tightline	A continuous length of pipe that conveys water from one point to another (typically down a steep slope) with no inlets or collection points in between.
Tile, Drain	Pipe made of burned clay, concrete, or similar material, in short lengths, usually laid with open joints to collect and carry excess water from the soil.
Tile drainage	Land drainage by means of a series of tile lines laid at a specified depth and grade.
Till	A layer of poorly sorted soil deposited by glacial action that generally has very low infiltration rates.
Time of concentration	The time period necessary for surface runoff to reach the outlet of a subbasin from the hydraulically most remote point in the tributary drainage area.
Topography	General term to include characteristics of the ground surface such as plains, hills, mountains, degree of relief, steepness of slopes, and other physiographic features.
Topsoil	Topsoil shall be per ASTM D5268 standard specification, and water permeability shall be 0.6 inches per hour or greater. Organic matter shall have not more than 10 percent of nutrients in mineralized water-soluble forms. Topsoil shall not have phytotoxic characteristics.
Topsoil	<u>The upper portion of a soil, usually dark colored and rich in organic material. It is more or less equivalent to the upper portion of an A horizon in an ABC soil.</u>
Total dissolved solids	The dissolved salt loading in surface and subsurface waters.
Total Petroleum Hydrocarbons (TPH)	TPH-Gx: The qualitative and quantitative method (extended) for volatile (“gasoline”) petroleum products in water; and TPH-Dx: The qualitative and quantitative method (extended) for semi-volatile (“diesel”) petroleum products in water.
Total solids	The solids in water, sewage, or other liquids, including the dissolved, filterable, and nonfilterable solids. The residue left when the moisture is evaporated and the remainder is dried at a specified temperature, usually 130°C.
Total suspended solids	That portion of the solids carried by stormwater that can be captured on a standard glass filter.
Total Maximum Daily Load (TMDL) – Water Cleanup Plan	A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources. A TMDL (also known as a Water Cleanup Plan) is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The calculation must include a margin of safety to ensure that the waterbody can be used for the purposes the State has designated. The

calculation must also account for seasonable variation in water quality. Water quality standards are set by states, territories, and tribes. They identify the uses for each waterbody, for example, drinking water supply, contact recreation (swimming), and aquatic life support (fishing), and the scientific criteria to support that use. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

Toxic	Poisonous, carcinogenic, or otherwise directly harmful to life.
Tract	A legally created parcel of property designated for special nonresidential and noncommercial uses.
Trash rack	A structural device used to prevent debris from entering a spillway or other hydraulic structure.
Travel time	The estimated time for surface water to flow between two points of interest.
Treatment BMP or Facility	A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are Wetponds, oil/water separators, biofiltration swales, and constructed wetlands.
Treatment BMP	A BMP that is intended to remove pollutants from stormwater. A few examples of treatment BMPs are Wetponds, oil/water separators, biofiltration swales, and constructed wetlands.
Treatment liner	A layer of soil that is designed to slow the rate of infiltration and provide sufficient pollutant removal so as to protect <u>groundwater</u> <u>ground water</u> quality.
Treatment train	A combination of two or more treatment facilities connected in series.
Turbidity	Dispersion or scattering of light in a liquid, caused by suspended solids and other factors; commonly used as a measure of suspended solids in a liquid.
Underdrain	Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration BMP, which are used to collect and remove excess runoff.
Undisturbed buffer	A zone where development activity shall not occur, including logging, and/or the construction of utility trenches, roads, and/or surface and stormwater facilities.
Undisturbed low gradient uplands	Forested land, sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.
Unstable slopes	Those sloping areas of land which have in the past exhibited, are currently exhibiting, or will likely in the future exhibit, mass movement of earth.
Unusual biological	Assemblages of interacting organisms that are relatively uncommon

community types	regionally.
Urbanized area	Areas designated and identified by the U.S. Bureau of Census according to the following criteria: an incorporated place and densely settled surrounding area that together have a maximum population of 50,000.
U.S. EPA	The United States Environmental Protection Agency.
Values	Wetland processes or attributes that are valuable or beneficial to society (also see Functions Functions). Wetland values include support of commercial and sport fish and wildlife species, protection of life and property from flooding, recreation, education, and aesthetic enhancement of human communities.
Variance	See Exception Exception .
Vegetation	All organic plant life growing on the surface of the earth.
<u>Vehicular Use</u>	<u>Regular use of an impervious or pervious surface by motor vehicles. The following are subject to regular vehicular use: roads, un-vegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unrestricted access fire lanes, vehicular equipment storage yards, and airport runways.</u> <u>The following are not considered subject to regular vehicular use: paved bicycle pathways separated from and not subject to drainage from roads for motor vehicles, restricted access fire lanes, and infrequently used maintenance access roads.</u>
Waterbody	Surface waters including rivers, streams, lakes, marine waters, estuaries, and wetlands.
Water Cleanup Plan	See Total Maximum Daily Load
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 design storm	The 24-hour rainfall amount with a 6-month return frequency. Commonly referred to as the 6-month, 24-hour storm.
Water quality standards	Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonate, pH, total dissolved salts, etc. In Washington, the Department of Ecology sets water quality standards.
Watershed	A geographic region within which water drains into a particular river, stream, or body of water. Watersheds can be as large as those identified and numbered by the State of Washington Water Resource Inventory Areas (WRIAs) as defined in Chapter 173-500 WAC Chapter 173-500 WAC .

Water table	The upper surface or top of the saturated portion of the soil or bedrock layer, indicates the uppermost extent of ground water.
Weir	Device for measuring or regulating the flow of water.
Weir notch	The opening in a weir for the passage of water.
Wetlands	Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetlandnon-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetlandnon-wetland areas to mitigate the conversion of wetlands. (Waterbodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)
Wetland edge	Delineation of the wetland edge shall be based on the U.S. Army Corps of Engineers <u>Wetlands Delineation Manual</u> , Technical Report Y-87-1, U.S. Army Engineers Waterways Experiment Station, Vicksburg, Miss. (1987)
Wetponds and wetvaults	Drainage facilities for water quality treatment that contain permanent pools of water that are filled during the initial runoff from a storm event. They are designed to optimize water quality by providing retention time in order to settle out particles of fine sediment to which pollutants such as heavy metals absorb, and to allow biologic activity to occur that metabolizes nutrients and organic pollutants.
Wetpool	A pond or constructed wetland that stores runoff temporarily and whose normal discharge location is elevated so as to maintain a permanent pool of water between storm events.
Zoning ordinance	An ordinance based on the police power of government to protect the public health, safety, and general welfare. It may regulate the type of use and intensity of development of land and structures to the extent necessary for a public purpose. Requirements may vary among various geographically defined areas called zones. Regulations generally cover such items as height and bulk of buildings, density of dwelling units, off-street parking, control of signs, and use of land for residential, commercial, industrial, or agricultural purposes. A zoning ordinance is one of the major methods for implementation of a comprehensive plan.

Stormwater Management Manual for Western Washington

Volume II **Construction Stormwater** **Pollution Prevention**

Prepared by:
Washington State Department of Ecology
Water Quality Program

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***Dedication**

Volume II is dedicated to the memory of Ron Devitt. Ron was with Ecology from its earliest days. He will always be remembered by the many lives he touched both within the agency and outside of the agency, and for all the good he did for Washington State's environmental health. At Ron's retirement in May 2004, an award for "Excellence in the Field" was established in his name by the Water Quality Program.

Glossary

Acronyms

AKART	All known, available, and reasonable means have been taken <u>methods of prevention, control, and treatment.</u>
ATB	Asphalt Treated Base
BFM	Bonded Fiber Matrix
BMPs	Best Management Practices
CESCL	Contractor <u>Certified</u> Erosion and Spill <u>Sediment</u> Control Lead
CESCP	Contractor's Erosion and Sediment Control Plan
<u>CFR</u>	<u>Code of Federal Regulations</u>
CPESC	Certified Professional in Erosion and Sediment Control
<u>CSWGP</u>	<u>Construction Stormwater General Permit</u>
Ecology	Washington State Department of Ecology
EPA	<u>U.S.</u> Environmental Protection Agency
ESA	<u>The Federal</u> Endangered Species Act
ESC	Erosion and Sediment Control
FCWA	Federal Clean Water Act
FEMA	Federal Emergency Management Agency
IECA	International Erosion Control Association
MBFM	Mechanically Bonded Fiber Matrix
<u>Min.</u>	<u>Minimum</u>
NOEC	No observed effects concentration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
PAM	Polyacrylamide
RUSLE	Revised Universal Soil Loss Equation
SWPPP	Stormwater Pollution Prevention Plan
TESC	Temporary Erosion and Sediment Control
TMDLs <u>TMDL</u>	Total Maximum Daily Load
USDA	United States Department of Agriculture
WSDOT	Washington State Department of Transportation

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Chapter 1 - Introduction to Construction Stormwater Pollution Prevention

1.1 Purpose of this Volume

Volume II ~~of this Stormwater Management Manual is entirely devoted to focuses on managing~~ stormwater ~~effects and controls~~ impacts associated with construction activities. Best management practices (BMPs) that are properly planned, installed, and maintained can minimize stormwater impacts, such as heavy stormwater flows, soil erosion, water-borne sediment from exposed soils, and degradation of water quality, from on-site pollutant sources. Ecology's Construction Stormwater General Permit, Ecology's Municipals Stormwater Permits, and many local jurisdictions require the implementation of the BMPs listed in this volume (See Chapter 2-It.)

Volume II addresses the planning, design, and implementation of ~~stormwater management activities prior to BMPs before~~ and during the construction ~~phase of~~ projects.

~~The objective of this volume is to provide guidance for avoiding adverse stormwater impacts from construction activities on downstream resources and on-site stormwater facilities. Minimization of stormwater flows, prevention of soil erosion, capture of water-borne sediment that has been unavoidably released from exposed soils, and protection of water quality from on-site pollutant sources are~~ A collaborative planning process with all readily achievable when the proper Best Management Practices (BMPs) are planned, installed, and properly maintained.

~~Initial discussions between the project proponents and their designer (owners, designers, contractors, engineers), and compliance inspectors can identify approaches to accomplishing reviewers is critical. Such a process can result in a high-quality, cost-effective project without compromising with excellent environmental protection. Often new ways are found to stage, time, and phase parts of a project to economize a contractor's schedule and use of construction materials. This collaborative planning process can produce methods to minimize or eliminate vulnerability and~~ It can also minimize unnecessary risk associated with some traditional construction practices and techniques. By planning your project phasing, you will better manage your contractor's schedule and materials.

The construction phase of a project is usually ~~considered~~ a temporary condition, ~~which will be supplanted by the ultimately giving way to permanent improvements and facilities for the completed project.~~ However, construction work may take place over an extended period of time, ~~including several seasons of multiple years. At.~~ Ensure that all of your management practices and control facilities used in the course of

~~construction should be~~ of sufficient size, strength, and durability to ~~readily~~ outlast the longest possible construction schedule and the worst anticipated rainfall conditions.

Linear projects, such as roadway construction and utility installations, ~~are special cases of construction activities and may~~ present ~~their own, a~~ unique set of stormwater protection challenges. You can adapt or modify many of the BMPs ~~can be adapted and modified~~ discussed in this volume to provide the controls needed to ~~adequately~~ address these projects. It may ~~by~~ be advantageous to ~~segment phase portions of~~ long, linear projects ~~into a series of separate units that can and~~ apply all necessary controls ~~pertinent to that particular unit in a timely manner. individual phases.~~

The ~~goal of a~~ Construction Stormwater Pollution Prevention Plan (SWPPP) ~~is serves as a tool for the site operator to manage the site and~~ to avoid immediate and long-term environmental loss ~~and degradation typically caused by poorly managed construction sites. Prompt implementation of.~~ Implementing a Construction SWPPP, designed in accordance with ~~Chapters 3~~ Chapters 3 and 44 of this volume, can provide a number of benefits. These include ~~minimizing construction delays, reducing resources spent on repairing erosion~~ limiting adverse effects on the environment, improving the relationship between the contractor and the permitting authority staying on schedule, and ~~limiting adverse effects on the environment~~ saving money otherwise spent on repairing erosion.

Many of the BMPs contained in this volume can be adapted and modified to provide the erosion and sediment controls needed for other activities such as mining.

1.2 ~~Content and~~ Content, Organization, and Use of this Volume

Volume II consists of four chapters that address the key considerations ~~and mechanics~~ of preparing and implementing the Construction SWPPP. Volume II should be used in developing SWPPPs:

, which are a required component of a Stormwater Site Plans (see Volume I, Chapter 43).

Chapter 1 highlights the importance of construction stormwater management in preventing pollution of surface waters. The chapter briefly lists the 13 elements (12 elements listed in the Construction General Permit and 1 additional element covering Low Impact Development) of pollution prevention ~~to be considered for all projects. The elements are fully detailed later in this volume., and discusses~~ erosion and sedimentation processes and impacts ~~are discussed.~~ Users should refer to Chapter 1 for an overview of construction stormwater issues.

Chapter 2 ~~Chapter 2~~ contains the regulatory requirements that apply to construction sites and their stormwater discharges. The Department of Ecology's (Ecology) National Pollutant Discharge Elimination System

(NPDES) discharge ~~permit and municipal construction site runoff control programs~~ permits are discussed. ~~Chapter 2~~ Chapter 2 lists Washington's Water Quality Standards pertaining to construction stormwater and explains how they apply to field situations. Users should consult Chapter 2 to determine how regulatory requirements apply to a construction sites, including permit requirements. Volume I, Section 1.6 contains more information about the relationships of this manual to the various levels of regulatory requirements.

~~Chapter 3~~ Chapter 3 presents a step-by-step method for developing a Construction SWPPP. ~~It and details the 13 elements. It includes lists of suggested BMPs to meet each element.~~ Chapter 3 encourages the examination of all ~~possible~~ conditions that could ~~reasonably~~ affect a ~~particular~~ project's stormwater control systems during the ~~project~~ construction phase. Users should read Chapter 3 of the project, to determine the organization, content, and development of a Construction SWPPP.

~~Chapter 4~~ Chapter 4 contains BMPs for construction stormwater control and site management. The first section of ~~Chapter 4~~ Chapter 4 contains BMPs for source control. The second section addresses runoff, conveyance, and treatment BMPs. Use various combinations of these BMPs ~~should be used~~ in the Construction SWPPP to satisfy each of the ~~12~~13 elements applying to the project (WAC 173-201A-510).

~~1.3~~ How to Use This Volume

~~This volume should be used in developing the Construction Stormwater Pollution Prevention Plan, which is a required component of a Stormwater Site Plan (see Volume I, Chapter 3). Users should). Users should also refer to Chapter 4 this introductory chapter for an overview of construction stormwater issues, particularly related to erosion and sedimentation. Chapter 2 should be consulted to determine the regulatory requirements that apply to a construction site, including permit requirements that deal with stormwater at construction sites. Users should read Chapter 3 to determine the organization and content of the Construction SWPPP. This chapter includes lists of suggested BMPs to meet each element of construction stormwater pollution prevention. Based on these lists, the project proponent should refer to Chapter 4 to determine which BMPs will be included in the Construction SWPPP, and to design and document application of these BMPs to the project construction site.~~

~~1.4~~ ~~Twelve~~3 ~~Thirteen~~ Elements of Construction Stormwater Pollution Prevention

The ~~12~~13 Elements listed below must be considered in the development of the Construction SWPPP unless site conditions render the element

unnecessary. If an element is considered unnecessary, the Construction SWPPP must provide the justification.

These elements cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources.

The ~~12~~13* Elements are:

1. Preserve Vegetation/Mark Clearing Limits
2. Establish Construction Access
3. Control Flow Rates
4. Install Sediment Controls
5. Stabilize Soils
6. Protect Slopes
7. Protect Drain Inlets
8. Stabilize Channels and Outlets
9. Control Pollutants
10. Control ~~De-Watering~~Dewatering
11. Maintain BMPs
12. Manage the Project
13. Protect Low Impact Development BMPs*

*Element 13 is not listed in the 2010 Construction Stormwater General Permit. Cities and counties covered under the Municipal Stormwater General Permits may require it as part of their Construction SWPPP review.

A complete description of each element and associated BMPs is given in Chapter 3~~Chapter 3.~~

1.54 Erosion and Sedimentation Impacts

Soil erosion and the resulting sedimentation produced by land development impacts the environment, damaging aquatic and recreational resources, as well as aesthetic qualities. Erosion and sedimentation ultimately affect everyone.

Common examples of the impacts of erosion and sedimentation are:

- Natural, nutrient-rich topsoils ~~are eroded away, making re-establishment of erode. Re-establishing~~ vegetation ~~is~~ difficult. ~~Consequently, without applying~~ soil amendments and fertilizers ~~must be applied. A properly functioning soil system is a sustained stormwater management mechanism. Vegetation and soil are not effectively sustained unless both are maintained in good condition.~~
- ~~Siltation~~Silt fills culverts and storm drains, decreasing capacities and increasing flooding and maintenance frequency.
- Detention facilities fill rapidly with sediment, decreasing storage capacity and increasing flooding.
- Sediment clogs infiltration devices ~~become clogged and fail-, causing failure.~~
- Sediment causes obstructions in streams and harbors ~~must be dredged to remove obstructions caused by sedimentation in order, requiring dredging~~ to restore navigability.
- ~~Sediment~~ Shallow areas in lakes ~~builds more form~~ rapidly. ~~Resulting shallow areas become covered by-, resulting in growth of~~ aquatic plants, ~~reducing and reduced~~ usability.
- ~~Increased~~ Nutrient loading from phosphorus and nitrogen attached to soil particles and transported to lakes and streams ~~can~~ cause a change in the water pH, algal blooms, and oxygen depletion ~~that lead, leading~~ to eutrophication and fish kills.
- ~~Treatment of water~~ Water treatment for domestic uses becomes more difficult and costly.
- Turbid water replaces aesthetically pleasing, clear, clean water ~~is replaced with turbid water~~ in streams and ~~lakeshores-lakes.~~
- Eroded soil particles decrease the viability of macro-invertebrates and food-chain organisms, impair the feeding ability of aquatic animals, clog gill passages of fish, and reduce photosynthesis.
- ~~Successful fish spawning is diminished by~~ Sediment-clogged gravel. ~~Sedimentation following diminishes fish~~ spawning and can smother the eggs or young fry.

Costs associated with these impacts ~~can~~may be obvious or subtle. Some are difficult to quantify, such as the loss of aesthetic values or recreational opportunities. Restoration and management of a single lake can cost millions of dollars. Reductions in spawning habitat, and subsequent reduction in salmon and trout production, cause economic losses to ~~sportsport~~ fisheries ~~and~~, traditional Native American fisheries ~~-, and the~~ fishing industry. The maintenance costs of man-made structures and harbors are readily quantifiable. Citizens pay repeatedly for these avoidable costs ~~as city, county, state, and federal taxpayers in their tax~~ dollars.

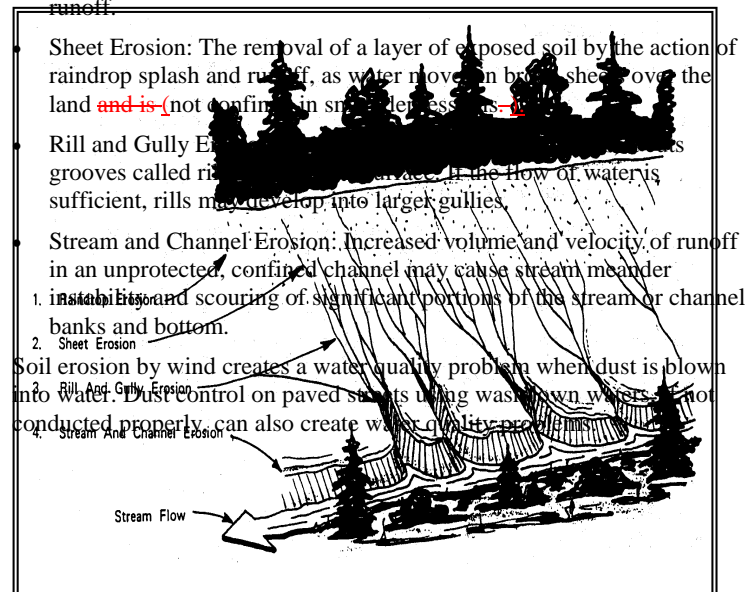
Effective erosion and sediment control practices on construction sites can greatly reduce undesirable environmental impacts and costs. Being aware of the erosion and sedimentation process is helpful in understanding the role of BMPs in controlling stormwater runoff.

1.65 Erosion and Sedimentation Processes

1.65.1 Soil Erosion

Soil erosion is defined as the removal of soil from its original location by the action of water, ice, gravity, or wind. In construction activities, soil erosion is largely caused by the force of falling and flowing water. Erosion by water includes the following processes (see ~~Figure 1.5.1~~ Figure 1-1):

- Raindrop Erosion: The direct impact of falling drops of rain on soil dislodges soil particles so that they can then be easily transported by runoff.



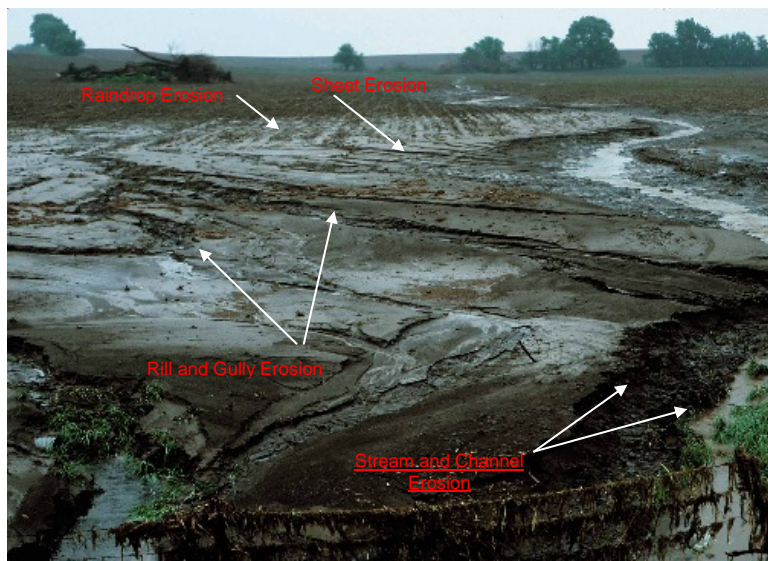


Photo by Lynn Betts, USDA Natural Resources Conservation

Figure 1.5.1 – Types of Erosion

1.65.2 Sedimentation

Sedimentation is defined as the gravity-induced settling of soil particles transported by water. The process is accelerated in slower-moving, quiescent stretches of natural waterbodies or in treatment facilities such as sediment ponds and wetponds.

Sedimentation occurs when the velocity of water in which soil particles are suspended is slowed for a sufficient time to allow particles to settle. The settling rate ~~is dependent~~depends on the soil particle size. Heavier particles, such as sand and gravel, ~~can~~ settle more rapidly than fine particles such as clay and silt. Sedimentation of clay soil particles is reduced due to clay's ~~relatively~~relative low density and electro-charged surfaces, which discourage aggregation. The presence of clay particles in stormwater runoff can result in highly turbid water, which is not amenable to treatment by settling.

Turbidity, an indirect measure of soil particles in water, is one of the primary water quality standards in Washington State law ([WAC 173-201A-200](#)~~(WAC 173-201A-030)~~). Turbidity is increased when erosion carries soil particles into receiving waters. Treating stormwater to reduce turbidity can be an expensive, difficult process with limited effectiveness. Any actions or prevention measures that reduce the volume of water needing treatment for turbidity are beneficial.

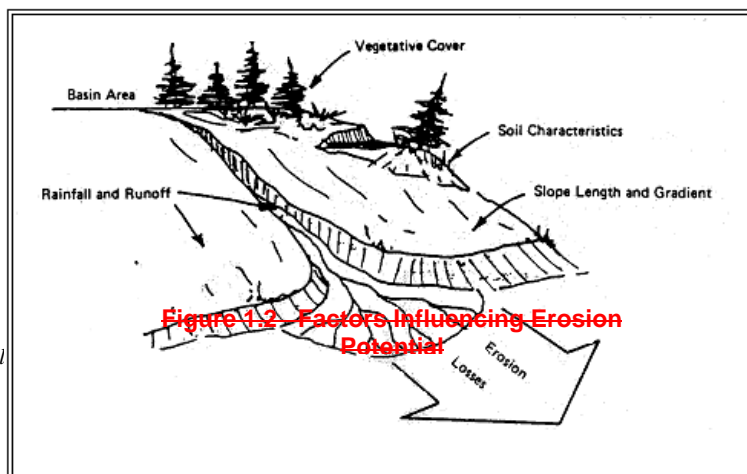
1.76 Factors Influencing Erosion Potential

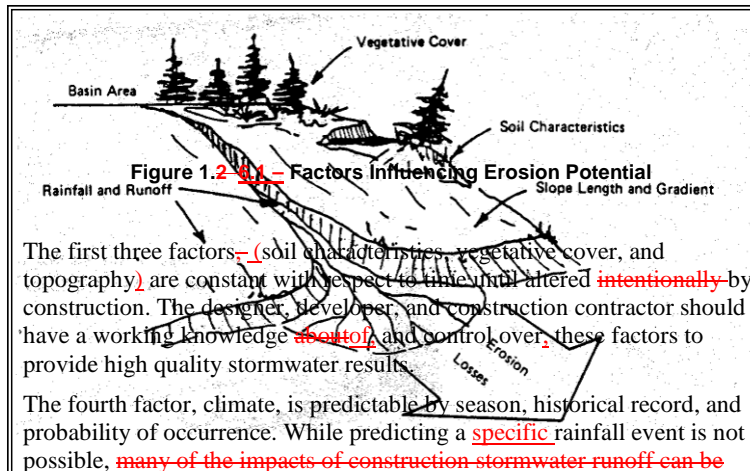
The erosion potential of soils can be readily determined using various models such as the Flaxman Method or the Revised Universal Soil Loss Equation (RUSLE).

The soil erosion potential of an area, including a construction site, is determined by four interrelated factors (see [Figure 1.6.1](#)~~Figure 1.2~~):

- Soil characteristics;
- Vegetative cover;
- Topography ~~and~~
- Climate.

~~Collection, analysis~~Collect, analyze, and use ~~of~~ detailed information specific to the construction site for each of these four factors ~~can~~to provide the basis for an effective construction stormwater management system.





The first three factors—(soil characteristics, vegetative cover, and topography)—are constant with respect to time until altered intentionally by construction. The designer, developer, and construction contractor should have a working knowledge ~~as well as~~ and control over these factors to provide high quality stormwater results.

The fourth factor, climate, is predictable by season, historical record, and probability of occurrence. While predicting a specific rainfall event is not possible, many of the impacts of construction stormwater runoff can be minimized or avoided by planning appropriate seasonal construction activity and using properly designed BMPs to minimize or avoid many of the impacts of construction stormwater runoff.

1.76.1 Soil Characteristics

The vulnerability of soil to erode is determined by soil characteristics: particle size, organic content, soil structure, and soil permeability.

Particle Size: Soils that contain high proportions of silt and very fine sand are generally the most erodible and are easily detached and carried away. The erodibility of soil decreases as the percentage of clay or organic matter increases; clay acts as a binder and tends to limit erodibility. Most soils with high clay content are relatively resistant to detachment by rainfall and runoff. Once eroded, however, clays are easily suspended and settle out very slowly.

Organic Content: Organic matter creates a favorable soil structure, improving its stability and permeability. This increases infiltration capacity, delays the start of erosion, and reduces the amount of runoff.

The addition of organic matter increases infiltration rates (and, therefore, reduces surface flows and erodibility), water retention, pollution control, and pore space for oxygen.

Soil Structure: Organic matter, particle size, and gradation affect soil structure, which is the arrangement, orientation, and organization of particles. When the soil system is protected from compaction, the natural decomposition of plant debris on the surface maintains a healthy soil food web. The soil food web in turn maintains the porosity both on and below the surface.

Soil Permeability: Soil permeability refers to the ease with which water passes through a given soil. Well-drained and well-graded gravel and gravel mixtures with little or no silt are the least erodible soils. Their high permeability and infiltration capacity helps prevent or delay runoff.

1.7.6.2 Vegetative Cover

Vegetative cover plays an extremely important role in controlling erosion by:

- Shielding the soil surface from the impact of falling rain.
- Slowing the velocity of runoff, thereby permitting greater infiltration.
- Maintaining the soil's capacity to absorb water through root zone uptake and evapotranspiration.
- Holding soil particles in place.

~~Erosion can be significantly reduced by~~ Limiting the removal of existing vegetation and ~~by~~ decreasing duration of soil exposure to rainfall events. ~~can reduce erosion.~~ Give special consideration to ~~the preservation of~~ preserving existing ~~vegetative cover~~ vegetation on areas with a high potential for erosion such as erodible soils, steep slopes, drainage ways, and the banks of streams. When it is necessary to remove vegetation, such as ~~for removing~~ noxious ~~weed eradication~~ weeds, revegetate these areas immediately.

1.7.6.3 Topography

The size, shape, and slope of a construction site influence the amount and rate of stormwater runoff. Each site's unique dimensions and characteristics provide both opportunities for and limitations on the use of specific control measures to protect vulnerable areas from high runoff amounts and rates. Slope length, steepness, and surface texture are key elements in determining the volume and velocity of runoff. As slope length and/or steepness increase, the rate of runoff and the potential for erosion increases. Slope orientation is also a factor in determining erosion potential. For example, a slope that faces south and contains ~~drought~~ dry soils may provide such poor growing conditions that ~~vegetative cover~~ vegetation will be difficult to re-establish.

1.7.6.4 Climate

Seasonal temperatures and the frequency, intensity, and duration of rainfall are fundamental ~~factors~~ in determining amounts of runoff. As the volume and the velocity of runoff increase, the likelihood of erosion increases. Where storms are frequent, intense, or ~~of long duration~~, erosion risks are high. Seasonal changes in temperature, as well as variations in rainfall, help to define the period of the year when there is a high erosion

risk. When precipitation falls as snow, ~~no erosion occurs. It may not occur~~
~~until~~ the spring, ~~when~~ melting snow adds to the runoff, and erosion
potential will be higher. ~~If the ground is still~~ Partially frozen, ~~ground~~
~~reduces~~ infiltration capacity ~~is reduced~~. Rain-on-snow events are common
in western Washington between 1,500- and 3,000-foot ~~elevation~~ ~~elevations~~.

Western Washington is characterized in fall, winter, and spring by storms
that are mild and long lasting. The fall and early winter events saturate the
soil profile and fill stormwater detention ponds, increasing the amount of
runoff leaving the construction site. Shorter-term, more intense storms
occur in the summer. These storms can cause problems if adequate BMPs
have not been installed on ~~site~~.

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Chapter 2 - Regulatory Requirements

Construction site stormwater runoff is regulated on the federal, state, and local level ~~and at the State level.~~

- ~~• The Puget Sound Water Quality Management Plan requires communities in the Puget Sound Basin to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites.~~
- ~~• Phase I municipal National Pollutant Discharge Elimination System (NPDES) permits require large urban cities and counties to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites.~~
- ~~• The Phase II NPDES municipal permit program will require many municipalities throughout the state to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites.~~
- ~~• Construction projects must apply for coverage under the NPDES General Permit for Stormwater Associated with Construction Activities if
 - ~~— the project results in the disturbance of one or more acres of land area, including clearing, grading, and excavation activities, and~~
 - ~~— the project discharges stormwater from the site into a surface water or discharge to a storm drain system that discharges to a surface water.~~~~
- ~~• Some construction projects may require an individual NPDES permit.~~

2.1 Requirements under the Puget Sound Water Quality Management Plan

~~The Puget Sound Water Quality Management Plan directs the approximately 120 cities and counties in the Puget Sound Basin to adopt and implement programs to prevent stormwater pollution and to enhance water quality within the municipal jurisdictions. The plan requires the municipalities to adopt ordinances implementing controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites. These ordinances must include all of the Minimum Requirements contained in Volume I of the Stormwater Management Manual, or requirements determined by the Department of Ecology (Ecology) to be technically equivalent.~~

~~Minimum Requirement #2, Construction Stormwater Pollution Prevention, requires that new development and redevelopment projects address stormwater pollution prevention during construction. Construction projects must consider all of the 12 elements of construction stormwater pollution prevention and develop controls for all of the elements that pertain to the project site.~~

~~Projects that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) that is reviewed by the Plan Approval Authority of the local government. The Construction SWPPP must contain sufficient information to satisfy the Plan Approval Authority that the problems of pollution have been adequately addressed for the proposed project. Projects that add or replace less than 2,000 square feet of impervious surface or clearing projects of less than 7,000 square feet are not required to prepare a Construction SWPPP. However, these projects must consider all of the 12 elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site.~~

2.2 NPDES Stormwater Permits

~~*Background*—The Federal Clean Water Act (FCWA, 1972, and later modifications, 1977, 1981, and 1987) established establishes water quality goals for the navigable (surface) waters of the United States. One of the mechanisms for achieving the goals of the Clean Water Act is the NPDES and achieves them through the National Pollutant Discharge Elimination System (NPDES) permit program, administered by the U.S. Environmental Protection Agency (EPA). EPA~~

~~The state of Washington has delegated responsibility from EPA to administer the NPDES permit program to the state of Washington on the basis of Chapter 90.48 RCW, which statewide. Chapter 90.48 RCW defines Ecology's authority and obligations in administering the wastewater discharge permit program.~~

~~Regulations adopted by Washington State include procedures for issuing permits (Chapter 173-220 WAC), water quality criteria for surface and ground waters (Chapters 173-201A and 200 WAC), and sediment management standards (Chapter 173-204 WAC). These regulations require that a permit be issued before discharge of wastewater to waters of the state is allowed. The regulations also establish the basis for effluent limitations and other requirements included in permits.~~

~~*Stormwater*—In 1987, Congress added section 402(p) to the Clean Water Act to establish a comprehensive framework for addressing municipal and industrial stormwater discharges under the NPDES permit program. Section 402(p)(4) of the Clean Water Act clarifies the requirement for EPA and delegated state agencies to issue NPDES permits for stormwater discharges associated with industrial activity. The federal regulations~~

require an NPDES permit for listed industrial facilities and those construction activities which will disturb five or more acres of land, that discharge "stormwater associated with industrial activities" directly to surface waters, or indirectly through municipal storm drains. The regulations include a definition of "stormwater associated with industrial activity," and a listing of application requirements for stormwater permits.

The first implementation phase of the 1987 Clean Water Act amendments (The state administers the NPDES program by issuing separate individual NPDES permits and multiple statewide general permits. There are three main general stormwater permits:

The Phase I also requires NPDES permits for municipal stormwater discharges from municipalities that:

- Have a separate storm sewer system that discharges to surface water or to drainage ditches that discharge to surface water; and
- Have a population served by the storm sewer system that is greater than 100,000 people.

The final **and Phase II** stormwater regulations were issued by EPA on December 8, 1999. The Phase II regulation requires NPDES municipal stormwater permits for all municipalities within census urbanized areas. For municipalities outside of census urbanized areas, with a population exceeding 10,000 and a population density greater than 1,000 per square mile, Ecology must develop criteria to determine whether an NPDES permit is necessary. Implementation of municipal stormwater programs through Phase II permits will be phased in by 2008.

Census urbanized areas are defined as a central place (or places) and the adjacent densely settled surrounding area that together have a minimum population of 50,000 and a minimum average density of 1,000 per square mile.

- Both the Phase I and Phase II NPDES permit programs require permitted municipalities **Municipal Stormwater General Permit**; requires urban cities and counties to adopt ordinances implementing. These ordinances implement stormwater controls for new development and redevelopment, including measures for control of erosion, sedimentation, and other pollutants on construction sites. Under the Phase I NPDES permit, these ordinances must include all of the Minimum Requirements contained in Volume I of the Stormwater Management Manual, or requirements determined by the Department of Ecology to be technically equivalent. Ecology expects to include similar requirements in the Phase II permit, which must be issued by December 2002. One of these ordinances requires all new development and redevelopment to have a Construction Stormwater Pollution Prevention Plan (SWPPP).

- **The Construction Stormwater General Permit:** requirements are detailed in [Section 2.1](#).
- **The Industrial Stormwater General Permit:** requires designated industries that discharge stormwater ~~are required to surface waters~~ to apply for coverage ~~under the Baseline General Permit for Stormwater Discharges Associated with Industrial Activities (the Industrial General Permit).~~ Facilities that only discharge stormwater runoff from administrative building roofs, [Volumes IV](#) and employee parking lots ~~are not required to obtain~~ [Volumes V](#) contain more information about [this permit coverage.](#) ~~Industrial facilities.~~

Many local governments within Washington State have established their own additional permits, such as clearing and grading permits. Local permitting authorities may qualify for a waiver (conditional exemption) if they can demonstrate that there will be no exposure of industrial materials and activities also review Construction SWPPPs. Permittees should check with their jurisdiction about local requirements related to construction stormwater.

2.2.1 The Construction Stormwater General Permit for Stormwater Discharges Associated with Construction Activities

The goal of the ~~General Permit for Stormwater Discharges Associated with Construction Activities (the Construction~~ Construction Stormwater General Permit (CSWGP) is to minimize harm to surface waters from construction activities.

Coverage under the ~~Construction General Permit is~~ CSWGP is generally required for any clearing, grading, or excavating that will disturb one or more acres of land area and that will discharge if the project site discharges:

- Stormwater from the site into surface water(s) ~~of the State,~~ or
- Into storm drainage systems that discharge to a surface water ~~—(s) of the State.~~

The permit is also required for projects or construction activities that **And**

- ~~Disturbs one or more acres of land area, or~~
- Disturb less than one acre of land area, if the project or activity is part of a larger common plan of development or sale ~~that will ultimately disturb one or more acre of land area. EPA broadly defines a “common plan of development or sale” as any announcement or piece of documentation (including a sign, public notice or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor markings, etc.) indicating construction activities may occur on a specific plot.~~

The permit is not required for routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site. For example, re-grading a dirt road or cleaning out a roadside drainage ditch to maintain its "as built" state does not require permit coverage.

Any size construction activity discharging stormwater to waters of the State that Ecology ~~and/or the Plan Approval Authority of the local government determined~~ determines to be a "significant contributor of pollutants" to waters of the State or that Ecology reasonably expects to waters of the state cause a violation of any water quality standard may also be required to ~~apply for and obtain~~ require permit coverage, ~~regardless of project size.~~

Construction activities that are generally not required to ~~apply for~~ have coverage include:

- Construction activities that discharge all stormwater ~~only and non-~~ stormwater ~~to the ground~~ water, sanitary sewer, or combined sewer, and have no point source discharge to either surface water or a municipal storm sewer at any time during construction; system that drains to surface waters of the State.
- ~~Any part of a facility with a stormwater discharge resulting from remedial action under an order or consent decree;~~
- ~~Any emergency construction activity required to protect public health and safety; and~~
- ~~Any construction activity for~~ Construction activities that meet the requirements of an Erosivity Waiver.
- Routine maintenance ~~of existing facilities that is~~ to maintain the original line and grade, or hydraulic capacity, or original purpose of a facility.

~~Facilities~~ Stormwater discharges generally excluded from coverage include:

- Post-construction stormwater discharges that originate from the site after completion of construction activities when the site has undergone final stabilization. Final stabilization means the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as riprap, gabions, or geotextiles) which prevents erosion.
- Nonpoint source silvicultural activities;
- ~~Any facility that discharges to surface water~~ Stormwater from any federal project or project on federal land or land within an Indian Reservation except for the Puyallup Reservation—(these projects are required to obtain CSWGP coverage from the US Environmental

Protection Agency). Within the Puyallup Reservation, any facility that discharges to surface water on land held in trust by the federal government may be covered by this permit.

- ~~Stormwater discharges that originate from the any site after construction has been completed and the site has undergone final stabilization. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures such as riprap, gabions, or geotextiles which will prevent erosion; and~~
- ~~Any facility~~ covered under an existing NPDES individual ~~or general~~ permit in which stormwater management and/or treatment requirements ~~or both~~ are included for all stormwater discharges associated with construction activity.
- Stormwater from a site where an applicable Total Maximum Daily Load (TMDL) requirement specifically precludes or prohibits discharges from construction activity.

The CSWGP define a “common plan of development or sale” as a site where multiple separate and distinct construction activities may be taking place at different times on different schedules and/or by different contractors, but still under a single plan. If the project is part of a common plan of development or sale, the disturbed area of the entire plan must be used in determining permit requirements.

Examples of a common plan of development or sale include:

1. Phased projects and projects with multiple filings or lots, even if the separate phases or filings/lots will be constructed under separate contract or by separate owners.
2. A development plan that may be phased over multiple years, but is still under a consistent plan for long-term development.
3. Projects in a contiguous area that may be unrelated but still under the same contract.
4. Linear projects, such as roads, pipelines, or utilities.

If the project is part of a common plan of development or sale, the disturbed area of the entire plan must be used in determining permit requirements.

The specific application requirements for obtaining coverage under the ~~Construction Stormwater General Permit~~ CSWGP are set forth in the permit. Copies of the permit, and permit application forms are available at Ecology’s stormwater website:

www.ecy.wa.gov/programs/wq/stormwater/construction/

2.2.2 Construction Stormwater Pollution Prevention **Plans**

A Construction Stormwater Pollution Prevention Plan (SWPPP) is required if one of the following applies:

- The construction project must have coverage under the CSWGP. See [Section 2.1 Facilities](#) of this volume.
- The construction project is located in a municipality covered under the Construction General Permit must prepare one of the following Municipal Stormwater Permits and implement meets the thresholds in the permit:
 - Phase 1
 - Western Washington Phase II
- The local permitting authority requires a Construction SWPPP. ~~The Construction SWPPP must consist of~~ Permittees should check with their jurisdiction about local requirements related to construction stormwater.
- Ecology and ~~make provisions for~~ or the local permitting authority determined the project, site, or facility to be a significant contributor of pollutants to waters of the state.
- ~~The Construction SWPPP must include the permit's 12 elements (13 elements if the local jurisdiction requires it) described in Chapter 3 Erosion prevention and sediment control, and~~
- ~~Control of other pollutants~~

unless site conditions render any of the elements unnecessary and the exemption from that element is clearly justified in the Construction SWPPP.

The Construction SWPPP must describe ~~construction best management practices, stabilization techniques, and structural~~ (BMPs that are to be implemented) to prevent erosion and minimize sediment transport. Erosion prevention, sediment control, and sedimentation, and to identify, reduce, eliminate or prevent stormwater contamination and water pollution from construction activity. [Chapter 3](#) and [Chapter 4](#) ~~control~~ provide BMP guidance and design criteria ~~are provided in Chapter 3 and Chapter 4 of this volume.~~

BMPs shall be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Reports summarizing the scope of inspections, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to the implementation of the Construction SWPPP, and actions taken as a result of these inspections shall be prepared and retained as part of the Construction SWPPP.

2.3 Water Quality Standards

2.3.1 Surface Water Quality Standards

“Numerical” water quality criteria are numerical values set forth in the state of Washington's Water Quality Standards for Surface Waters ([Chapter 173-201A WAC](#) ~~(Chapter 173-201A WAC)~~). They specify the levels of pollutants allowed in ~~a~~-receiving ~~water that are protective of waters to protect~~ aquatic life.

EPA has promulgated 91 numeric water quality criteria ~~for the protection of to protect~~ human health that ~~are applicable~~ apply to Washington State (EPA 1992). These criteria are designed to protect humans from cancer and other ~~diseased~~ diseases, and are primarily applicable to fish and shellfish consumption and drinking water obtained from surface waters.

In addition to numerical criteria, "narrative" water quality criteria (e.g., [WAC 173-201A-200](#), ~~-240~~ [WAC 173-201A-200](#), [240](#), and ~~-250~~ [250](#)) limit concentrations of toxic, radioactive, or ~~deleterious~~ otherwise harmful material below ~~those~~ concentrations that have the potential to adversely affect characteristic water uses, cause acute or chronic toxicity to biota, impair aesthetic values, or adversely affect human health. Narrative criteria protect the specific beneficial uses of fresh ~~(WAC 173-201A-600)~~ [\(WAC 173-201A-600\)](#) and ~~-602~~ [-602](#)) and marine ~~(WAC 173-201A-610)~~ [\(WAC 173-201A-610\)](#) and ~~-612~~ [-612](#)) waters in the state of Washington.

Pollutants that might be expected in the discharge from construction sites are turbidity, pH, and petroleum products. The surface water quality standards for turbidity and pH for waters designated for the salmon and trout spawning, core rearing, and migration use are:

Turbidity: shall not exceed 5 nephelometric turbidity units (NTU) over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

pH: shall be within the range of 6.5 to 8.5 (freshwater) or 7.0 to 8.5 (marine water) with a human-caused variation within a range of less than 0.2 units. For Class A and lower water classifications, the permissible induced increase is 0.5 units.

Although there is no specific surface or ground water quality standard for petroleum products, the narrative surface water quality criteria prohibits any visible sheen in a discharge to surface water.

The ground water quality criteria require protection from contamination in order to support the beneficial uses of the ground water, such as for drinking water. Therefore, the primary water quality consideration for stormwater discharges to ground water from construction sites ~~are~~ is the

control of contaminants other than sediment. Sediment control is necessary to protect permanent infiltration facilities from clogging during the construction phase.

2.3.2 Compliance with Standards

Stormwater discharges ~~associated with from~~ construction ~~activity are~~ ~~subject sites must not cause or contribute to applicable state violations of~~ Washington State's surface water quality standards ([Chapter 173-201A WAC](#)), sediment management standards ([Chapter 173-204 WAC](#)), ground water quality standards ([Chapter 173-200 WAC](#)), and human health based criteria in the National Toxics Rule ([40 CFR Part 131.36](#)).

~~Before the site can discharge stormwater and non-stormwater to waters of the State, the permittee must apply all known, available, and reasonable methods of prevention, control, and treatment (AKART). This includes preparing and implementing a Construction SWPPP, with all appropriate BMPs installed and maintained in accordance with the SWPPP and the terms and conditions of the Construction Stormwater General Permit.~~

~~In accordance with Chapter 90.48 RCW does not authorize the violation of those standards. Ecology expects that the selection and implementation of appropriate BMPs outlined in this volume of the SWMM or equivalent manuals will result in (ESSB 6415), compliance with water quality standards is presumed unless discharge monitoring data or other site specific information demonstrates otherwise, when the permittee fully:~~

- ~~• Complies with permit conditions for planning, sampling, monitoring, reporting, and recordkeeping; and~~
- ~~• Implements the BMPs contained in this manual or BMPs that are demonstrably equivalent to BMPs contained in stormwater technical manuals approved by Ecology, including the proper selection, implementation, and maintenance of all applicable and appropriate BMPs for on-site pollution control. Proper implementation and maintenance of appropriate BMPs is critical to adequately control any adverse water quality impacts from construction activity.~~

~~Stormwater discharges from construction sites must not cause or contribute to violations of Washington State's surface water quality standards (Chapter 173-201A WAC), sediment management standards (Chapter 173-204 WAC), ground water quality standards (Chapter 173-200 WAC), and human health based criteria in the National Toxics Rule (Federal Register, Vol. 57, No. 246, Dec. 22, 1992, pages 60848-60923).~~

~~In accordance with Chapter 90.48 RCW (ESSB 6415), compliance with water quality standards shall be presumed unless site specific information demonstrates otherwise, when the permittee is:~~

- ~~• In compliance with permit conditions for planning, sampling, monitoring, reporting, and recordkeeping; and~~
- ~~• Following stormwater management practices, or practices that are demonstrably equivalent to practices contained in stormwater technical manuals approved by the Department of Ecology, including the proper selection, implementation, and maintenance of appropriate best management practices for on-site pollution control.~~

~~In determining compliance, Ecology will consider:~~

- ~~• Weather conditions as related to design storms for BMPs;~~
- ~~• Available dilution and background conditions in the receiving water if the SWPPP and its implementation are determined adequate. Mixing zones may be allowed through individual NPDES permits per WAC 173-201A-100; and~~
- ~~• Other requirements of Chapters 173-200 WAC, 173-201A WAC, and 173-204 WAC.~~
- ~~• The point of compliance for the water quality standards is in the surface receiving water body or in the ground water.~~

2.4 Endangered Species Act

The Endangered Species Act (ESA) is of concern for construction sites because of ~~the~~ potential adverse impacts to receiving waters from discharges of sediment, turbidity, or abnormal pH. Specific adverse impacts include:

- Suffocation of eggs or fry~~;~~₂
- Displacement and elimination of aquatic invertebrates ~~utilized~~used for food~~;~~₂
- Reduction in the biodiversity of aquatic invertebrates~~;~~₂
- Reduction of foraging abilities in turbid water~~;~~₂
- Irritation of gill tissue that can lead to disease or death~~;~~₂
- ~~and~~ Filling of resting~~;~~ or feeding areas, or spawning gravels with sediment.

These impacts could be determined to be a “take” under ESA.

The stranding of listed species behind erosion and sediment control features or the impairment of their access into certain areas due to the presence of erosion and sediment control features could also be determined to be a take under ESA.

For more information on ESA and how it affects your project, please contact the National ~~Marine~~Oceanic and Atmospheric Administration Fisheries Service at: <http://www.nmfs.noaa.gov/pr/laws/esa/> or the U.S. Fish and Wildlife Service at: <http://www.fws.gov/endangered/>.

2.5 Other Applicable Regulations and Permits

Other ~~regulations~~regulatory or agency conditions and permits may require ~~the implementation of~~implementing BMPs to control pollutants in construction site stormwater runoff. They include:

- Total Maximum Daily Load (TMDLs) or Water Clean Up Plans.
- Hydraulic Project Approval Permits.
- General provisions from ~~the~~Washington State Department of Transportation (WSDOT).
- ~~Contaminated site~~-Remediation agreements- for contaminated sites (such as Model Toxics Control Act or Voluntary Cleanup Program sites).
- Local permits and approvals, such as clearing and grading permits.

See Volume I, Section 1.6 for further information ~~on these regulations and permits~~.

Chapter 3 - Planning

This chapter provides an overview of the important components of, and the process for, developing and implementing a Construction Stormwater Pollution Prevention Plan (SWPPP).

[Section 3.1](#) ~~Section 3.1~~ contains general guidelines with which site planners should become familiar. It describes criteria for plan format and content and ideas for improved plan effectiveness.

[Section 3.2](#) ~~Section 3.2~~ discusses the two main components of a Construction SWPPP, the narrative and the drawings.

[Section 3.3](#) outlines and describes a recommended step-by-step procedure for developing a Construction SWPPP from data collection to finished product. [Step 3 in Section 3.3](#) provides a description of each of the SWPPP elements. This procedure is written in general terms to be applicable to all types of projects. [Section 3.3](#)

~~Section 3.3~~ also includes a [checklist](#) ~~checklist~~ for developing a Construction SWPPP.

Design standards and specifications for Best Management Practices (BMPs) referred to in this chapter are found in [Chapter 4](#) ~~Chapter 4.~~

The Construction SWPPP may be a subset of the Stormwater Site Plan or construction plan set. ~~Full details on~~ [Chapter 3, of Volume I, discusses](#) how to ~~integrate the Construction SWPPP with~~ [prepare](#) a Stormwater Site Plan ~~are provided in Volume I.~~

3.1 General Guidelines

3.1.1 What is a Construction [SWPPP](#)?

[Construction](#) Stormwater Pollution Prevention Plan?

~~The Construction (SWPPP is) means a document that describes the potential for pollution problems on a construction project. written plan to implement measures to identify, prevent, and control the contamination of point source discharge of stormwater.~~ The Construction SWPPP explains and illustrates the measures ~~to be taken on, usually in the form of best management practices (BMPs), to take on a~~ construction site to control ~~those potential pollution~~ problems.

A Construction SWPPP [is required](#) for projects [meeting the requirements in Section 2.2](#) ~~that add or replace 2,000 square feet or more of impervious surface or clear more than 7,000 square feet must have a narrative as well as drawings and details. The local permitting authority must review these Construction SWPPPs. The local permitting authority may allow single-~~

~~family home construction projects to prepare a simpler Construction SWPPP, consisting of a checklist and a plot plan.~~

While it is a good idea to include standards and specifications from the Construction SWPPP in the contract documents, the Construction SWPPP should be a separate document that can stand alone.

As site work progresses, the plan must be modified routinely in prescribed time periods to reflect changing site conditions, subject to the rules for plan modification by the CSWGP and/or the local permitting authority.

3.1.2 Who is responsible for the Construction SWPPP?

The owner or lessee of the land being developed has the responsibility for SWPPP preparation and submission to local authorities. The owner or lessee may designate someone (that is, an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but the owner retains the ultimate responsibility for environmental protection at the site.

The Construction SWPPP must be located on the construction site or within reasonable access to the site for construction and inspection personnel, although a copy of the drawings must be kept on the construction site at all times.

~~As site work progresses, the plan must be modified to reflect changing site conditions, subject to the rules for plan modification by the local permitting authority.~~

~~The owner or lessee of the land being developed has the responsibility for Construction SWPPP preparation and submission to local authorities. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but he/she retains the ultimate responsibility.~~

3.1.23 What is an Adequate Plan?

The Construction SWPPP ~~for projects adding or replacing 2,000 square feet of impervious surface or more or clearing 7,000 square feet or more must must~~ contain sufficient information to satisfy the ~~Plan Approval Authority of the local government~~ permitting authority (state, local, or both) that the problems of construction pollution have been adequately addressed for the proposed project.

An adequate Construction SWPPP includes a narrative and drawings. The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project. ~~The narrative is a written statement to explain and justify the pollution prevention decisions made for a particular project.~~ The narrative contains concise, site specific, information about existing ~~site~~ conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings

~~and notes describe where and when the various~~ show, on a site map, the specific BMPs ~~should~~ which shall be installed. Provide text notes on the drawings to describe the performance standards the BMPs are expected to ~~be taken~~ achieve, and actions to ~~be taken~~ take if the performance goals are not achieved.

Reports summarizing the scope of inspections, the personnel conducting the inspection, the date(s) of the inspection, major observations relating to implementing the Construction SWPPP, and actions taken as a result of these inspections must be prepared and retained as part of the Construction SWPPP.

On construction sites that discharge to surface water, the primary concern in the preparation of the Construction SWPPP is compliance with Washington State Water Quality Standards. ~~Each of the 12 elements must be included in the Construction SWPPP unless an element is determined not to be applicable to the project and the exemption is justified in the narrative. The step-by-step procedure outlined in Section 3.2 of this volume is recommended for the development of the Construction SWPPPs. The checklists in Section 3.3 may be helpful in preparing and reviewing the Construction SWPPP.~~

On construction sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP is the protection of the infiltration facilities from fine sediments during the construction phase and protection of ground water from other pollutants. Several of the other elements are very important at these sites as well, such as marking the clearing limits, establishing the construction access, and managing the project.

Whether the stormwater discharges to surface water or completely infiltrates, each of the 12 elements (13 elements if required by the local jurisdiction) must be included in the Construction SWPPP, unless an element is determined not to be applicable to the project and the exemption is justified in the narrative.

The step-by-step procedure outlined in Section 3.3 of this volume is recommended for the development of Construction SWPPPs. The checklists in Section 3.3 may be helpful in preparing and reviewing the Construction SWPPP.

3.1.34 BMP Standards and Specifications

~~Chapter 4~~ BMPs refer to schedules of activities, prohibitions of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce the pollution of waters of the State. BMPs include treatment systems, operating procedures, and practices to control:

- Stormwater associated with construction activity.
- Ground water associated with construction activity.

- Spillage or leaks.
- Sludge or waste disposal.
- Drainage from raw material storage.

Chapter 4 contains standards and specifications for the BMPs ~~referred to in this Chapter. Wherever any of these BMPs are to be employed~~ commonly used in Construction SWPPPs to address the 12 elements (13 if required by the local jurisdiction). BMPs can be used singularly or in combination. If a site, construction SWPPP makes use of a BMP, the narrative and drawings must clearly reference the specific BMP title and number of the BMP should be clearly referenced in the narrative and marked on the drawings.

The standards and specifications in Chapter 4 ~~Chapter 4 of this volume~~ are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. ~~In those instances where appropriate BMPs are not in this chapter, Construction SWPPPs can contain experimental management practices can be considered. BMPs or make~~ minor modifications to standard ~~practices may also be employed. BMPs.~~ However, ~~such practices must be approved by the plan approval~~ permitting authority of the (state, local government, or both) must approve such practices before they may be used. use. All experimental ~~management practices~~ BMPs and modified ~~standard practices are required to~~ BMPs must achieve the same or better performance than the BMPs listed in Chapter 4 ~~Chapter 4.~~

Construction SWPPPs can also contain BMPs from other guidance documents or manuals which Ecology has approved as providing an equivalent level of pollution prevention.

If a Construction SWPPP uses an experimental, modified, or approved equivalent BMP, then the SWPPP must contain the following:

1. The technical basis for the selection of the experimental, modified, or approved equivalent BMP (scientific, technical studies, and/or modeling) that support the performance claims for the BMP.
2. An assessment of how the experimental, modified, or approved equivalent BMP will satisfy all known, available, and reasonable methods of prevention, control and treatment (AKART) requirements and the applicable federal technology-based treatment requirements under 40 Code of Federal Regulations (CFR) part 125.3.

3.1.5 General Principles

The CSWGP outlines numerous specific requirements related to elements 1 through 12 that the SWPPP must address. The SWMMWW and the Municipal Stormwater General Permits include element number 13 which applies to new and redevelopment construction projects. The CSWGP

does not contain element number 13. All permittees should be familiar with the requirements in their permits.

3.2 Construction SWPPP Requirements

The Construction SWPPP consists of two parts: a narrative and the drawings. Both parts shall contain information specific to the construction site. Not all items listed below are applicable to all construction projects. The author of the Construction SWPPP should ensure that the applicable sections are addressed. The following two sections describe the contents of the narrative and the drawings. A checklist is included in Section 3.3 of this volume as a quick reference to determine if all the major items are included in the Construction SWPPP.

3.2.1 Narrative

The author of the Construction SWPPP should evaluate the following subject areas for inclusion in the Construction SWPPP narrative. The subject areas below are not an outline for the Construction SWPPP narrative.

- General Information on the Existing Site and Project
 - Project description: Describe the nature and purpose of the construction project. Include the total size of the area, any increase in existing impervious area; the total area expected to be disturbed by clearing, grading, excavation or other construction activities, including off-site borrow and fill areas; and the volumes of grading cut and fill that are proposed.

3.1.4 General Principles

The following general principles should be applied to the development of the Construction SWPPP.

- ~~The duff layer, native topsoil, and natural vegetation should be retained in an undisturbed state to the maximum extent practicable.~~
- ~~Prevent pollutant release. Select source control BMPs as a first line of defense. Prevent erosion rather than treat turbid runoff.~~
 - Select BMPs depending on Existing site characteristics ~~(conditions: Describe the existing topography, vegetation, and drainage. Include a description of any structures or development on the parcel including the area of existing impervious surfaces.~~
 - ~~soil type, ground cover, and critical Adjacent areas) and the:~~ Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that might be affected by the construction plan/project. Describe how upstream drainage areas

may affect the site. Provide a description of the upstream drainage leading to the site and the downstream drainage leading from the site to the receiving body of water.

- o Critical areas: Describe areas on or adjacent to the site that are classified as critical areas. Critical areas that receive runoff from the site shall be described up to ¼ mile away. The local permitting authority may increase the distance. Describe special requirements for working near or within these areas.
- o Soil: Describe the soil on the site, giving such information as soil names, mapping unit, erodibility, settleability, permeability, depth, depth to ground water, texture, and soil structure.
- o Potential erosion problem areas: Describe areas on the site that have potential erosion problems.
- Twelve (12) elements (13 elements if required by the local jurisdiction): Describe how the Construction SWPPP addresses each of the 12 (13) required elements. Include the type and location of BMPs used to satisfy the required element. Often using a combination of BMPs is the best way to satisfy required elements. If an element is not applicable to a project, provide a written justification for why it is not necessary.
- Construction Schedule and phasing: Describe the construction schedule. If the schedule extends into the wet season, describe what activities will continue during the wet season and how the transport of sediment from the construction site to receiving waters will be prevented. Describe the intended sequence and timing of construction activities and any proposed construction phasing.
- Financial/ownership responsibilities: Describe ownership and obligations for the project. Include bond forms and other evidence of financial responsibility for environmental liabilities associated with construction.
- Engineering calculations: Attach any calculations made for the design of such items as sediment ponds, diversions, and waterways, as well as calculations for runoff and stormwater detention design (if applicable). Engineering calculations must bear the signature and stamp of an engineer licensed in the state of Washington.
- Certified Erosion and Sediment Control Lead (CESCL): Identify along with their contact information and expiration of their CESCL certification.

3.2.2 Drawings

- Vicinity map: Provide a map with enough detail to identify the location of the construction site, adjacent roads, and receiving waters.

- Site map: Provide a site map(s) showing the features numbered below. The site map requirements may be met using multiple plan sheets for ease of legibility.
 1. A legal description of the property boundaries or an illustration of property lines (including distances) in the drawings.
 2. The direction of north in relation to the site.
 3. Existing structures and roads, if present.
 4. The boundaries of and labels indicating different soil types.
 - 4.5. Areas of potential erosion problems.
 - 5.6. Any on-site and adjacent surface waters, critical areas, their buffers, FEMA base flood boundaries, and Shoreline Management boundaries.
 - 6.7. Existing contours and drainage basins and the direction of flow for the different drainage areas.
 - 7.8. Final and interim grade contours as appropriate, drainage basins, and the direction of stormwater flow during and upon completion of construction.
 - 8.9. Areas of soil disturbance, including all areas affected by clearing, grading and excavation.
 - 9.10. Locations where stormwater discharges to surface waters during and upon completion of construction.
 - 10.11. Existing unique or valuable vegetation and the vegetation that is to be preserved.
 - 11.12. Cut and fill slopes indicating top and bottom of slope catch lines.
 - 12.13. Stockpile, waste storage, and vehicle storage/maintenance areas.
 - 13.14. Total cut and fill quantities and the method of disposal for excess material.
- Conveyance systems: Show on the site map the following temporary and permanent conveyance features:
 1. Locations for temporary and permanent swales, interceptor trenches, or ditches.
- Drainage pipes, ditches, or cut-off trenches associated with erosion and sediment control and stormwater management. Divert runoff away from exposed areas wherever possible. Keep clean water clean.
- Limit the extent of clearing operations and phase construction operations.

- ~~Before reseeding a disturbed soil area, amend all soils with compost wherever topsoil has been removed.~~
- ~~Incorporate natural drainage features whenever possible, using adequate buffers and protecting areas where flow enters the drainage system.~~
- ~~Minimize slope length and steepness.~~
- ~~Reduce runoff velocities to prevent channel erosion.~~
- ~~Prevent the tracking of sediment off site.~~
 - 2. Select appropriate BMPs
 - 3. Temporary and permanent pipe inverts and minimum slopes and cover.
 - 4. Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes.
 - 5. Details for bypassing off-site runoff around disturbed areas.
 - 6. Locations and outlets of any dewatering systems.
- Location of detention BMPs: Show on the site map the locations of stormwater detention BMPs.
- Erosion and Sediment Control (ESC) BMPs: Show on the site map all major structural and nonstructural ESC BMPs including:
 - 1. The location of sediment pond(s), pipes and structures.
 - 2. Dimension pond berm widths and inside and outside pond slopes.
 - 3. The trap/pond storage required and the depth, length, and width dimensions.
 - 4. Typical section views through pond and outlet structure.
 - 5. Typical details of gravel cone and standpipe, and/or other filtering devices.
 - 6. Stabilization technique details for inlets and outlets.
 - 7. Control/restrictor device location and details.
 - 8. Stabilization practices for berms, slopes, and disturbed areas.
 - 9. Rock specifications and detail for rock check dam, if used.
 - 10. Spacing for rock check dams as required.
 - 11. Front and side sections of typical rock check dams.
 - 12. The location, detail, and specification for silt fence.
 - 13. The construction entrance location and a detail.

- Detailed drawings: Any structural source control practices used that are not referenced in this manual or other local manuals must be explained and illustrated with detailed drawings.
- Other pollutant BMPs: Indicate on the site map the location of BMPs to be used for the control of pollutants other than sediment such as high or low pH and hydrocarbons.
- Monitoring locations: Indicate on the site map the water quality sampling locations, if required by the local permitting authority or the Department of Ecology. Sampling stations must be located in accordance with applicable permit requirements.
- ~~Standard notes are suggested in [Appendix II-A](#). Be realistic about the limitations of controls that you specify and the operation and maintenance of those controls. Anticipate what can go wrong, how you can prevent it from happening, and what will need to be done to fix it.~~
- Notes addressing construction phasing and scheduling must be included on the drawings.

3.23 Step-By-Step Procedure

There are three basic steps in producing a Construction SWPPP:

Step 1 — Data Collection

Step 2 — Data Analysis

Step 3 — Construction SWPPP Development and Implementation

~~Steps 1 and 2 described below are intended~~ A Construction SWPPP is required for projects meeting the requirements in Section 2.2 that are adding or replacing 2,000 square feet or more of impervious surface, or clearing 7,000 square feet or more. The Local permitting authority~~authorities~~ may allow ~~single-family homes~~ small construction projects to prepare a simpler Construction SWPPP, consisting of a checklist and ~~a plot plan~~ drawings. Permittees should check with their jurisdiction about local requirements related to construction stormwater.

3.23.1 Step 1 - Data Collection

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP. ~~The information gathered should be explained in the narrative and shown on the drawings. The Construction SWPPP author may use the information collected during the development of the Stormwater Site Plan to augment the information discussed below.~~

Topography: Prepare a topographic drawing of the site to show the existing contour elevations at intervals of 1 to 5 feet depending upon the slope of the terrain.

Drainage: - Locate and clearly mark existing drainage swales and patterns on the drawing, including existing storm drain pipe systems.

Soils: Identify and label soil type(s) and erodibility (low, medium, high or an index value ~~from the NRCS manual~~) on the drawing. ~~Soils information can be obtained from a soil survey if one has been published for the county. If a soil survey is not available, a request can be made to a district Natural Resource Conservation Service Office, or in the narrative.~~

~~Soils must be characterized~~ Characterize soils for permeability, percent organic matter, and effective depth ~~by a qualified soil professional or engineer.~~ Express these qualities ~~should be expressed~~ in averaged or nominal terms for the subject site or project. This information is frequently available in published literature. ~~by qualified soil professionals or engineers.~~ For example, the 1983 Soil Survey of Snohomish County lists the following information for each soil mapping unit or designation (e.g., a Sultan silt loam):

- A sieve analysis of the soils

- Permeability (in/hr)
- Available water-holding capacity (in/in)
- The percent of organic matter

Soils information can be obtained from a Natural Resource Conservation Service (NRCS) manual (if one has been published for the county where the construction project is located) or the NRCS' Web Soil Survey website at <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. This information is typical for many published SCS soil surveys in Washington State.

. If a soil survey is not available, make a request to a District NRCS.

Additionally, soil data can be obtained through site soil analysis as a part of preparation of a Stormwater Site Plan (See Volume I, Chapter 3).

Ground Cover: Label existing vegetation on the drawing. ~~Such~~Show features such as tree clusters, grassy areas, and unique or sensitive vegetation ~~should be shown.~~ Unique vegetation may include existing trees above a given diameter. Investigate local requirements regarding tree preservation ~~should be investigated.~~ ~~In addition,~~ Indicate existing denuded or exposed soil areas ~~should be indicated.~~

Critical Areas: Delineate critical areas adjacent to or within the site on the drawing. ~~Such~~Show features such as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas, ~~etc., should be shown.~~ Delineate ~~set backs~~setbacks and buffer limits for these features on the drawings. On the drawings, show other related jurisdictional boundaries such as Shorelines Management and the Federal Emergency Management Agency (FEMA) base floodplain ~~should also be shown on the drawings.~~

Adjacent Areas: Identify existing buildings, roads, and facilities adjacent to or within the project site on the drawings. Identify existing and proposed utility locations, construction clearing limits and erosion and sediment control BMPs on the drawings.

Existing Encumbrances: Identify wells, existing and abandoned septic drainfield, utilities, easements, setbacks, and site constraints.

Precipitation Records: Determine the average monthly rainfall and rainfall intensity for the required design storm events. These records may be available from the local permitting agency. Volume III also has resources for determining rainfall values.

3.23.2 Step 2 - Data Analysis

Consider the data collected in Step 1 to visualize potential problems and limitations of the site. Determine those areas that have critical erosion hazards. The following are some important factors to consider in data analysis:

Topography: The primary topographic considerations are slope steepness and ~~slope~~ length. ~~Because of the effect of runoff, the Steeper and longer and steeper the slope, the slopes have~~ greater ~~the~~ erosion potential. ~~Erosion potential should be determined by than do flat and short slopes.~~ A qualified engineer, soil professional, or certified erosion control specialist ~~should determine erosion potential.~~

Drainage: ~~Convey runoff through the use of~~ natural drainage patterns that consist of overland flow, swales and depressions ~~should be used to convey runoff through the site~~ to avoid constructing an artificial drainage system. ~~Properly stabilize~~ man-made ditches and waterways ~~will become part of the erosion problem if so~~ they ~~are do~~ not properly stabilized. ~~Care should also be taken create erosion problems. Take care~~ to ensure that increased runoff from the site will not erode or flood the existing natural drainage system. ~~Consider~~ possible sites for temporary stormwater retention and detention ~~should be considered at this point.~~

~~Construction should be directed~~ Direct construction away from areas of saturated soil ~~—areas—~~ where ground water may be encountered ~~—and away from~~ critical areas where drainage will concentrate. Preserve natural drainage patterns on the site.

Soils: Evaluate soil properties such as surface and subsurface runoff characteristics, depth to impermeable layer, depth to seasonal ground water table, permeability, shrink-swell potential, texture, settleability, and erodibility. Develop the Construction SWPPP based on known soil characteristics. Protect infiltration sites ~~should be properly protected~~ from clay and silt, which will reduce infiltration capacities.

Ground Cover: Ground cover is the most important factor in terms of preventing erosion. Existing vegetation that can be saved will prevent erosion better than constructed BMPs. Trees and other vegetation protect the soil structure. If the existing vegetation cannot be saved, consider such practices as phasing construction, temporary seeding, and mulching. Phasing ~~of~~ construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

Critical Areas: Critical areas may include flood hazard areas, mine hazard areas, slide hazard areas, sole source aquifers, wetlands, streambanks, fish-bearing streams, and other water bodies. Any critical areas within or adjacent to the development should exert a strong influence on land development decisions. Delineate critical areas and their buffers ~~shall be delineated~~ on the drawings and clearly ~~flagged~~ flag critical areas in the field. For example, chain link fencing may be more useful than flagging to assure that equipment operators stay out of critical areas. Only unavoidable work should take place within critical areas and their buffers. Such unavoidable work will require special BMPs, permit restrictions, and mitigation plans. ~~—~~ documented routinely in the SWPPP.

Adjacent Areas: An analysis of adjacent properties should focus on areas upslope and downslope from the construction project. Water bodies that will receive direct runoff from the site are a major concern. Evaluate the types, values, and sensitivities of and risks to downstream resources, such as private property, stormwater facilities, public infrastructure, or aquatic systems. ~~should be evaluated...~~ Select erosion and sediment controls ~~should be selected~~ accordingly.

Precipitation Records: Refer to Volume III to determine the required rainfall records and the method of analysis for design of BMPs.

Timing of the Project: ~~An important consideration in selecting BMPs is~~ Consider the timing and duration of the project. ~~when selecting BMPs.~~ Projects that will proceed during the wet season and projects that will last through several seasons must take all necessary precautions to remain in compliance with the water quality standards.

3.23.3 Step 3 - Construction SWPPP Development and Implementation

After collecting and analyzing the data to determine the site limitations, the planner can then develop a Construction SWPPP. ~~Each of the~~ The first 12 elements below must be considered and included in the Construction SWPPP; unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP. In addition, construction projects in a jurisdiction under the Municipal Stormwater General Permits must include the element 13 in their Construction SWPPP.

Element #1: Preserve Vegetation/Mark Clearing Limits

Prior to Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Before beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area. ~~These shall be clearly marked, both in the field and on the plans, to prevent damage and offsite impacts.~~
- ~~Plastic, metal, or stake wire fence may be used to mark the clearing limits.~~
- Retain the duff layer, native top soil, and natural vegetation ~~shall be retained~~ in an undisturbed state to the maximum ~~extent practicable.~~ degree practical.

Additional Guidance

- Plastic, metal, or fabric fence may be used to mark the clearing limits. [Note: the difference between the practical use and proper installation of silt fencing and the proper use of clearing boundary fencing.]
- If it is not ~~practicable~~practical to retain the duff layer in place, then stockpile it should be stockpiled on-site, coveredcover it to prevent erosion, and replacedreplace it immediately ~~upon completion of the groundwhen you finish~~ disturbing activities. ~~the site.~~

Suggested BMPs

- [BMP C101: Preserving Natural Vegetation](#)
- [BMP C102: Buffer Zones](#)
- [BMP C103: High Visibility Plastic or Metal Fence](#)
- [BMP C233: Silt Fence](#)

~~BMP C101: Preserving Natural Vegetation~~

~~BMP C102: Buffer Zones~~

~~BMP C103: High Visibility Plastic or Metal Fence~~

~~BMP C104: Stake and Wire Fence~~

Element #2: Establish Construction Access

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Limit construction vehicle access and exit ~~shall be limited~~ to one route, if possible, ~~or two for linear projects such as roadways where more than one.~~
- ~~Stabilize~~ access ~~is necessary for large equipment maneuvering.~~
- Access points ~~shall be stabilized~~ with a pad of quarry spalls ~~or~~ crushed rock ~~prior to traffic leaving the construction site, or other equivalent BMPs,~~ to minimize ~~the~~ tracking of sediment onto ~~public~~ roads.
- Locate wheel wash or tire baths ~~should be located~~ on site, if ~~applicable,~~ the stabilized construction entrance is not effective in preventing tracking sediment onto roads.
- If sediment is tracked off site, ~~public roads shall be cleaned~~clean the affected roadway thoroughly at the end of each day, or more frequently as necessary (for example, during wet weather, if necessary to prevent). Remove sediment from ~~entering waters of the state.~~ ~~Sediment shall be removed from~~ roads by shoveling ~~or pickup,~~ sweeping, or pick up and ~~shall be transported~~transport the sediment to a controlled sediment disposal area.
- Conduct street washing ~~will be allowed~~ only after sediment is removed in ~~this manner,~~accordance with the above bullet.

- Control street wash wastewater ~~shall be controlled~~ by pumping back on site or otherwise ~~be prevented~~ preventing it from discharging into systems tributary to ~~state surface waters-- of the State.~~

Additional Guidance

- Minimize construction site access points along linear projects, such as roadways. Street washing may require local jurisdiction approval.

Suggested BMPs

- [BMP C105: Stabilized Construction Entrance/Exit](#)
- [BMP C106: Wheel Wash](#)
- [BMP C107: Construction Road/Parking Area Stabilization](#)

~~BMP C105: Stabilized Construction Entrance~~

~~BMP C106: Wheel Wash~~

~~BMP C107: Construction Road/Parking Area Stabilization~~

Element #3: Control Flow Rates

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Protect properties and waterways downstream ~~from~~ development sites ~~shall be protected~~ from erosion and the associated discharge of turbid waters due to increases in the ~~volume~~, velocity, and peak volumetric flow rate of stormwater runoff from the project site, as required by local plan approval authority.¹
- Where necessary to comply with the bullet above, construct stormwater retention or detention facilities as one of the first steps in grading. Assure that detention facilities function properly before constructing site improvements (e.g. impervious surfaces).
- If permanent infiltration ponds are used for flow control during construction, protect these facilities from siltation during the construction phase.

¹ The Municipal Stormwater Permit Requirements do not include the language “as required by local permitting authority.”

Additional Guidance

- Conduct downstream analysis ~~is necessary~~ if changes in ~~offsite/off-site~~ flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat. See Volume I, Chapter 3 for ~~offsite/off-site~~ analysis guidelines.
- ~~Where necessary to comply with Minimum Requirement #7, stormwater retention/detention facilities shall be constructed as one of the first steps in grading. Detention facilities shall be functional prior to construction of site improvements (e.g. impervious surfaces).~~
- Even gently sloped areas need flow controls such as straw wattles or other energy dissipation / filtration structures. Place dissipation facilities closer together on steeper slopes. These methods prevent water from building higher velocities as it flows downstream within the construction site.
- Outlet structures designed for permanent detention ponds are not appropriate for use during construction without modification. If used during construction, install an outlet structure that will allow for long-term storage of runoff and enable sediment to settle. Verify that the pond is sized appropriately for this purpose. Restore ponds to their original design dimensions, remove sediment, and install a final outlet structure at completion of the project.
- Erosion has the potential to occur because of increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site. The local permitting agency may require pond designs that provide additional or different stormwater flow control ~~if. These requirements may be~~ necessary to address local conditions or to protect properties and waterways downstream ~~from erosion due to increases in the volume, velocity, and peak flow rate of stormwater runoff from the project site.~~
- ~~If permanent infiltration ponds are used for flow control during construction, these facilities should be protected from siltation during the construction phase.~~
- Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from ½ of the 2-year flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond and treatment cells.

Suggested BMPs

- [BMP C203: Water Bars](#)
- [BMP C207: Check Dams](#)
- [BMP C209: Outlet Protection](#)
- [BMP C235: Wattles](#)
- [BMP C240: Sediment Trap](#)
- [BMP C241: Temporary Sediment Pond](#)
- ~~BMP C240: Sediment Trap~~
- ~~BMP C241: Temporary Sediment Pond~~
- Refer to Volume 3, Detention Facilities, Infiltration Stormwater Quantity and Flow Control

Element #4: Install Sediment Controls

Prior Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

The Permittee must design, install and maintain effective erosion controls and sediment controls to leaving a construction site or prior minimize the discharge of pollutants. At a minimum, the Permittee must design, install and maintain such controls to discharge to an infiltration facility;²

- Construct sediment control BMPs (sediment ponds, traps, filters, etc.) as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.
- Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.
- Direct stormwater runoff from disturbed areas shall pass through a sediment pond or other appropriate sediment removal BMP, before the runoff leaves a construction site or before discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard ~~of~~in Element #3, bullet #1.
- Locate BMPs intended to trap sediment on site in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.

² The Municipal Stormwater Permit Requirements do not include this paragraph, but do include a similar requirement.

- Provide and maintain natural buffers around surface waters, direct stormwater to vegetated areas to increase sediment removal, and maximize stormwater infiltration, unless infeasible.³
- Where feasible, design outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column.

Additional Guidance

- Outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column are for the construction period only. If the pond using the construction outlet control is used for permanent stormwater controls, the appropriate outlet structure must be installed after the soil disturbance has ended.
- Seed and mulch earthen structures such as dams, dikes, and diversions according to the timing indicated in Element #5.
- Full stabilization ~~means~~includes concrete or asphalt paving; quarry spalls used as ditch lining; or the use of rolled erosion products, a bonded fiber matrix product, or vegetative cover in a manner that will fully prevent soil erosion. ~~—The Local Permitting Authority shall inspect and approve areas fully stabilized by means other than pavement or quarry spalls.~~
- ~~Sediment ponds, vegetated buffer strips, sediment barriers or filters, dikes, and other BMPs intended to trap sediment on site shall be constructed as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.~~
- ~~Earthen structures such as dams, dikes, and diversions shall be seeded and mulched according to the timing indicated in Element #5.~~
- ~~BMPs intended to trap sediment on site must be located in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages, often during non-storm events, in response to rain event changes in stream elevation or wetted area.~~
- The Local Permitting Authority may inspect and approve areas fully stabilized by means other than pavement or quarry spalls.
- If installing a floating pump structure, include a stopper to prevent the pump basket from hitting the bottom of the pond.

Suggested BMPs

- [BMP C231: Brush Barrier](#)
- [BMP C232: Gravel Filter Berm](#)

³ The Municipal Stormwater Permit Requirements do not include this bullet.

- [BMP C233: Silt Fence](#)
- [BMP C234: Vegetated Strip](#)
- [BMP C235: Wattles](#)
- [BMP C240: Sediment Trap](#)
- [BMP C241: Temporary Sediment Pond](#)
- [BMP C250: Construction Stormwater Chemical Treatment](#)
- [BMP C251: Construction Stormwater Filtration](#)

~~BMP C230: Straw Bale Barrier~~

~~BMP C231: Brush Barrier~~

~~BMP C232: Gravel Filter Berm~~

~~BMP C233: Silt Fence~~

~~BMP C234: Vegetated Strip~~

~~BMP C235: Straw Wattles~~

~~BMP C240: Sediment Trap~~

~~BMP C241: Temporary Sediment Pond~~

~~BMP C250: Construction Stormwater Chemical Treatment~~

~~BMP C251: Construction Stormwater Filtration~~

Element #5: Stabilize Soils⁴

All Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- ~~Stabilize~~ exposed and unworked soils ~~shall be stabilized by~~ application of effective BMPs that ~~protect the soil from the erosive forces of raindrop impact, flowing water, and wind.~~
- ~~From October 1 through 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. This condition applies to all soils on site, whether at final grade or not. These time limits may be adjusted by the local permitting authority if it can be shown that the average time between storm events justifies a different standard.~~
- ~~Soils shall be stabilized at the end of the shift before a holiday or weekend if needed based on the weather forecast.~~
- prevent erosion. Applicable ~~practices~~BMPs include, but are not limited to: temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base early on areas to be paved, and dust control.

⁴ The Construction Stormwater General Permit refers to “the Permittee” throughout this section of permit requirements. This language was removed here to be consistent with the Municipal Stormwater Permits.

- Control stormwater volume and velocity within the site to minimize soil erosion.
- Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.
- Soils must not remain exposed and unworked for more than the time periods set forth below to prevent erosion.
 - During the dry season (May 1 - Sept. 30): 7 days
 - During the wet season (October 1 - April 30): 2 days
- Stabilize soils at the end of the shift before a holiday or weekend if needed based on the weather forecast.
- Stabilize soil stockpiles from erosion, protect with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways, and drainage channels.
- Minimize the amount of soil exposed during construction activity.
- Minimize the disturbance of steep slopes.
- Minimize soil compaction and, unless infeasible, preserve topsoil.

Additional Guidance

- Soils must not remain exposed and unworked for more than the time periods set forth above to prevent erosion for linear projects.
- Soil stabilization measures should be appropriate for the time of year, site conditions, estimated duration of use, and potential water quality impacts that stabilization agents may have on downstream waters or ground water.
- ~~• Soil stockpiles must be stabilized from erosion, protected with sediment trapping measures, and when possible, be located away from storm drain inlets, waterways and drainage channels.~~
- ~~• Linear construction activities, including right-of-way and easement clearing, roadway development, pipelines, and trenching for utilities, shall be conducted to meet the soil stabilization requirement. Contractors shall install the bedding materials, roadbeds, structures, pipelines, or utilities and re-stabilize the disturbed soils so that:~~
 - ~~— from October 1 through April 30 no soils shall remain exposed and unworked for more than 2 days and~~
 - ~~— from May 1 to September 30, no soils shall remain exposed and unworked for more than 7 days.~~
- Ensure that gravel base used for stabilization is clean and does not contain fines or sediment.

Suggested BMPs

- [BMP C120: Temporary and Permanent Seeding](#)
- [BMP C121: Mulching](#)
- [BMP C122: Nets and Blankets](#)
- [BMP C123: Plastic Covering](#)
- [BMP C124: Sodding](#)
- [BMP C125: Topsoiling/Composting](#)
- [BMP C126: Polyacrylamide for Soil Erosion Protection](#)
- [BMP C130: Surface Roughening](#)
- [BMP C131: Gradient Terraces](#)
- [BMP C140: Dust Control](#)

~~BMP C120: Temporary and Permanent Seeding~~
~~BMP C121: Mulching~~
~~BMP C122: Nets and Blankets~~
~~BMP C123: Plastic Covering~~
~~BMP C124: Sodding~~
~~BMP C125: Topsoiling~~
~~BMP C126: Polyacrylamide for Soil Erosion Protection~~
~~BMP C130: Surface Roughening~~
~~BMP C131: Gradient Terraces~~
~~BMP C140: Dust Control~~
~~BMP C180: Small Project Construction Stormwater Pollution Prevention~~

Element #6: Protect Slopes⁵

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- ~~Design and construct cut-and-fill slopes in a manner that will to~~ minimize erosion.
- ~~Consider soil type and its potential for erosion.~~
- ~~Reduce slope runoff velocities by~~ Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, ~~reduced~~reducing slope steepness, and ~~roughen slope surface~~roughening slope surfaces (for example, track walking).
- Divert off-site stormwater (run-on) ~~shall be diverted or ground water~~ away from slopes and disturbed areas with interceptor dikes, pipes, and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.
- At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion. ~~Temporary pipe slope drains shall handle the peak flow from a 10 year, 24 hour event assuming a Type 1A rainfall distribution. Alternatively, the 10 year and 25 year, 1 hour flow rates indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. Consult the local drainage requirements for sizing permanent pipe slope drains.~~
- ~~Provide drainage to remove ground water intersecting the slope surface of exposed soil areas.~~

⁵ The Construction Stormwater General Permit refers to “the Permittee” throughout this section of permit requirements. This language was removed here to be consistent with the Municipal Stormwater Permits.

- Temporary pipe slope drains must handle the peak 10-minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must 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 must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.
- Place excavated material ~~shall be placed~~ on the uphill side of trenches, consistent with safety and space considerations.
- Place check dams ~~shall be placed~~ at regular intervals within constructed channels that are cut down a slope.

Additional Guidance

- Where 15-minute time steps are available in an approved continuous runoff model, they may be used directly without a correction factor.
- Consider soil type and its potential for erosion.
- Stabilize soils on slopes, as specified in Element #5.
- BMP combinations are the most effective method of protecting slopes with disturbed soils. For example use both mulching and straw erosion control blankets in combination.

Suggested BMPs

- [BMP C120: Temporary and Permanent Seeding](#)
- [BMP C121: Mulching](#)
- [BMP C122: Nets and Blankets](#)
- [BMP C130: Surface Roughening](#)
- [BMP C131: Gradient Terraces](#)
- [BMP C200: Interceptor Dike and Swale](#)
- [BMP C201: Grass-Lined Channels](#)
- [BMP C203: Water Bars](#)
- [BMP C204: Pipe Slope Drains](#)
- [BMP C205: Subsurface Drains](#)
- [BMP C206: Level Spreader](#)
- [BMP C207: Check Dams](#)

- [BMP C208: Triangular Silt Dike \(Geotextile-Encased Check Dam\)](#)

~~BMP C120: Temporary and Permanent Seeding~~

~~BMP C130: Surface Roughening~~

~~BMP C131: Gradient Terraces~~

~~BMP C200: Interceptor Dike and Swale~~

~~BMP C201: Grass-Lined Channels~~

~~BMP C204: Pipe Slope Drains~~

~~BMP C205: Subsurface Drains~~

~~BMP C206: Level Spreader~~

~~BMP C207: Check Dams~~

~~BMP C208: Triangular Silt Dike (Geotextile-Encased Check Dam)~~

Element #7: Protect Drain Inlets

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Protect all storm drain inlets made operable during construction ~~shall be protected~~ so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.
- Clean or remove and replace inlet protection devices when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

Additional Guidance

- Where possible, protect all existing storm drain inlets so that stormwater runoff does not enter the conveyance system without first being filtered or treated to remove sediment.
- Keep all approach roads ~~shall be kept~~ clean. Do not allow sediment and street wash water ~~shall not be allowed~~ to enter storm drains without prior and adequate treatment unless treatment is provided before the storm drain discharges to waters of the State.
- Inlets should be inspected weekly at a minimum and daily during storm events. ~~Inlet protection devices should 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).~~

Suggested BMPs

- [BMP C220: Storm Drain Inlet Protection](#)

~~BMP C220: Storm Drain Inlet Protection~~

Element #8: Stabilize Channels and Outlets

~~All temporary~~ Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Design, construct, and stabilize all on-site conveyance channels ~~shall be designed, constructed and stabilized~~ to prevent erosion from the following expected peak ~~40~~ flows:
 - Channels must handle the peak 10-minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must 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 must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped area.
- Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent streambanks, slopes, and downstream reaches ~~shall be provided~~ at the outlets of all conveyance systems.

Additional Guidance

The best method for stabilizing channels is to completely line the channel with a blanket product first, then add check dams as necessary to function as an anchor and to slow the flow of water.

Suggested BMPs

- [BMP C202: Channel Lining](#)
- [BMP C122: Nets and Blankets](#)
- [BMP C207: Check Dams](#)
- [BMP C209: Outlet Protection](#)

~~BMP C202: Channel Lining~~
~~BMP C209: Outlet Protection~~

Element #9: Control Pollutants

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants.⁶
- Handle and dispose of all pollutants, including waste materials and demolition debris; that occur ~~onsite shall be handled and disposed of on-site~~ in a manner that does not cause contamination of stormwater. ~~Woody debris may be chopped and spread on site.~~
- Provide cover, containment, and protection from vandalism ~~shall be provided~~ for all chemicals, liquid products, petroleum products, and ~~non-inert wastes present on the site (see Chapter 173-304 WAC for other materials that have the definition of inert waste)~~ potential to pose a threat to human health or the environment. On-site fueling tanks ~~shall~~ must include secondary containment. Secondary containment means placing tanks or containers within an impervious structure capable of containing 110% of the volume contained in the largest tank within the containment structure. Double-walled tanks do not require additional secondary containment.
- ~~Maintenance~~ Conduct maintenance, fueling, and repair of heavy equipment and vehicles involving using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as closed-loop recirculation or upland land application, or to the sanitary sewer, with local sewer district approval.
- Apply fertilizers and pesticides in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Follow manufacturers' label requirements for application rates and procedures.
- Use BMPs to prevent contamination of stormwater runoff by pH-modifying sources. The sources for this contamination include, but are not limited to: bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, concrete pumping and mixer washout waters.
- Adjust the pH of stormwater if necessary to prevent violations of the water quality standards.
- Assure that washout of concrete trucks is performed off-site or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams. Do not dump excess concrete on site, except in designated

⁶ The Construction Stormwater General Permit refers to "the Permittee" throughout this section of permit requirements. This language was removed here to be consistent with the Municipal Stormwater Permits.

concrete washout areas. Concrete spillage or concrete discharge to surface waters of the State is prohibited.

- Obtain written approval from Ecology before using chemical treatment other than CO₂ or dry ice to adjust pH.

Additional Guidance

- Wheel wash or tire bath wastewater should not include wastewater from concrete washout areas.
- Do not use upland land applications for discharging wastewater from concrete washout areas.
- Woody debris may be chopped and spread on site.
- Conduct oil changes, hydraulic system drain down, solvent and degreasing cleaning operations, fuel tank drain down and removal, and other activities which may result in discharge or spillage of pollutants to the ground or into stormwater runoff ~~must be conducted~~ using spill prevention measures, such as drip pans.
- Clean contaminated surfaces ~~shall be cleaned~~ immediately following any discharge or spill incident. Emergency repairs may be performed on-site using temporary plastic placed beneath and, if raining, over the vehicle.
- ~~Wheel wash or tire bath wastewater shall be discharged to a separate on-site treatment system or to the sanitary sewer.~~
- ~~Application of agricultural chemicals, including fertilizers and pesticides, shall be conducted in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Manufacturers' recommendations for application rates and procedures shall be followed.~~
- ~~BMPs shall be used to prevent or treat contamination of stormwater runoff by pH modifying sources. These sources include, but are not limited to, bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, and concrete pumping and mixer washout waters. Stormwater discharges shall not cause or contribute to a violation of the water quality standard for pH in the receiving water.~~
- ~~Construction sites with significant concrete work shall adjust the pH of stormwater if necessary to prevent violations of water quality standards.~~

Suggested BMPs

- [BMP C151: Concrete Handling](#)
- [BMP C152: Sawcutting and Surfacing Pollution Prevention](#)

- [BMP C153: Material Delivery, Storage and Containment](#)
- [BMP C154: Concrete Washout Area](#)
- [BMP C250: Construction Stormwater Chemical Treatment](#)
- [BMP C251: Construction Stormwater Filtration](#)
- [BMP C252: High pH Neutralization Using CO₂](#)
- [BMP C253: pH Control for High pH Water](#)
- ~~BMP C151: Concrete Handling~~
- ~~BMP C152: Sawcutting and Surfacing Pollution Prevention~~
- See Volume IV – Source Control BMPs

Element #10: Control De-Watering⁷

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Discharge foundation, vault, and trench ~~de-watering~~dewatering water, which have ~~similar~~ characteristics similar to stormwater runoff at the site, ~~shall be discharged~~ into a controlled conveyance system ~~prior to before~~ discharge to a sediment trap or sediment pond. ~~Channels must be stabilized, as specified in Element #8.~~
- Discharge clean, non-turbid de-watering water, such as well-point ground water, ~~can be discharged~~ to systems tributary to ~~state, or~~ directly into surface waters of the State, as specified in Element #8, provided the de-watering flow does not cause erosion or flooding of receiving waters. ~~These or interfere with the operation of the system.~~ Do not route clean ~~waters should not be routed~~dewatering water through stormwater sediment ponds. Note that “surface waters of the State” may exist on a construction site as well as off site; for example, a creek running through a site.
- Handle highly turbid or contaminated dewatering water ~~from construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam, shall be handled~~ separately from stormwater.
- Other treatment or disposal options, ~~depending on site constraints~~, may include:
 1. Infiltration.
 2. Transport ~~offsite~~off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.
 3. Ecology-approved on-site chemical treatment or other suitable treatment technologies.

⁷ ~~The Construction Stormwater General Permit refers to “the Permittee” throughout this section of permit requirements. This language was removed here to be consistent with the Municipal Stormwater Permits.~~

4. Sanitary or combined sewer discharge with local sewer district approval, if there is no other option, ~~or~~.
5. Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Additional Guidance

- Channels must be stabilized, as specified in Element #8.
- Construction equipment operation, clamshell digging, concrete tremie pour, or work inside a cofferdam can create highly turbid or contaminated dewatering water.
- Discharging sediment-laden (muddy) water into waters of the State likely constitutes violation of water quality standards for turbidity. The easiest way to avoid discharging muddy water is through infiltration and preserving vegetation.

Suggested BMPs

- [BMP C203: Water Bars](#)
- [BMP C236: Vegetative Filtration](#)

Element #11: Maintain BMPs⁸

Construction Stormwater General Permit and Municipal Stormwater Permits Requirements

- Maintain and repair all temporary and permanent erosion and sediment control BMPs ~~shall be maintained and repaired~~ as needed to assure continued performance of their intended function. ~~Maintenance and repair shall be conducted~~ in accordance with BMP specifications.
- Remove all temporary erosion and sediment control BMPs ~~shall be removed~~ within 30 days after achieving final site stabilization is ~~achieved~~ or after the temporary BMPs are no longer needed. ~~Trapped sediment~~

Additional Guidance

- Note: Some temporary erosion and sediment control BMPs are bio-degradable and designed to remain in place following construction such as compost socks.
- Provide protection to all BMPs installed for the permanent control of stormwater from sediment and compaction. All BMPs that are to remain in place following completion of construction shall be examined and placed in full operating conditions. If sediment enters the BMPs during construction, it shall be removed and the facility

⁸ The Construction Stormwater General Permit refers to “the Permittee” throughout this section of permit requirements. This language was removed here to be consistent with the Municipal Stormwater Permits.

shall be ~~removed or stabilized~~ returned to the conditions specified in the construction documents.

- Remove or stabilize trapped sediment on site. Permanently stabilize disturbed soil resulting from removal of BMPs or vegetation.

Suggested BMPs

- [BMP C150: Materials On Hand](#)
- [BMP C160: Certified Erosion and Sediment Control Lead](#)

Element #12: Manage the Project

Construction Stormwater General Permit and Municipal Stormwater Permit Requirements

- Phase development projects to the maximum degree practicable and take into account seasonal work limits.
- Inspection and monitoring – Inspect, maintain, and repair all BMPs as needed to assure continued performance of their intended function. Conduct site inspections and monitoring in accordance with the Construction Stormwater General Permit or local plan approval authority.
- Maintaining an updated construction SWPPP – Maintain, update, and implement the SWPPP in accordance with the Construction Stormwater General Permit.

Municipal Stormwater Permit Requirements

- Projects that disturb one or more acres must have, site inspections conducted by a Certified Erosion and Sediment Control Lead (CESCL). Project sites less than one acre (not part of a larger common plan of development or sale) may have a person without CESCL certification conduct inspections. By the initiation of construction, the SWPPP must identify the CESCL or inspector, who shall be permanently present on-site or on-call at all times.

Additional Guidance for Site Inspections

- The CESCL or inspector (project sites less than one acre) must have the skills to assess the:
 - Site conditions and construction activities that could impact the quality of stormwater.
 - Effectiveness of erosion and sediment control measures used to control the 25 quality of stormwater discharges.
- The CESCL or inspector must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen. They must evaluate the effectiveness of BMPs and determine if it is necessary to install, maintain, or repair BMPs to improve the quality of stormwater discharges.

Based on the results of the inspection, construction site operators must correct the 31 problems identified by:

- Reviewing the SWPPP for compliance with the 13 construction SWPPP elements and making appropriate revisions within 7 days of the inspection.
- Immediately beginning the process of fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible, addressing the problems no later than within 10 days of the inspection. If installation of necessary treatment BMPs is not feasible within 10 days, the construction site operator may request an extension within the initial 10-day response period.
- Documenting BMP implementation and maintenance in the site log book (sites larger than 1 acre).
- The CESCL or inspector must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at least once every calendar week and within 24 hours of any discharge from the site. (For purposes of this condition, individual discharge events that last more than one day do not require daily inspections. For example, if a stormwater pond discharges continuously over the course of a week, only one inspection is required that week.) The CESCL or inspector may reduce the inspection frequency for temporary stabilized-, inactive sites to once every calendar month

Element #12: ——— Manage the Project

Additional Guidance

- Phasing of Construction.

Phase development projects ~~shall be phased~~ where feasible in order to prevent soil erosion and, to the maximum extent ~~practicable, the transport of~~ practical, and prevent transporting sediment from the site during construction. ~~Revegetation of~~ Revegetate exposed areas and ~~maintenance of~~ maintain that vegetation ~~shall be~~ as an integral part of the clearing activities for any phase.

Clearing and grading activities for developments shall be permitted only if conducted ~~pursuant to~~ using an approved site development plan (e.g., subdivision approval) that establishes permitted areas of clearing, grading, cutting, and filling. Minimize removing trees and disturbing or compacting native soils when establishing ~~these~~ permitted clearing and grading areas. ~~consideration should be given to minimizing removal of existing trees and minimizing disturbance/compaction of native soils except as needed for building purposes. These. Show on the site plans and the development site~~ permitted clearing and grading areas and any other areas required to preserve critical or sensitive areas, buffers, native growth protection easements, or tree retention

areas as may be required by local jurisdictions, ~~shall be delineated on the site plans and the development site.~~

- Seasonal Work Limitations

From October 1 through April 30, clearing, grading, and other soil disturbing activities ~~shall only be~~ permitted only if shown to the satisfaction of the local permitting authority that the site operator will prevent silt-laden runoff ~~will be prevented~~ from leaving the site through a combination of the following:

1. Site conditions including existing vegetative coverage, slope, soil type, and proximity to receiving waters; ~~and.~~
2. ~~Limitations on~~ Limit activities and the extent of disturbed areas; ~~and.~~
3. Proposed erosion and sediment control measures.

Based on the information provided and/or local weather conditions, the local permitting authority may expand or restrict the seasonal limitation on site disturbance. The local permitting authority ~~shall~~ has ~~the authority to~~ take enforcement action ~~—~~ such as a notice of violation, administrative order, penalty, or stop-work order under the following circumstances:

- If, during the course of any construction activity or soil disturbance during the seasonal limitation period, sediment leaves the construction site causing a violation of the surface water quality standard; or
- If clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained.

The following activities are exempt from the seasonal clearing and grading limitations:

1. Routine maintenance and necessary repair of erosion and sediment control BMPs;
2. Routine maintenance of public facilities or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil; ~~and.~~
3. Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sediment control facilities.

- 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 Construction SWPPP.

- Inspection and Monitoring

All BMPs ~~shall~~must be inspected, maintained, and repaired as needed to assure continued performance of their intended function. Site inspections ~~shall~~must be conducted by a person ~~who is~~ knowledgeable in the principles and practices of erosion and sediment control. The person must have the skills to 1) assess the site conditions and construction activities that could impact the quality of stormwater, and 2) assess the effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

For construction sites one acre or larger that discharge stormwater to surface waters of the state, a ~~Certified Erosion and Sediment Control Specialist shall~~CESCL must be identified in the construction SWPPP ~~and shall; this person must~~ be on-site or on-call at all times. Certification ~~may~~must be obtained through an approved training program that meets the erosion and sediment control training standards established by Ecology.

Appropriate BMPs or design changes shall be implemented as soon as possible whenever inspection and/or monitoring reveals that the BMPs identified in the Construction SWPPP are inadequate, due to the actual discharge of / or potential to discharge a significant amount of any pollutant; ~~appropriate BMPs or design changes shall be implemented as soon as possible.~~

- Maintaining an Updated Construction SWPPP

Retain the Construction SWPPP ~~shall be retained~~ on-site or within reasonable access to the site.

Modify the SWPPP ~~shall be modified~~ whenever there is a change in the design, construction, operation, or maintenance at the construction site that has, or could have, a significant effect on the discharge of pollutants to waters of the state.

The SWPPP ~~shall~~must be modified if, during inspections or investigations conducted by the owner/operator, or the applicable local or state regulatory authority, it is determined that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. Modify the SWPPP ~~shall be modified~~ as necessary to include additional or modified BMPs designed to correct problems identified. Complete revisions to the SWPPP ~~shall be completed~~ within seven (7) days following the inspection.

Suggested BMPs

- [BMP C150: Materials On Hand](#)
- [BMP C160: Certified Erosion and Sediment Control Lead](#)
- [BMP C162: Scheduling](#) ~~3.3 Construction SWPPP~~

Element #13: Protect Low Impact Development BMPs

Municipal Stormwater Permits Requirements

The Construction SWPPP shall consist of two parts: a narrative and the drawings. The following two sections describe the contents of the narrative and the drawings. A checklist is included that can be used as a quick reference to determine if all the major items are included in the Construction SWPPP.

3.3.1 Narrative

- ~~Twelve (12) Elements—Describe how the Construction SWPPP addresses each of the 12 required elements. Include the type and location of BMPs used to satisfy the required element. If an element is not applicable to a project, provide a written justification for why it is not necessary.~~
 - ~~Project description—Describe the nature and purpose of the construction project. Include the total size of the area, any increase in existing impervious area, the total area expected to be disturbed by clearing, grading, excavation or other construction activities, including off-site borrow and fill areas, and the volumes of grading cut and fill that are proposed.~~
 - ~~Existing site conditions—Describe the existing topography, vegetation, and drainage. Include a description of any structures or development on the parcel including the area of existing impervious surfaces.~~
- ~~Adjacent areas—Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that might be affected by the construction project. Provide a description of the downstream drainage leading from the site to the receiving body of water.~~
- ~~Critical areas—Describe areas on or adjacent to the site that are classified as critical areas. Critical areas that receive runoff from the site shall be described up to ¼ mile away. The distance may be increased by the Plan Approval Authority. Describe special requirements for working near or within these areas.~~
- ~~Soil—Describe the soil on the site, giving such information as soil names, mapping unit, erodibility, settleability, permeability, depth, texture, and soil structure.~~
- ~~Potential erosion problem areas—Describe areas on the site that have potential erosion problems.~~
- Protect all Bioretention and Rain Garden BMPs from sedimentation through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain into the Bioretention and/or Rain Garden BMPs. Restore the BMPs to their fully functioning condition if they accumulate sediment during construction. Restoring

the BMP must include removal of sediment and any sediment-laden Bioretention/rain garden soils, and replacing the removed soils with soils meeting the design specification.

- Prevent compacting Bioretention and rain garden BMPs by excluding construction equipment and foot traffic. Protect completed lawn and landscaped areas from compaction due to construction equipment.
- Control erosion and avoid introducing sediment from surrounding land uses onto permeable pavements. Do not allow muddy construction equipment on the base material or pavement. Do not allow sediment-laden runoff onto permeable pavements.
- Pavements fouled with sediments or no longer passing an initial infiltration test must be cleaned using procedures from the local stormwater manual or the manufacturer's procedures.
- Keep all heavy equipment off existing soils under LID facilities that have been excavated to final grade to retain the infiltration rate of the soils.

Additional Guidance

- ~~See Chapter 5: Precision Site Preparation and Construction phasing—Describe the intended sequence and timing of construction activities any proposed construction phasing.~~
- ~~Construction schedule—Describe the construction schedule. If the schedule extends into the wet season, describe what activities will continue during the wet season and how the transport of sediment from the construction site to receiving waters will be prevented.~~
- ~~Financial/ownership responsibilities—Describe ownership and obligations for the project. Include bond forms and other evidence of financial responsibility for environmental liabilities associated with construction.~~
- ~~Engineering calculations—Attach any calculations made for the design of such items as sediment ponds, diversions, and waterways, as well as calculations for runoff and stormwater detention design (if applicable). Engineering calculations must bear the signature and stamp of an engineer licensed in the state of Washington.~~
- ~~in the *LID Technical Guidance Manual for Puget Sound* A responsible, certified erosion control specialist shall be identified. Telephone and/or pager numbers should be included.~~

3.3.2 Drawings

- ~~Vicinity map—Provide a map with enough for more detail to identify the location of the construction site; adjacent roads; and receiving waters.~~

- ~~Site map—Provide a site map(s) showing the following features. The site map requirements may be met using multiple plan sheets for ease of legibility.~~
 - ~~14.15. A legal description of the property boundaries or an illustration of property lines (including distances) in the drawings.~~
 - ~~15.16. The direction of north in relation to the site.~~
 - ~~16.17. Existing structures and roads, if present.~~
 - ~~17. The boundaries of and label the different soil types.~~
 - ~~18. Areas of potential erosion problems.~~
 - ~~19. Any on-site and adjacent surface waters, critical areas, their buffers, FEMA base flood boundaries, and Shoreline Management boundaries.~~
 - ~~20. Existing contours and drainage basins and the direction of flow for the different drainage areas.~~
 - ~~21. Final and interim grade contours as appropriate, drainage basins, and the direction of stormwater flow during and upon completion of construction.~~
 - ~~22. Areas of soil disturbance, including all areas affected by clearing, grading and excavation.~~
 - ~~23. Locations where stormwater discharges to surface waters during and upon completion of construction.~~
 - ~~24. Existing unique or valuable vegetation and the vegetation that is to be preserved.~~
 - ~~25. Cut and fill slopes indicating top and bottom of slope catch lines.~~
 - ~~26. Stockpile, waste storage, and vehicle storage/maintenance areas.~~
 - ~~27. Total cut and fill quantities and the method of disposal for excess material.~~
- ~~Conveyance systems—Show on the site map the following temporary and permanent conveyance features:~~
 - ~~1. Locations for swales, interceptor trenches, or ditches.~~
 - ~~2. Drainage pipes, ditches, or cut off trenches associated with erosion and sediment control and stormwater management.~~
 - ~~3. Temporary and permanent pipe inverts and minimum slopes and cover.~~
 - ~~4. Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes.~~
 - ~~5. Details for bypassing off-site runoff around disturbed areas.~~

- 6. ~~Locations and outlets of any dewatering systems.~~
- ~~Location of detention BMPs—Show on the site map the locations of stormwater detention BMPs.~~
- ~~Erosion and Sediment Control (ESC) BMPs—Show on the site map all major structural and nonstructural ESC BMPs including:~~
 - 1. ~~The location of sediment pond(s), pipes and structures.~~
 - 2. ~~Dimension pond berm widths and inside and outside pond slopes.~~
 - 3. ~~The trap/pond storage required and the depth, length, and width dimensions.~~
 - 4. ~~Typical section views through pond and outlet structure.~~
 - 5. ~~Typical details of gravel cone and standpipe, and/or other filtering devices.~~
 - 6. ~~Stabilization technique details for inlets and outlets.~~
 - 7. ~~Control/restrictor device location and details.~~
- ~~8. Stabilization protecting LID integrated management practices for berms, slopes, and disturbed areas.~~
- 9. ~~Rock specifications and detail for rock check dam, if used.~~
- 10. ~~Spacing for rock check dams as required.~~
- 11. ~~Front and side sections of typical rock check dams.~~
- 12. ~~The location, detail, and specification for silt fence.~~
- 13. ~~The construction entrance location and a detail.~~
- ~~Detailed drawings—Any structural practices used that are not referenced in this manual or other local manuals should be explained and illustrated with detailed drawings.~~
- ~~Other pollutant BMPs—Indicate on the site map the location of BMPs to be used for the control of pollutants other than sediment.~~
- ~~Monitoring locations—Indicate on the site map the water quality sampling locations, if required by the local permitting authority or the Department of Ecology. Sampling stations shall be located in accordance with applicable permit requirements.~~
- ~~Standard notes are suggested in Appendix II A. Notes addressing construction phasing and scheduling shall be included on the drawings.~~

Suggested BMPs

- [BMP C102: Buffer Zone](#)
- [BMP C103: High Visibility Fence](#)
- [BMP C200: Interceptor Dike and Swale](#)
- [BMP C201: Grass-Lined Channels](#)

- [BMP C207: Check Dams](#)
- [BMP C208: Triangular Silt Dike \(TSD\) \(Geotextile-Encased Check Dam\)](#)
- [BMP C231: Brush Barrier](#)
- [BMP C233: Silt Fence](#)
- [BMP C234: Vegetated Strip](#)

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____
City Reference No. _____
Construction Permit No. _____
Review Date: _____
On-site Inspection Review Date: _____
Construction SWPPP Reviewer: _____

Section I – Construction SWPPP Narrative

~~1.~~ Construction Stormwater Pollution Prevention Elements

1. ____ ~~a.~~ Describe how each of the Construction Stormwater Pollution Prevention Elements has been addressed through the Construction SWPPP.
2. ____ ~~b.~~ Identify the type and location of BMPs used to satisfy the required element.
3. ____ ~~e.~~ Provide written justification identifying the reason an element is not applicable to the proposal.

~~12~~ Thirteen Required Elements - Construction Stormwater Pollution Prevention Plan

1. ____ ~~1.~~ Mark Clearing Limits
2. ____ ~~2.~~ Establish Construction Access
3. ____ ~~3.~~ Control Flow Rates
4. ____ ~~4.~~ Install Sediment Controls
5. ____ ~~5.~~ Stabilize Soils
6. ____ ~~6.~~ Protect Slopes
7. ____ ~~7.~~ Protect Drain Inlets
8. ____ ~~8.~~ Stabilize Channels and Outlets
9. ____ ~~9.~~ Control Pollutants
10. ____ ~~10.~~ Control De-Watering
11. ____ ~~11.~~ Maintain BMPs
12. ____ ~~12.~~ Manage the Project

~~13.~~ ~~2.~~ Protect Low Impact Development BMPs

Project Description

1. ____ ~~a.~~ Total project area
2. ____ ~~b.~~ Total proposed impervious area

- 3. ~~___e.~~ Total proposed area to be disturbed, including off-site borrow and fill areas.
- 4. ~~___d.~~ Total volumes of proposed cut and fill.

3. Existing Site Conditions

- ~~___a. Description of the existing topography.~~
- ~~___b. Description of the existing vegetation.~~
- ~~___c. Description of the existing drainage.~~

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____

Construction Permit No. _____

City Reference No. _____

4. Existing Site Conditions

1. Description of the existing topography

2. Description of the existing vegetation

3. Description of the existing drainage

Adjacent Areas

1. ~~I.~~ Description of adjacent areas which may be affected by site disturbance or drain to project site.

- a. Streams
- b. Lakes
- c. Wetlands
- d. Residential Areas
- e. Roads
- f. Other

2. ~~II.~~ Description of the downstream drainage path leading from the site to the receiving body of water. (Minimum distance of 400 yards.)

5. Critical Areas

- 1. ~~a.~~ Description of critical areas that are on or adjacent to the site.
- 2. ~~b.~~ Description of special requirements for working in or near critical areas.

6. Soils

- 1. Description of on-site soils.
 - a. Soil name(s)
 - b. Soil mapping unit
 - c. Erodibility
 - d. Settleability
 - e. Permeability
 - f. Depth
 - g. Texture
 - h. Soil Structure

7. Erosion Problem Areas

== Description of potential erosion problems on site.

8. Construction Phasing

== a. Construction sequence

== b. Construction phasing (if proposed)

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____

Construction Permit No. _____

City Reference No. _____

9. Erosion Problem Areas

1. _____ Description of potential erosion problems on site.

Construction Phasing

1. _____ Construction sequence
2. _____ Construction phasing (if proposed)

Construction Schedule

1. _____ ~~I.~~ Provide a proposed construction schedule.
2. _____ ~~II.~~ Wet Season Construction Activities
 - _____ a. Proposed wet season construction activities.
 - _____ b. Proposed wet season construction restraints for environmentally sensitive/critical areas.

10. Financial/Ownership Responsibilities

1. _____ ~~a.~~ Identify the property owner responsible for the initiation of bonds and/or other financial securities.
2. _____ ~~b.~~ Describe bonds and/or other evidence of financial responsibility for liability associated with erosion and sedimentation impacts.

11. Engineering Calculations

1. _____ ~~I.~~ Provide Design Calculations.
 - _____ a. Sediment Ponds/Traps
 - _____ b. Diversions
 - _____ c. Waterways
 - _____ d. Runoff/Stormwater Detention Calculations

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____

Construction Permit No. _____

City Reference No. _____

Section II - Erosion and Sediment Control Plans

~~1.~~ General

1. ___ ~~a.~~ Vicinity Map
2. ___ ~~b.~~ City/County of _____ Clearing and Grading Approval Block
3. ___ ~~c.~~ Erosion and Sediment Control Notes

~~2.~~ Site Plan

1. ___ ~~a.~~ Note legal description of subject property.
2. ___ ~~b.~~ Show North Arrow.
3. ___ ~~c.~~ Indicate boundaries of existing vegetation, e.g. tree lines, pasture areas, etc.
4. ___ ~~d.~~ Identify and label areas of potential erosion problems.
5. ___ ~~e.~~ Identify ~~any~~ on-site or adjacent surface waters, critical areas and associated buffers.
6. ___ ~~f.~~ Identify FEMA base flood boundaries and Shoreline Management boundaries (if applicable).
7. ___ ~~g.~~ Show existing and proposed contours.
8. ___ ~~h.~~ Indicate drainage basins and direction of flow for individual drainage areas.
9. ___ ~~i.~~ Label final grade contours and identify developed condition drainage basins.
10. ___ ~~j.~~ Delineate areas that are to be cleared and graded.
11. ___ ~~k.~~ Show all cut and fill slopes indicating top and bottom of slope catch lines.

~~3.~~ Conveyance Systems

1. ___ ~~a.~~ Designate locations for swales, interceptor trenches, or ditches.
2. ___ ~~b.~~ Show all temporary and permanent drainage pipes, ditches, or cut-off trenches required for erosion and sediment control.
3. ___ ~~c.~~ Provide minimum slope and cover for all temporary pipes or call out pipe inverts.
4. ___ ~~d.~~ Show grades, dimensions, and direction of flow in all ditches, swales, culverts and pipes.
5. ___ ~~e.~~ Provide details for bypassing off-site runoff around disturbed areas.
6. ___ ~~f.~~ Indicate locations and outlets of any dewatering systems.

~~4.~~ Location of Detention BMPs

1. ~~___~~ Identify location of detention BMPs.

Construction Stormwater Pollution Prevention Plan Checklist

Project Name: _____

Construction Permit No. _____

City Reference No. _____

5. Erosion and Sediment Control Facilities

1. ~~a.~~ Show the locations of sediment trap(s), pond(s), pipes and structures.
2. ~~b.~~ Dimension pond berm widths and inside and outside pond slopes.
3. ~~c.~~ Indicate the trap/pond storage required and the depth, length, and width dimensions.
4. ~~d.~~ Provide typical section views through pond and outlet structure.
5. ~~e.~~ Provide typical details of gravel cone and standpipe, and/or other filtering devices.
6. ~~f.~~ Detail stabilization techniques for outlet/inlet.
7. ~~g.~~ Detail control/restrictor device location and details.
8. ~~h.~~ Specify mulch and/or recommended cover of berms and slopes.
9. ~~i.~~ Provide rock specifications and detail for rock check dam(s), if applicable.
10. ~~j.~~ Specify spacing for rock check dams as required.
11. ~~k.~~ Provide front and side sections of typical rock check dams.
12. ~~l.~~ Indicate the locations and provide details and specifications for silt fabric.
13. ~~m.~~ Locate the construction entrance and provide a detail.

6. Detailed Drawings

1. ~~a.~~ Any structural practices used that are not referenced in the Ecology Manual should be explained and illustrated with detailed drawings.

7. Other Pollutant BMPs

1. ~~a.~~ Indicate on the site plan the location of BMPs to be used for the control of pollutants other than sediment, e.g. concrete wash water.

8. Monitoring Locations

1. ~~a.~~ Indicate on the site plan the water quality sampling locations to be used for monitoring water quality on the construction site, if applicable.

Chapter 4 - **Best Management Practices** Standards and Specifications ~~for Best Management Practices~~

Best Management Practices (BMPs) are defined as schedules of activities, prohibitions of practices, maintenance procedures, and structural and/or managerial practices, that when used singly or in combination, prevent or reduce the release of pollutants to waters of Washington State. This chapter contains standards and specifications for temporary BMPs to be used as applicable during the construction phase of a project. Often using BMPs in combination is the best method to meet Construction Stormwater Pollution Prevention Plan (SWPPP) requirements.

~~Section 4.1~~ None of the BMPs listed below will work successfully through the construction project without inspection and maintenance. Regular inspections to identify problems with the operation of each BMP, and the timely repair of any problems are essential to the continued operation of the BMPs.

Section 4.1 contains the standards and specifications for Source Control BMPs.

Section 4.2~~Section 4.2~~ contains the standards and specifications for Runoff Conveyance and Treatment BMPs.

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

1. ~~1.~~ Purpose
2. ~~2.~~ Conditions of Use
3. ~~3.~~ Design and Installation Specifications
4. ~~4.~~ Maintenance Standards

Note that the “Conditions of Use” ~~always~~ refers to site conditions. As site conditions change, BMPs must be changed to remain in compliance.

~~Information on streambank stabilization is available in the *Integrated Streambank Protection Guidelines*, Washington State Department of Fish and Wildlife, 2000.~~

4.1 Source Control BMPs

This section contains the standards and specifications for Source Control BMPs. Table 4.1.1, below, shows the relationship of the BMPs in Section 4.1 to the Construction Stormwater Pollution Prevention Plan (SWPPP) Elements described in Section 3.3.3. Elements not shown on Table 4.1.1 are not satisfied through installation of Source Controls.

Table 4.1.1 Source Control BMPs by SWPPP Element

BMP or Element Name	Element #1 Preserve Vegetation/Mark Clearing Limits	Element #2 Establish Construction Access	Element #5 Stabilize Soils	Element #6 Protect Slopes	Element #9 Control Pollutants	Element #11 Maintain BMPs	Element #12 Manage the Project	Element #13 Protect Low Impact Development
BMP C101: Preserving Natural Vegetation	✓							
BMP C102: Buffer Zones	✓							✓
BMP C103: High Visibility Plastic or Metal Fence	✓							✓
BMP C105: Stabilized Construction Entrance / Exit		✓						
BMP C106: Wheel Wash		✓						
BMP C107: Construction Road/Parking Area Stabilization		✓						
BMP C120: Temporary and Permanent Seeding			✓	✓				
BMP C121: Mulching			✓	✓				
BMP C122: Nets and Blankets			✓	✓				
BMP C123: Plastic Covering			✓					
BMP C124: Sodding			✓					
BMP C125: Topsoiling / Composting			✓					
BMP C126: Polyacrylamide for Soil Erosion Protection			✓					
BMP C130: Surface Roughening			✓	✓				
BMP C131: Gradient Terraces			✓	✓				
BMP C140: Dust Control			✓					
BMP C150: Materials On Hand						✓	✓	
BMP C151: Concrete Handling					✓			
BMP C152: Sawcutting and Surfacing Pollution Prevention					✓			
BMP C153: Material Delivery, Storage and Containment					✓			
BMP C154: Concrete Washout Area					✓			
BMP C160: Certified Erosion and Sediment Control Lead						✓	✓	
BMP C162: Scheduling							✓	

BMP C101: Preserving Natural Vegetation

Purpose The purpose of preserving natural vegetation is to reduce erosion wherever practicable. Limiting site disturbance is the single most effective method for reducing erosion. For example, conifers can hold up to about 50 percent of all rain that falls during a storm. Up to 20-30 percent of this rain may never reach the ground but is taken up by the tree or evaporates. Another benefit is that the rain held in the tree can be released slowly to the ground after the storm.

Conditions of Use Natural vegetation should be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in wooded areas.

- As required by local governments.
- Phase construction to preserve natural vegetation on the project site for as long as possible during the construction period.

Design and Installation Specifications

Natural vegetation can be preserved in natural clumps or as individual trees, shrubs and vines.

The preservation of individual plants is more difficult because heavy equipment is generally used to remove unwanted vegetation. The points to remember when attempting to save individual plants are:

- Is the plant worth saving? Consider the location, species, size, age, vigor, and the work involved. Local governments may also have ordinances to save natural vegetation and trees.
- Fence or clearly mark areas around trees that are to be saved. It is preferable to keep ground disturbance away from the trees at least as far out as the dripline.

Plants need protection from three kinds of injuries:

- *Construction Equipment* - This injury can be above or below the ground level. Damage results from scarring, cutting of roots, and compaction of the soil. Placing a fenced buffer zone around plants to be saved prior to construction can prevent construction equipment injuries.
- *Grade Changes* - Changing the natural ground level will alter grades, which affects the plant's ability to obtain the necessary air, water, and minerals. Minor fills usually do not cause problems although sensitivity between species does vary and should be checked. Trees can typically tolerate fill of 6 inches or less. For shrubs and other plants, the fill should be less.

When there are major changes in grade, it may become necessary to supply air to the roots of plants. This can be done by placing a layer of gravel and a tile system over the roots before the fill is made. A tile system protects a tree from a raised grade. The tile system should be

laid out on the original grade leading from a dry well around the tree trunk. The system should then be covered with small stones to allow air to circulate over the root area.

Lowering the natural ground level can seriously damage trees and shrubs. The highest percentage of the plant roots are in the upper 12 inches of the soil and cuts of only 2-3 inches can cause serious injury. To protect the roots it may be necessary to terrace the immediate area around the plants to be saved. If roots are exposed, construction of retaining walls may be needed to keep the soil in place. Plants can also be preserved by leaving them on an undisturbed, gently sloping mound. To increase the chances for survival, it is best to limit grade changes and other soil disturbances to areas outside the dripline of the plant.

- *Excavations* - Protect trees and other plants when excavating for drainfields, power, water, and sewer lines. Where possible, the trenches should be routed around trees and large shrubs. When this is not possible, it is best to tunnel under them. This can be done with hand tools or with power augers. If it is not possible to route the trench around plants to be saved, then the following should be observed:

Cut as few roots as possible. When you have to cut, cut clean. Paint cut root ends with a wood dressing like asphalt base paint if roots will be exposed for more than 24-hours.

Backfill the trench as soon as possible.

Tunnel beneath root systems as close to the center of the main trunk to preserve most of the important feeder roots.

Some problems that can be encountered with a few specific trees are:

- Maple, Dogwood, Red alder, Western hemlock, Western red cedar, and Douglas fir do not readily adjust to changes in environment and special care should be taken to protect these trees.
- The windthrow hazard of Pacific silver fir and ~~madronna~~madrona is high, while that of Western hemlock is moderate. The danger of windthrow increases where dense stands have been thinned. Other species (unless they are on shallow, wet soils less than 20 inches deep) have a low windthrow hazard.
- Cottonwoods, maples, and willows have water-seeking roots. These can cause trouble in sewer lines and infiltration fields. On the other hand, they thrive in high moisture conditions that other trees would not.
- Thinning operations in pure or mixed stands of Grand fir, Pacific silver fir, Noble fir, Sitka spruce, Western red cedar, Western hemlock, Pacific dogwood, and Red alder can cause serious disease problems. Disease can become established through damaged limbs, trunks, roots,

and freshly cut stumps. Diseased and weakened trees are also susceptible to insect attack.

Maintenance Standards

Inspect flagged and/or fenced areas regularly to make sure flagging or fencing has not been removed or damaged. If the flagging or fencing 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.

BMP C102: Buffer Zones

Purpose

Creation of 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.

Conditions of Use

Natural buffer zones are used along streams, wetlands and other bodies of water that need protection from erosion and sedimentation. Vegetative buffer zones can be used to protect natural swales and can be ~~incor-~~
~~porated~~**incorporated** into the natural landscaping of an area.

Critical-areas buffer zones should not be used as sediment treatment areas. These areas shall remain completely undisturbed. The local permitting authority may expand the buffer widths temporarily to allow the use of the expanded area for removal of sediment.

Design and Installation Specifications

- 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.
- Mark clearing limits and keep all equipment and construction debris out of the natural areas ~~and buffer zones~~. Steel construction fencing is the most effective method in protecting sensitive areas and buffers. Alternatively, wire-backed silt fence on steel posts is marginally effective. Flagging alone is typically not effective.
- Keep all excavations outside the dripline 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.
- Vegetative buffer zones for streams, lakes or other waterways shall be established by the local permitting authority or other state or federal permits or approvals.

Maintenance Standards

Inspect the area frequently to make sure flagging remains in place and the area remains undisturbed. Replace all damaged flagging immediately.

BMP C103: High Visibility ~~Plastic or Metal~~ Fence

Purpose	<p>Fencing is intended to:</p> <ol style="list-style-type: none"><u>1.</u> (1) Restrict clearing to approved limits; (2).<u>2.</u> Prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3).<u>3.</u> Limit construction traffic to designated construction entrances, <u>exits</u>, or <u>internal</u> roads; and, (4).4. Protect areas where marking with survey tape may not provide adequate protection.
Conditions of Use	<p>To establish clearing limits, plastic, <u>fabric</u>, or metal fence may be used:</p> <ul style="list-style-type: none">• At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared.• As necessary to control vehicle access to and on the site.
Design and Installation Specifications	<p>High visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least four feet in height. Posts for the fencing shall be steel or wood and placed every 6 feet on center (maximum) or as needed to ensure rigidity. The fencing shall be fastened to the post every six inches with a polyethylene tie. On long continuous lengths of fencing, a tension wire or rope shall be used as a top stringer to prevent sagging between posts. The fence color shall be high visibility orange. The fence tensile strength shall be 360 lbs./ft. using the ASTM D4595 testing method.</p> <p>If appropriate install fabric silt fence in accordance with BMP C233 to act as high visibility fence. Silt fence shall be at least 3 feet high and must be highly visible to meet the requirements of this BMP.</p> <p>Metal fences shall be designed and installed according to the manufacturer's specifications.</p> <p>Metal fences shall be at least 3 feet high and must be highly visible.</p> <p>Fences shall not be wired or stapled to trees.</p>
Maintenance Standards	<p>If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.</p>

BMP C104: Stake and Wire Fence

Purpose — Fencing is intended to: (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and, (4) protect any areas where marking with survey tape may not provide adequate protection.

Conditions of Use — To establish clearing limits, stake or wire fence may be used:

- At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared.
- As necessary, to control vehicle access to and on the site.

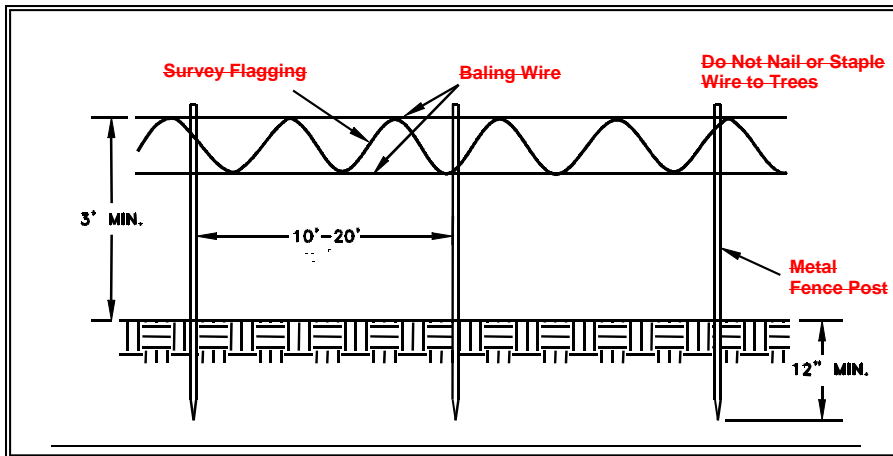


Figure 4.1 – Stake and Wire Fence

BMP C105: Stabilized Construction Entrance / Exit

Purpose

Stabilized Construction entrances are ~~stabilized~~established to reduce the amount of sediment transported onto paved roads by vehicles or equipment. This is done by constructing a stabilized pad of quarry spalls at entrances ~~to and exits for~~ construction sites.

Conditions of Use

Construction entrances shall be stabilized wherever traffic will be entering ~~or~~ leaving a construction site ~~and traveling on~~ paved roads or other paved areas are within 1,000 feet of the site.

For residential construction provide stabilized construction entrances for each residence, rather than only at the main subdivision entrance. Stabilized surfaces shall be of sufficient length/width to provide vehicle access/parking, based on lot size/configuration.

On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances not shown in the initial Construction SWPPP. It is difficult to determine exactly where access to these projects will take place; additional materials will enable the contractor to install them where needed.

Design and Installation Specifications

See [Figure 4.1.1](#) for details. Note: the 100' minimum length of the entrance shall be reduced to the maximum practicable size when the size or configuration of the site does not allow the full length (100').

Construct stabilized construction entrances with a 12-inch thick pad of 4-inch to 8-inch quarry spalls, a 4-inch course of asphalt treated base (ATB), or use existing pavement. Do not use crushed concrete, cement, or calcium chloride for construction entrance stabilization because these products raise pH levels in stormwater and concrete discharge to surface waters of the State is prohibited.

A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:

Grab Tensile Strength (ASTM D4751)	200 psi min.
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

- Consider early installation of the first lift of asphalt in areas that will paved; this can be used as a stabilized entrance. Also consider the installation of excess concrete as a stabilized entrance. During large concrete pours, excess concrete is often available for this purpose.

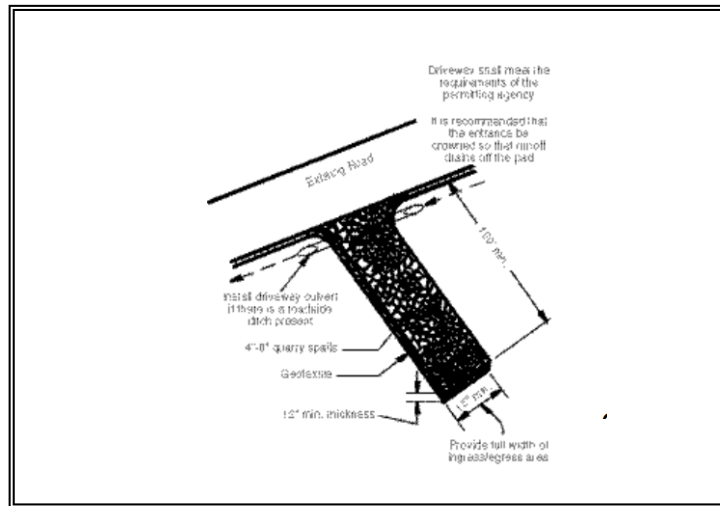
- ~~Hog fuel (wood-based mulch) may be substituted for or combined with quarry spalls in areas that will not be used for permanent roads. Hog fuel is generally less effective at stabilizing construction entrances and should be used only at sites where the amount of traffic is very limited. Hog fuel is not recommended for entrance stabilization in urban areas. The effectiveness of hog fuel is highly variable and it generally requires more maintenance than quarry spalls. The inspector may at any time require the use of quarry spalls if the hog fuel is not preventing sediment from being tracked onto pavement or if the hog fuel is being carried onto pavement. Hog fuel is prohibited in permanent roadbeds because organics in the subgrade soils cause degradation of the subgrade support over time.~~
- Fencing (see [BMP C103](#) ~~BMPs C103 and C104~~) shall be installed as necessary to restrict traffic to the construction entrance.
- Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.
- Construction entrances should avoid crossing existing sidewalks and back of walk drains if at all possible. If a construction entrance must cross a sidewalk or back of walk drain, the full length of the sidewalk and back of walk drain must be covered and protected from sediment leaving the site.

Maintenance Standards

Quarry spalls shall be added if the pad is no longer in accordance with the specifications.

- 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 replacement/cleaning of the existing quarry spalls, street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash.
- 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. The pavement shall not be cleaned by washing down the street, except when high efficiency sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump to contain the wash water shall be considered. The sediment would then be washed into the sump where it can be controlled.
- Perform street sweeping by hand or with a high efficiency sweeper. Do not use a non-high efficiency mechanical sweeper because this creates dust and throws soils into storm systems or conveyance ditches.
- Any quarry spalls that are loosened from the pad, which end up on the roadway shall be removed immediately.

- If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see [BMP C103](#) ~~BMPs C103 and C104~~) shall be installed to control traffic.
- Upon project completion and site stabilization, all construction accesses intended as permanent access for maintenance shall be permanently stabilized.



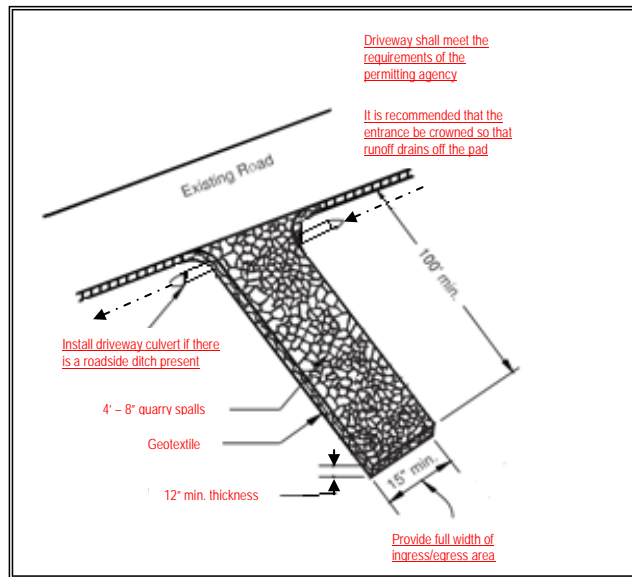


Figure 4.21.1 – Stabilized Construction Entrance

Approved as Equivalent

Ecology has approved products as able to meet the requirements of [BMP C105](#). The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology's website at <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html>

BMP C106: Wheel Wash

Purpose

Wheel washes reduce the amount of sediment transported onto paved roads by motor vehicles.

Conditions of Use

When a stabilized construction entrance (see [BMP C105](#)~~BMP C105~~) is not preventing sediment from being tracked onto pavement.

- Wheel washing is generally an effective BMP when installed with careful attention to topography. For example, a wheel wash can be detrimental if installed at the top of a slope abutting a right-of-way where the water from the dripping truck can run unimpeded into the street.

Design and Installation Specifications

- Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot x 10-foot sump can be very effective.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as closed-loop recirculation or upland land application, or to the sanitary sewer with local sewer district approval.
- Wheel wash or tire bath wastewater should not include wastewater from concrete washout areas.

Suggested details are shown in [Figure 4.1.2](#). The Local Permitting Authority may allow other designs. 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 wheel wash.

Use a low clearance truck to test the wheel 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.

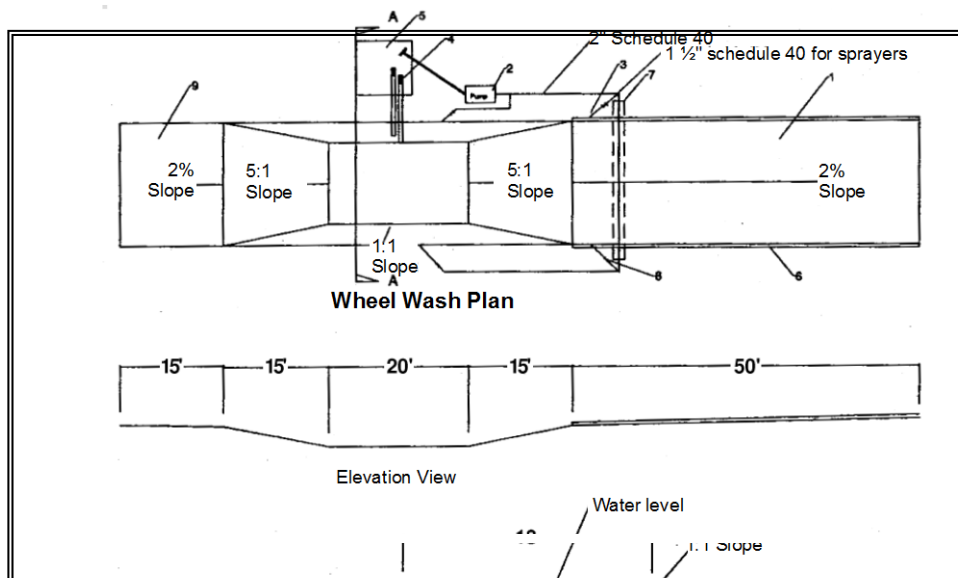
Midpoint spray nozzles are only needed in extremely muddy conditions.

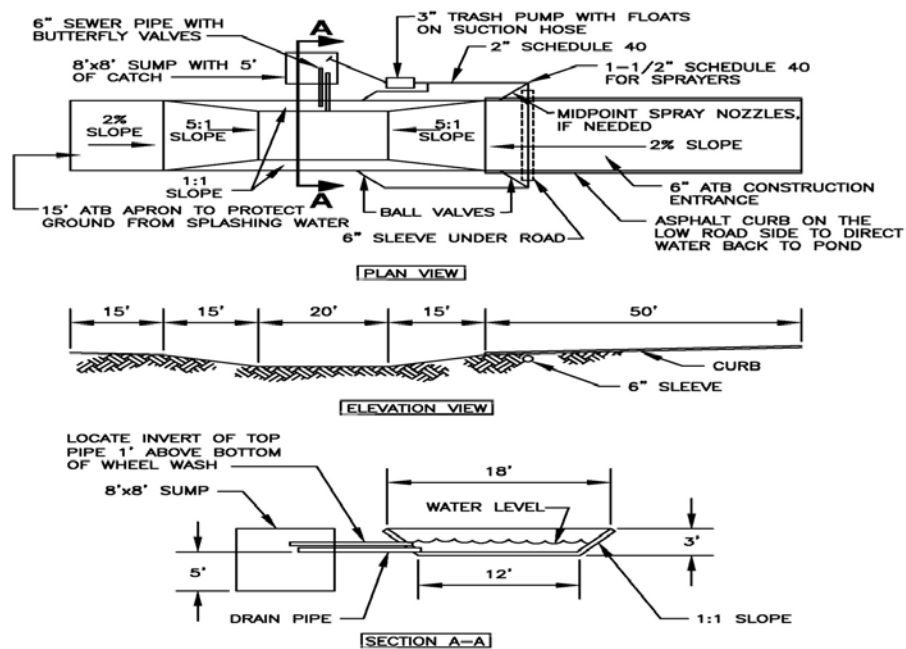
Wheel wash systems should be designed with a small grade change, ~~6-~~ 12-1 inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent re-suspension of sediment. A drainpipe with a 2- to 3-foot riser should be installed on the low side of the pond to allow for easy cleaning and refilling. Polymers may be used to promote coagulation and flocculation in a closed-loop system. Polyacrylamide (PAM) added to the wheel wash water at a rate of 0.25 - 0.5 pounds 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.

Maintenance Standards

The wheel 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 10-20 trucks per hour are expected, the wash water will need to be changed more often.





NOTES:
1. BUILD 8'x8' SUMP TO ACCOMMODATE CLEANING BY TRACKHOE.

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Figure 4.31.2 – Wheel Wash

Notes:

1. Asphalt construction entrance 6 in. 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 x 8 foot sump with 5 feet of catch. Build so the sump can be cleaned with a 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.

BMP C107: Construction Road/Parking Area Stabilization

Purpose	Stabilizing subdivision roads, parking areas, and other onsite <u>on-site</u> vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or runoff.
Conditions of Use	Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
Design and Installation Specifications	<ul style="list-style-type: none">• <u>High Visibility</u> Fencing (see BMP C103BMPs C103 and C104) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.• On areas that will receive asphalt as part of the project, install the first lift as soon as possible.• A 6-inch depth of 2- to 4-inch crushed rock, gravel base, or crushed surfacing base course shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If cement or cement kiln dust is used for roadbase stabilization, pH monitoring and BMPs (BMPs C252 and C253) are necessary to evaluate and minimize the effects on stormwater. If the area will not be used for permanent roads, parking areas, or structures, a 6-inch depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade.• Temporary road gradients shall not exceed 15 percent. Roadways shall be carefully graded to drain. Drainage ditches shall be provided on each side of the roadway in the case of a crowned section, or on one side in the case of a super-elevated section. Drainage ditches shall be directed to a sediment control BMP.• Rather than relying on ditches, it may also be possible to grade the road so that runoff sheet-flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation <u>that water can flow through</u>, then it is generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include wetlands— or their buffers. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.• Storm drain inlets shall be protected to prevent sediment-laden water entering the storm drain system (see BMP C220BMP C220).
Maintenance Standards	Inspect stabilized areas regularly, especially after large storm events. Crushed rock, gravel base, etc. shall be added as required to maintain a

stable driving surface and to stabilize any areas that have eroded.

Following construction, these areas shall be restored to pre-construction condition or better to prevent future erosion.

Perform street cleaning at the end of each day or more often if necessary.

BMP C120: Temporary and Permanent Seeding

Purpose

Seeding ~~is intended to reduce~~reduces erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

Conditions of Use

Use seeding throughout the project on disturbed areas that have reached final grade or that will remain unworked for more than 30 days.

The optimum seeding windows for western Washington are April 1 through June 30 and September 1 through October 1.

Between July 1 and August 30 seeding requires irrigation until 75 percent grass cover is established.

Between October 1 and March 30 seeding requires a cover of mulch with straw or an erosion control blanket until 75 percent grass cover is established.

Review all disturbed areas in late August to early September and complete all seeding by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.

- ~~• Channels that will be vegetated should be installed before major earthwork and hydroseeded with a Bonded Fiber Matrix. 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 blankets 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 over hydromulch and blankets.~~
- ~~• Retention/detention ponds should be seeded as required.~~
- Mulch is required at all times for seeding because it protects seeds from heat, moisture loss, and transport due to runoff. Mulch can be applied on top of the seed or simultaneously by hydroseeding. See BMP C121: Mulching for specifications.
- ~~• All disturbed areas shall be reviewed in late August to early September and all seeding should be completed by the end of September. Otherwise, vegetation will not establish itself enough to provide more than average protection.~~
- At final site stabilization~~Seed and mulch~~, all disturbed areas not otherwise vegetated ~~or stabilized shall be seeded and mulched at final~~

**Design and
Installation
Specifications**

site stabilization. Final stabilization means the completion of all soil disturbing activities at the site and the establishment of a permanent vegetative cover, or equivalent permanent stabilization measures (such as pavement, riprap, gabions or geotextiles) which will prevent erosion.

Seed retention/detention ponds as required.

Install channels intended for vegetation before starting major earthwork and hydroseed with a Bonded Fiber Matrix. For vegetated channels that will have high flows, install erosion control blankets over hydroseed. Before allowing water to flow in vegetated channels, establish 75 percent vegetation cover. If vegetated channels cannot be established by seed before water flow; install sod in the channel bottom—over hydromulch and erosion control blankets.

- ~~To prevent seed from being washed away, confirm that~~ Confirm the installation of all required surface water control measures ~~have been installed to prevent seed from washing away.~~
- ~~The seedbed should be firm and rough. All soil should be roughened no matter what the slope. If compaction is required for engineering purposes, slopes must be track walked before seeding. Backblading or smoothing of slopes greater than 4:1 is not allowed if they are to be seeded.~~
- ~~New and more effective restoration-based landscape practices rely on deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical the subgrade should be initially ripped to improve long-term permeability, infiltration, and water-inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches the rototilling process should be done in multiple lifts, or the prepared soil system shall be prepared properly and then placed to achieve the specified depth.~~
- ~~Organic matter is the most appropriate form of “fertilizer” because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form. A natural system typically releases 2–10 percent of its nutrients annually. Chemical fertilizers have since been formulated to simulate what organic matter does naturally.~~
- ~~In general, 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer can be used at a rate of 90 pounds per acre. Slow-release fertilizers should always be used because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of~~

~~fertilizer. Fertilizer should not be added to the hydromulch machine and agitated more than 20 minutes before it is to be used. If agitated too much, the slow release coating is destroyed.~~

- ~~• There are numerous products available on the market that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal is a good source of long term, slow release, available nitrogen.~~
- Hydroseed applications shall include a minimum of 1,500 pounds per acre of mulch with 3 percent tackifier. [See BMP C121: Mulching](#)
~~Mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, and kenaf; compost; or blends of these. Tackifier shall be plant based, such as guar or alpha plantago, or chemical based such as polyacrylamide or polymers. Any mulch or tackifier product used shall be installed per manufacturer's instructions. Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application for specifications.~~
- ~~• Mulch is always required for seeding. Mulch can be applied on top of the seed or simultaneously by hydroseeding.~~
- ~~• On steep slopes, Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products should be used. BFM/MBFM products are applied at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Application is made so that a minimum of 95 percent soil coverage is achieved. Numerous products are available commercially and should be installed per manufacturer's instructions. Most products require 24-36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.~~

~~BFMs and MBFMs have some advantages over blankets:~~

- ~~• No surface preparation required;~~
- ~~• Can be installed via helicopter in remote areas;~~
- ~~• On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;~~
- ~~• They are at least \$1,000 per acre cheaper installed.~~

~~In most cases, the shear strength of blankets is not a factor when used on slopes, only when used in channels. BFMs and MBFMs are good alternatives to blankets in most situations where vegetation establishment is the goal.~~

- Areas that will have seeding only and not landscaping may need compost or meal-based mulch included in the hydroseed in order to

establish vegetation. Re-install native topsoil on the disturbed soil surface before application.

- When installing seed via hydroseeding operations, only about 1/3 of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. ~~One way~~ To overcome this ~~is to increase~~, consider increasing seed quantities by up to 50 percent.
- Enhance vegetation establishment ~~can also be enhanced~~ by dividing the hydromulch operation into two phases:
 1. Phase 1- Install all seed and fertilizer with 25-30 percent mulch and tackifier onto soil in the first lift.
 2. Phase 2- Install the rest of the mulch and tackifier over the first lift.

~~An alternative is to install~~ Or, enhance vegetation by:

1. Installing the mulch, seed, fertilizer, and tackifier in one lift.
2. ~~Then,~~ Spread or blow straw over the top of the hydromulch at a rate of ~~about~~ 800-1000 pounds per acre.
3. Hold straw in place with a standard tackifier.

Both of these approaches will increase cost moderately but will greatly improve and enhance vegetative establishment. The increased cost may be offset by the reduced need for:

- Irrigation.
- Reapplication of mulch.
- Repair of failed slope surfaces.

This technique works with standard hydromulch (1,500 pounds per acre minimum) and BFM/MBFMs (3,000 pounds per acre minimum).

- Seed may be installed by hand if:
 - Temporary and covered by straw, mulch, or topsoil.
 - Permanent in small areas (usually less than 1 acre) and covered with mulch, topsoil, or erosion blankets.
- The seed mixes listed in the tables below include recommended mixes for both temporary and permanent seeding.
 - Apply these mixes, with the exception of the wetland mix, at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used.
 - Consult the local suppliers or the local conservation district for their recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the local authority may be used.

- Other mixes may be appropriate, depending on the soil type and hydrology of the area.
- Table 4.1.2 lists the standard mix for areas requiring a temporary vegetative cover.

<u>Table 4.1.2</u> <u>Temporary Erosion Control Seed Mix</u>			
	<u>% Weight</u>	<u>% Purity</u>	<u>% Germination</u>
<u>Chewings or annual blue grass</u> <u><i>Festuca rubra</i> var. <i>commutata</i> or</u> <u><i>Poa annua</i></u>	<u>40</u>	<u>98</u>	<u>90</u>
<u>Perennial rye -</u> <u><i>Lolium perenne</i></u>	<u>50</u>	<u>98</u>	<u>90</u>
<u>Redtop or colonial bentgrass</u> <u><i>Agrostis alba</i> or <i>Agrostis tenuis</i></u>	<u>5</u>	<u>92</u>	<u>85</u>
<u>White dutch clover</u> <u><i>Trifolium repens</i></u>	<u>5</u>	<u>98</u>	<u>90</u>

- Table 4.1.3 lists a recommended mix for landscaping seed.

<u>Table 4.1.3</u> <u>Landscaping Seed Mix</u>			
	<u>% Weight</u>	<u>% Purity</u>	<u>% Germination</u>
<u>Perennial rye blend</u> <u><i>Lolium perenne</i></u>	<u>70</u>	<u>98</u>	<u>90</u>
<u>Chewings and red fescue blend</u> <u><i>Festuca rubra</i> var. <i>commutata</i></u> <u>or <i>Festuca rubra</i></u>	<u>30</u>	<u>98</u>	<u>90</u>

- [Table 4.1.4](#) lists a turf seed mix for dry situations where there is no need for watering. This mix requires very little maintenance.

Table 4.1.4 <u>Low-Growing Turf Seed Mix</u>			
	<u>% Weight</u>	<u>% Purity</u>	<u>% Germination</u>
<u>Dwarf tall fescue (several varieties)</u> <u><i>Festuca arundinacea</i> var.</u>	<u>45</u>	<u>98</u>	<u>90</u>
<u>Dwarf perennial rye (Barclay)</u> <u><i>Lolium perenne</i> var. <i>barclay</i></u>	<u>30</u>	<u>98</u>	<u>90</u>
<u>Red fescue</u> <u><i>Festuca rubra</i></u>	<u>20</u>	<u>98</u>	<u>90</u>
<u>Colonial bentgrass</u> <u><i>Agrostis tenuis</i></u>	<u>5</u>	<u>98</u>	<u>90</u>

- [Table 4.1.5](#) lists a mix for bioswales and other intermittently wet areas.

Table 4.1.5 <u>Bioswale Seed Mix*</u>			
	<u>% Weight</u>	<u>% Purity</u>	<u>% Germination</u>
<u>Tall or meadow fescue</u> <u><i>Festuca arundinacea</i> or <i>Festuca</i></u> <u><i>elatior</i></u>	<u>75-80</u>	<u>98</u>	<u>90</u>
<u>Seaside/Creeping bentgrass</u> <u><i>Agrostis palustris</i></u>	<u>10-15</u>	<u>92</u>	<u>85</u>
<u>Redtop bentgrass</u> <u><i>Agrostis alba</i> or <i>Agrostis gigantea</i></u>	<u>5-10</u>	<u>90</u>	<u>80</u>

* Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

- [Table 4.1.6 lists a low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Apply this mixture at a rate of 60 pounds per acre. Consult Hydraulic Permit Authority \(HPA\) for seed mixes if applicable.](#)

Table 4.1.6 Wet Area Seed Mix*			
	% Weight	% Purity	% Germination
Tall or meadow fescue <i>Festuca arundinacea</i> or <i>Festuca elatior</i>	60-70	98	90
Seaside/Creeping bentgrass <i>Agrostis palustris</i>	10-15	98	85
Meadow foxtail <i>Alephocurus pratensis</i>	10-15	90	80
Alsike clover <i>Trifolium hybridum</i>	1-6	98	90
Redtop bentgrass <i>Agrostis alba</i>	1-6	92	85

* Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

- [Table 4.1.7 lists a recommended meadow seed mix for infrequently maintained areas or non-maintained areas where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. Consider the appropriateness of clover, a fairly invasive species, in the mix. Amending the soil can reduce the need for clover.](#)

Table 4.1.7 Meadow Seed Mix			
	% Weight	% Purity	% Germination
Redtop or Oregon bentgrass <i>Agrostis alba</i> or <i>Agrostis oregonensis</i>	20	92	85
Red fescue <i>Festuca rubra</i>	70	98	90
White dutch clover <i>Trifolium repens</i>	10	98	90

- **Roughening and Rototilling:**
 - The seedbed should be firm and rough. Roughen all soil no matter what the slope. Track walk slopes before seeding if engineering purposes require compaction. Backblading or smoothing of slopes greater than 4H:1V is not allowed if they are to be seeded.
 - Restoration-based landscape practices require deeper incorporation than that provided by a simple single-pass rototilling treatment. Wherever practical, initially rip the subgrade to improve long-term permeability, infiltration, and water inflow qualities. At a minimum, permanent areas shall use soil amendments to achieve organic matter and permeability performance defined in engineered soil/landscape systems. For systems that are deeper than 8 inches complete the rototilling process in multiple lifts, or prepare the engineered soil system per specifications and place to achieve the specified depth.
- **Fertilizers:**
 - Conducting soil tests to determine the exact type and quantity of fertilizer is recommended. This will prevent the over-application of fertilizer.
 - Organic matter is the most appropriate form of fertilizer because it provides nutrients (including nitrogen, phosphorus, and potassium) in the least water-soluble form.
 - In general, use 10-4-6 N-P-K (nitrogen-phosphorus-potassium) fertilizer at a rate of 90 pounds per acre. Always use slow-release fertilizers because they are more efficient and have fewer environmental impacts. Do not add fertilizer to the hydromulch machine, or agitate, more than 20 minutes before use. Too much agitation destroys the slow-release coating.
 - There are numerous products available that take the place of chemical fertilizers. These include several with seaweed extracts that are beneficial to soil microbes and organisms. If 100 percent cottonseed meal is used as the mulch in hydroseed, chemical fertilizer may not be necessary. Cottonseed meal provides a good source of long-term, slow-release, available nitrogen.
- **Bonded Fiber Matrix and Mechanically Bonded Fiber Matrix:**
 - On steep slopes use Bonded Fiber Matrix (BFM) or Mechanically Bonded Fiber Matrix (MBFM) products. Apply BFM/MBFM products at a minimum rate of 3,000 pounds per acre of mulch with approximately 10 percent tackifier. Achieve a minimum of 95 percent soil coverage during application. Numerous products are available commercially. Installed products per manufacturer's instructions. Most products require 24-36 hours to cure before rainfall and cannot be installed on wet or saturated soils.

Generally, products come in 40-50 pound bags and include all necessary ingredients except for seed and fertilizer.

- BFM and MBFMs provide good alternatives to blankets in most areas requiring vegetation establishment. Advantages over blankets include:
 - BFM and MBFMs do not require surface preparation.
 - Helicopters can assist in installing BFM and MBFMs in remote areas.
 - On slopes steeper than 2.5H:1V, blanket installers may require ropes and harnesses for safety.
 - Installing BFM and MBFMs can save at least \$1,000 per acre compared to blankets.

Maintenance Standards

Reseed any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows). If reseeding is ineffective, use an alternate method such as sodding, mulching, or nets/blankets. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the local authority when sensitive areas would otherwise be protected.

- Reseed and protect by mulch any areas that experience erosion after achieving adequate cover. Reseed and protect by mulch any eroded area.
- Supply seeded areas with adequate moisture, but do not water to the extent that it causes runoff.

Approved as Equivalent

Ecology has approved products as able to meet the requirements of [BMP C120](#). The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology's website at <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html>

BMP C121: Mulching

Purpose

Mulching soils provides immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. This section discusses only the most common types of mulch.

Conditions of Use

As a temporary cover measure, mulch should be used:

- For less than 30 days on disturbed areas that require cover.
- At all times for seeded areas, especially during the wet season and

during the hot summer months.

- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Mulch may be applied at any time of the year and must be refreshed periodically.

- For seeded areas mulch may be made up of 100 percent: cottonseed meal; fibers made of wood, recycled cellulose, hemp, kenaf; compost; or blends of these. Tackifier shall be plant-based, such as guar or alpha plantago, or chemical-based such as polyacrylamide or polymers. Any mulch or tackifier product used shall be installed per manufacturer's instructions. Generally, mulches come in 40-50 pound bags. Seed and fertilizer are added at time of application.

***Design and
Installation
Specifications***

For mulch materials, application rates, and specifications, see [Table 4.1.8](#). Always use a 2-inch minimum mulch thickness; increase the thickness until the ground is 95% covered (i.e. not visible under the mulch layer). Note: Thickness may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Mulch used within the ordinary high-water mark of surface waters should be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material. Consult Hydraulic Permit Authority (HPA) for mulch mixes if applicable.

***Maintenance
Standards***

- The thickness of the cover must be maintained.
- Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

**Table 4.1.8
Mulch Standards and Guidelines**

Mulch Material	Quality Standards	Application	
		Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2"-3" thick; 5 bales per 1,000 sf or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. The thickness of straw may be reduced by half when used in conjunction with seeding. In windy areas straw must be held in place by crimping, using a tackifier, or covering with netting. Blown straw always has to be held in place with a tackifier as even light winds will blow it away. Straw, however, has several deficiencies that should be considered when selecting mulch materials. It often introduces and/or encourages the propagation of weed species and it has no significant long-term benefits. It should also not be used within the ordinary high-water elevation of surface waters (due to flotation).
Hydromulch	No growth inhibiting factors.	Approx. 25-30 lbs per 1,000 sf or 1,500 - 2,000 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Fibers longer than about ¾-1 inch clog hydromulch equipment. Fibers should be kept to less than ¾ inch.
Composted Mulch and Compost	No visible water or dust during handling. Must be produced in accordance with WAC 173-350 , Solid Waste Handling Standards.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Composted mulch has a coarser size gradation than compost. It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use composted mulch near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Average size shall be several inches. Gradations from fines to 6 inches in length for texture, variation, and interlocking properties.	2" thick min.;	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.
Wood-based Mulch or Wood Straw	No visible water or dust during handling. Must be purchased from a supplier with a Solid Waste Handling Permit or one exempt from solid waste regulations.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs. per cubic yard)	This material is often called "hog or hogged fuel." The use of mulch ultimately improves the organic matter in the soil. Special caution is advised regarding the source and composition of wood-based mulches. Its preparation typically does not provide any weed seed control, so evidence of residual vegetation in its composition or known inclusion of weed plants or seeds should be monitored and prevented (or minimized).
Wood Strand Mulch	A blend of loose, long, thin wood pieces derived from native conifer or deciduous trees with high length-to-width ratio.	2" thick min.	Cost-effective protection when applied with adequate thickness. A minimum of 95-percent of the wood strand shall have lengths between 2 and 10-inches, with a width and thickness between 1/16 and ¾-inches. The mulch shall not contain resin, tannin, or other compounds in quantities that would be detrimental to plant life. Sawdust or wood shavings shall not be used as mulch. (WSDOT specification (9-14.4(4))

BMP C122: Nets and Blankets

Purpose Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainage ways during high flows. Nets (commonly called matting) are strands of material woven into an open, but high-tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

Conditions of Use Erosion control nets and blankets should be used:

- To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.
- For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.

Disadvantages of blankets include:

- Surface preparation required.
- On slopes steeper than 2.5H:1V, blanket installers may need to be roped and harnessed for safety.
- They cost at least \$4,000-6,000 per acre installed.

Advantages of blankets include:

- Installation without mobilizing special equipment.
- Installation by anyone with minimal training
- Installation in stages or phases as the project progresses.
- Installers can hand place seed and fertilizer as they progress down the slope.
- Installation in any weather.
- There are numerous types of blankets that can be designed with various parameters in mind. Those parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.

Design and Installation Specifications

- See [Figure 4.1.3](#) and [Figure 4.1.4](#) for typical orientation and installation of blankets used in channels and as slope protection. Note: these are typical only; all blankets must be installed per manufacturer's installation instructions.
- Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.
- Installation of Blankets on Slopes:
 1. Complete final grade and track walk up and down the slope.
 2. Install hydromulch with seed and fertilizer.
 3. Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
 4. Install the leading edge of the blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal, "U"-shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.
 5. Roll the blanket slowly down the slope as installer walks backwards. NOTE: The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.
 6. If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.
- With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consult the manufacturer's information and that a site visit takes place in order to ensure that the product specified is appropriate. Information is also available at the following web sites:
 1. WSDOT (Section 3.2.4):
<http://www.wsdot.wa.gov/NR/rdonlyres/3B41E087-FA86-4717-932D-D7A8556CCD57/0/ErosionTrainingManual.pdf>
 2. Texas Transportation Institute:
http://www.txdot.gov/business/doing_business/product_evaluation/erosion_control.htm

- Use jute matting in conjunction with mulch (BMP C121). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.
- In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
- Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high-energy environments. If synthetic blankets are used, the soil should be hydromulched first.
- 100-percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.
- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.

Maintenance Standards

- Maintain good contact with the ground. Erosion must not occur beneath the net or blanket.
- Repair and staple any areas of the net or blanket that are damaged or not in close contact with the ground.
- Fix and protect eroded areas if erosion occurs due to poorly controlled drainage.

BMP C123: Plastic Covering

<u>Purpose</u>	<u>Plastic covering provides immediate, short-term erosion protection to slopes and disturbed areas.</u>
<u>Conditions of Use</u>	<p>Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.</p> <ul style="list-style-type: none">• <u>Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term (greater than six months) applications.</u>• <u>Due to rapid runoff caused by plastic covering, do not use this method upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.</u>• <u>Plastic sheeting may result in increased runoff volumes and velocities, requiring additional on-site measures to counteract the increases. Creating a trough with wattles or other material can convey clean water away from these areas.</u>• <u>To prevent undercutting, trench and backfill rolled plastic covering products.</u>• <u>While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to \$1.50-2.00 per square yard.</u>• <u>Whenever plastic is used to protect slopes install water collection measures at the base of the slope. These measures include plastic-covered berms, channels, and pipes used to convey clean rainwater away from bare soil and disturbed areas. Do not mix clean runoff from a plastic covered slope with dirty runoff from a project.</u>• <u>Other uses for plastic include:</u><ol style="list-style-type: none"><u>1. Temporary ditch liner.</u><u>2. Pond liner in temporary sediment pond.</u><u>3. Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored.</u><u>4. Emergency slope protection during heavy rains.</u><u>5. Temporary drainpipe ("elephant trunk") used to direct water.</u>
<u>Design and Installation Specifications</u>	<ul style="list-style-type: none">• Plastic slope cover must be installed as follows:<ol style="list-style-type: none">1. Run plastic up and down slope, not across slope.2. Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet.3. Minimum of 8-inch overlap at seams.

	<ol style="list-style-type: none"> On long or wide slopes, or slopes subject to wind, tape all seams. 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. Place sand filled burlap or geotextile bags every 3 to 6 feet along seams and tie them together with twine to hold them in place. Inspect plastic for rips, tears, and open seams regularly and repair immediately. This prevents high velocity runoff from contacting bare soil which causes extreme erosion. Sandbags may be lowered into place tied to ropes. However, all sandbags must be staked in place.
Maintenance Standards	<ul style="list-style-type: none"> Plastic sheeting shall have a minimum thickness of 0.06 millimeters. <u>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.</u> Torn sheets must be replaced and open seams repaired. Completely remove and replace the plastic if it begins to deteriorate due to ultraviolet radiation.
Approved as Equivalent	<ul style="list-style-type: none"> <u>Completely remove plastic when no longer needed.</u> <u>Dispose of old tires used to weight down plastic sheeting appropriately.</u> <p>Ecology has approved products as able to meet the requirements of BMP C123. The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology’s website at http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html</p>

BMP C124: Sodding

Purpose The purpose of sodding is to establish permanent turf for immediate erosion protection and to stabilize drainage ways where concentrated overland flow will occur.

Conditions of Use Sodding may be used in the following areas:

- Disturbed areas that require short-term or long-term cover.
- Disturbed areas that require immediate vegetative cover.
- All waterways that require vegetative lining. Waterways may also be seeded rather than sodded, and protected with a net or blanket.

**Design and
Installation
Specifications**

Sod shall be free of weeds, of uniform thickness (approximately 1-inch thick), and shall have a dense root mat for mechanical strength.

The following steps are recommended for sod installation:

- Shape and smooth the surface to final grade in accordance with the approved grading plan. The swale needs to be overexcavated 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.
- Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. See <http://www.ecy.wa.gov/programs/swfa/organics/soil.html> for further information.
- Fertilize according to the supplier's recommendations.
- Work lime and fertilizer 1 to 2 inches into the soil, 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 into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.
- 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.

**Maintenance
Standards**

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy groundcover. If it is impossible to establish a healthy groundcover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

BMP C125: Topsoiling / Composting

Purpose

Topsoiling and composting provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling and composting are an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding.

Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer and pesticides needed to support

Conditions of Use

installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.

- Permanent landscaped areas shall contain healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation.
- Leave native soils and the duff layer undisturbed to the maximum extent practicable. Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. Preserve existing soil systems in undisturbed and uncompacted conditions if functioning properly.
- Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.
- Restore, to the maximum extent practical, native soils disturbed during clearing and grading to a condition equal to or better than the original site condition's moisture-holding capacity. Use on-site native topsoil, incorporate amendments into on-site soil, or import blended topsoil to meet this requirement.
- Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.
- Beware of where the topsoil comes from, and what vegetation was on site before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.
- Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Use commercially available mycorrhiza products when using off-site topsoil.

Design and Installation Specifications

Meet the following requirements for areas requiring disruption and topsoiling:

- Maximize the depth of the topsoil wherever possible to provide the maximum possible infiltration capacity and beneficial growth medium. Topsoil shall have:
 - A minimum depth of 8-inches. Scarify subsoils below the topsoil layer at least 4-inches with some incorporation of the upper material to avoid stratified layers, where feasible. Ripping or restructuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.

- A minimum organic content of 10% dry weight, and 5% organic matter content in turf areas. Incorporate organic amendments to a minimum 8-inch depth except where tree roots or other natural features limit the depth of incorporation.
- A pH between 6.0 and 8.0 or matching the pH of the undisturbed soil.
- If blended topsoil is imported, then fines should be limited to 25 percent passing through a 200 sieve.
- Accomplish the required organic content and pH by either returning native topsoil to the site and/or incorporating organic amendments.

- To meet the organic content use compost that meets the definition of “composted materials” in [WAC 173-350-220](#). This code is available online at:

<http://apps.leg.wa.gov/WAC/default.aspx?cite=173-350-220>.

The compost must also have an organic matter content of 35% to 65%, and a carbon to nitrogen ratio below 25H:1V.

The carbon to nitrogen ratio may be as high as 35H:1V for plantings composed entirely of plants native to the Puget Sound Lowlands region.

- ~~Areas to be permanently landscaped shall provide a healthy topsoil that reduces the need for fertilizers, improves overall topsoil quality, provides for better vegetal health and vitality, improves hydrologic characteristics, and reduces the need for irrigation. This can be accomplished in a number of ways:~~

- ~~Recent research has shown that the best method to improve~~For till soils ~~is to amend these soils with compost. The optimum~~use a mixture ~~is of~~ approximately two parts soil to one part compost. This equates to 4 inches of compost mixed to a depth of 12 inches in till soils. Increasing the concentration of compost beyond this level can have negative effects on vegetal health, while decreasing the concentrations can reduce the benefits of amended soils. ~~Please note: The compost should meet specifications for Grade A quality compost in Ecology Publication 94-038.~~

- ~~Other soils, such as~~Gravel or cobble outwash soils, may require different approaches. Organics and fines easily migrate through the loose structure of these soils. Therefore, the importation of at least 6 inches of quality topsoil, underlain by some type of filter fabric to prevent the migration of fines, may be more appropriate for these soils.

~~Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.~~

- ~~Areas that will be seeded only and not landscaped may need compost or meal based mulch included in the hydroseed in order to establish vegetation. Native topsoil should be re-installed on the disturbed soil surface before application.~~
- ~~Seed that is installed as a temporary measure may be installed by hand if it will be covered by straw, mulch, or topsoil. Seed that is installed as a permanent measure may be installed by hand on small areas (usually less than 1 acre) that will be covered with mulch, topsoil, or erosion blankets. The seed mixes listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Local suppliers or the local conservation district should be consulted for their recommendations because the appropriate mix depends on a variety of factors, including location, exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the local authority may be used.~~

~~Table 4.1 represents the standard mix for those areas where just a temporary vegetative cover is required.~~

~~Table 4.2 provides just one recommended possibility for landscaping seed.~~

~~This turf seed mix in Table 4.3 is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.~~

~~Table 4.4 presents a mix recommended for bioswales and other intermittently wet areas.~~

~~The seed mix shown in Table 4.5 is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas that are not regulated wetlands. Other mixes may be appropriate, depending on the soil type and hydrology of the area. Recent research suggests that bentgrass (agrostis sp.) should be emphasized in wet area seed mixes. Apply this mixture at a rate of 60 pounds per acre.~~

~~The meadow seed mix in Table 4.6 is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. The appropriateness of clover in the mix may need to be considered, as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.~~

- ~~After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is~~

~~drainage related, the problem shall be fixed and the eroded area
reseeded and protected by mulch.~~

- ~~• Seeded areas shall be supplied with adequate moisture, but not watered
to the extent that it causes runoff.~~

BMP C121: Mulching

Purpose — The purpose of mulching soils is to provide immediate temporary protection from erosion. ~~Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. Only the most common types are discussed in this section.~~

Conditions of Use — As a temporary cover measure, mulch should be used:

- On disturbed areas that require cover measures for less than 30 days.
- As a cover for seed during the wet season and during the hot summer months.
- During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.
- Mulch may be applied at any time of the year and must be refreshed periodically.

BMP C122: Nets and Blankets

~~**Purpose** Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainage ways during high flows. Nets (commonly called matting) are strands of material woven into an open, but high tensile strength net (for example, coconut fiber matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, coeclisor or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.~~

~~**Conditions of Use** Erosion control nets and blankets should be used:~~

- ~~• To aid permanent vegetated stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief;~~
- ~~• For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic Nets and blankets can be used to permanently stabilize channels and may provide a cost effective, environmentally preferable alternative to riprap. 100 percent synthetic blankets manufactured for use in ditches may be easily reused as temporary ditch liners.~~

~~Disadvantages of blankets include:~~

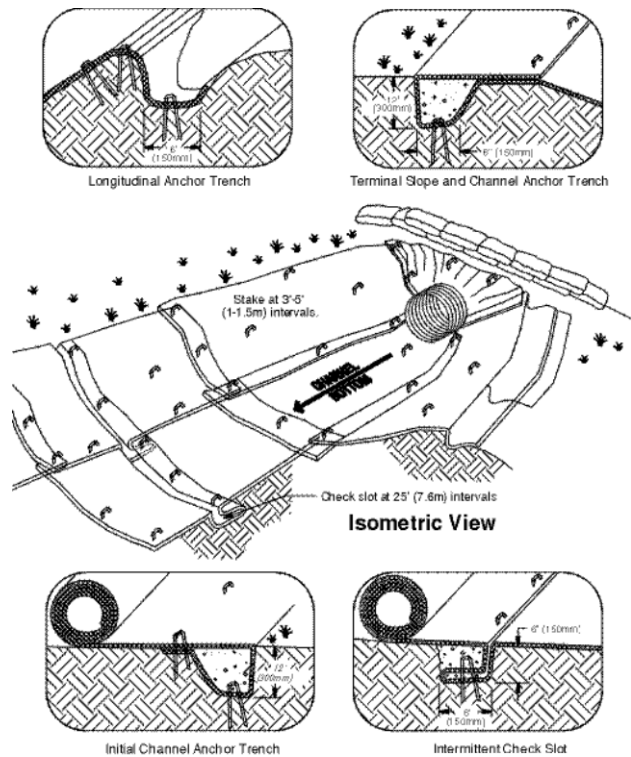
- ~~• Surface preparation required;~~
- ~~• On slopes steeper than 2.5:1, blanket installers may need to be roped and harnessed for safety;~~
- ~~• They cost at least \$4,000-6,000 per acre installed.~~

~~Advantages of blankets include:~~

- ~~• Can be installed without mobilizing special equipment;~~
- ~~• Can be installed by anyone with minimal training;~~
- ~~• Can be installed in stages or phases as the project progresses;~~
- ~~• Seed and fertilizer can be hand placed by the installers as they progress down the slope;~~
- ~~• Can be installed in any weather;~~
- ~~• There are numerous types of blankets that can be designed with various parameters in mind. These parameters include: fiber blend, mesh strength, longevity, biodegradability, cost, and availability.~~

7. ~~Complete final grade and track walk up and down the slope.~~
 8. ~~Install hydromulch with seed and fertilizer.~~
 9. ~~Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.~~
 10. ~~Install the leading edge of the blanket into the small trench and staple approximately every 18 inches. NOTE: Staples are metal, "U" shaped, and a minimum of 6 inches long. Longer staples are used in sandy soils. Biodegradable stakes are also available.~~
 11. ~~Roll the blanket slowly down the slope as installer walks backwards. NOTE: The blanket rests against the installer's legs. Staples are installed as the blanket is unrolled. It is critical that the proper staple pattern is used for the blanket being installed. The blanket is not to be allowed to roll down the slope on its own as this stretches the blanket making it impossible to maintain soil contact. In addition, no one is allowed to walk on the blanket after it is in place.~~
 12. ~~If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket should overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap should be installed in a small trench, stapled, and covered with soil.~~
- ~~With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer consults the manufacturer's information and that a site visit takes place in order to insure that the product specified is appropriate. Information is also available at the following web sites:~~
 1. ~~WSDOT: cscs/environmental/~~
 2. ~~Texas Transportation Institute: insdtdot.org/chart/emd/erosion/contents.htm~~
 - ~~Jute matting must be used in conjunction with mulch (BMP C121). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of erosion control nets and blankets on the market that may be appropriate in certain circumstances.~~
 - ~~In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.~~

- ~~Extremely steep, unstable, wet, or rocky slopes are often appropriate candidates for use of synthetic blankets, as are riverbanks, beaches and other high energy environments. If synthetic blankets are used, the soil should be hydromulched first.~~
- ~~100 percent biodegradable blankets are available for use in sensitive areas. These organic blankets are usually held together with a paper or fiber mesh and stitching which may last up to a year.~~
- ~~Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still in place several years after installation. This can be a problem if maintenance requires the use of mowers or ditch cleaning equipment. In addition, birds and small animals can become trapped in the netting.~~



NOTES:
 1. Check slots to be constructed per manufacturers specifications.
 2. Staking or stapling layout per manufacturers specifications.

Figure 4.4 – Channel Installation

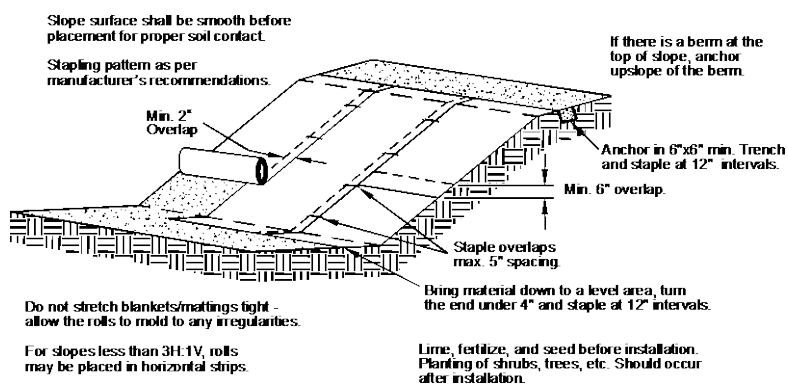


Figure 4.5—Slope Installation

BMP C423: Plastic Covering

- Purpose** — Plastic covering provides immediate, short term erosion protection to ~~slopes and disturbed areas.~~
- ~~Plastic is particularly useful for protecting cut and fill slopes and stockpiles. Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long term (greater than six months) applications.~~
 - ~~Clear plastic sheeting can be used over newly seeded areas to create a greenhouse effect and encourage grass growth if the hydroseed was installed too late in the season to establish 75 percent grass cover, or if the wet season started earlier than normal. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.~~
 - ~~Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.~~
 - ~~While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to \$1.50-2.00 per square yard.~~
 - ~~Whenever plastic is used to protect slopes, water collection measures must be installed at the base of the slope. These measures include plastic covered berms, channels, and pipes used to convey clean rainwater away from bare soil and disturbed areas. At no time is clean runoff from a plastic covered slope to be mixed with dirty runoff from a project.~~
 - ~~Other uses for plastic include:~~
 1. ~~Temporary ditch liner;~~
 2. ~~Pond liner in temporary sediment pond;~~
 3. ~~Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored;~~
 4. ~~Emergency slope protection during heavy rains; and,~~
 5. ~~Temporary drainpipe (“elephant trunk”) used to direct water.~~
 - ~~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.~~
 - ~~When the plastic is no longer needed, it shall be completely removed.~~
 - ~~Dispose of old tires appropriately.~~

BMP C124: Sodding

Purpose — The purpose of sodding is to establish permanent turf for immediate erosion protection and to stabilize drainage ways where concentrated overland flow will occur.

Conditions of Use — Sodding may be used in the following areas:

- ~~Disturbed areas that require short-term or long-term cover.~~
- ~~Disturbed areas that require immediate vegetative cover.~~
- ~~All waterways that require vegetative lining. Waterways may also be seeded rather than sodded, and protected with a net or blanket.~~
- ~~Shape and smooth the surface to final grade in accordance with the approved grading plan. The swale needs to be overexcavated 4 to 6 inches below design elevation to allow room for placing soil amendment and sod.~~
- ~~Amend 4 inches (minimum) of compost into the top 8 inches of the soil if the organic content of the soil is less than ten percent or the permeability is less than 0.6 inches per hour. Compost used should meet Ecology publication 94-038 specifications for Grade A quality compost.~~
- ~~Fertilize according to the supplier's recommendations.~~
- ~~Work lime and fertilizer 1 to 2 inches into the soil, 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 into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V. Staple the upstream edge of each sod strip.~~
- ~~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.~~

BMP C125: Topsoiling

Purpose——To provide a suitable growth medium for final site stabilization with vegetation. While not a permanent cover practice in itself, topsoiling is an integral component of providing permanent cover in those areas where there is an unsuitable soil surface for plant growth. ~~Native soils and disturbed soils that have been organically amended not only retain much more stormwater, but they also serve as effective biofilters for urban pollutants and, by supporting more vigorous plant growth, reduce the water, fertilizer and pesticides needed to support installed landscapes. Topsoil does not include any subsoils but only the material from the top several inches including organic debris.~~

- ~~Topsoiling is a required procedure when establishing vegetation on shallow soils, and soils of critically low pH (high acid) levels.~~
- ~~Stripping of existing, properly functioning soil system and vegetation for the purpose of topsoiling during construction is not acceptable. If an existing soil system is functioning properly it shall be preserved in its undisturbed and uncompacted condition.~~
- ~~Depending on where the topsoil comes from, or what vegetation was on site before disturbance, invasive plant seeds may be included and could cause problems for establishing native plants, landscaped areas, or grasses.~~
- ~~Topsoil from the site will contain mycorrhizal bacteria that are necessary for healthy root growth and nutrient transfer. These native mycorrhiza are acclimated to the site and will provide optimum conditions for establishing grasses. Commercially available mycorrhiza products should be used when topsoil is brought in from off site.~~
- The final composition and construction of the soil system will result in a natural selection or favoring of certain plant species over time. For example, ~~recent practices have shown that~~ incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.
- ~~Locate the topsoil stockpile so that it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.~~ Allow sufficient time in scheduling for topsoil ~~to be spread~~spreading prior to seeding, sodding, or planting.
- ~~Care must be taken not to apply to subsoil if the two soils have~~ Take care when applying top soil to subsoils with 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 re-structuring the subgrade may also provide additional benefits regarding the overall infiltration and interflow dynamics of the soil system.~~
- 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, and clay loam). Avoid areas of natural ground water recharge ~~should be avoided.~~
- Stripping shall be confined to the immediate construction area. A 4-inch 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.
- Do not place topsoil 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.
- In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas. Stockpiled topsoil is to be reapplied to other portions of the site where feasible.
- Locate the topsoil stockpile so that it meets specifications and does not interfere with work on the site. It may be possible to locate more than one pile in proximity to areas where topsoil will be used.

Stockpiling of topsoil shall occur in the following manner:

- Side slopes of the stockpile shall not exceed ~~2:1~~ 2H:1V.
- Between October 1 and April 30:
 - An interceptor dike with gravel outlet and silt fence shall surround all topsoil.
 - Within 2 days complete erosion control seeding, or covering stockpiles ~~between October 1 and April 30,~~ with clear plastic, or other mulching materials.
- Between May 1 and September 30,
 - An interceptor dike with gravel outlet and silt fence shall ~~be installed~~ surround all topsoil if the stockpile will remain in place for a longer period of time than active construction grading.

- ~~Within 7 days complete~~ erosion control seeding, or covering stockpiles with clear plastic, or other mulching materials ~~of stockpiles shall be completed within 2 days (October 1 through April 30) or 7 days (May 1 through September 30) of the formation of the stockpile. Native topsoil stockpiles shall not be covered with plastic.~~
- ~~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 bacterial, earthworms, and other beneficial organisms will not be destroyed:
 1. ~~Topsoil is to be re-installed~~Re-install topsoil within 4 to 6 weeks.
 2. ~~Topsoil is~~Do not to become saturatedallow the saturation of topsoil with water.
 3. ~~Plastic cover is~~Do not alloweduse plastic covering.
- Inspect stockpiles regularly, especially after large storm events. Stabilize any areas that have eroded.
- Establish soil quality and depth toward the end of construction and once established, protect from compaction, such as from large machinery use, and from erosion.
- Plant and mulch soil after installation.
- Leave plant debris or its equivalent on the soil surface to replenish organic matter.
- Reduce and adjust, where possible, the use of irrigation, fertilizers, herbicides and pesticides, rather than continuing to implement formerly established practices.

Maintenance Standards

BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection

Purpose

Polyacrylamide (PAM) is used on construction sites to prevent soil erosion.

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.

Conditions of Use

PAM shall not be directly applied to water or allowed to enter a water body.

In areas that drain to a sediment pond, PAM can be applied to bare soil under the following conditions:

- During rough grading operations.
- In Staging areas.
- Balanced cut and fill earthwork.
- Haul roads prior to placement of crushed rock surfacing.
- Compacted soil roadbase.
- Stockpiles.
- After final grade and before paving or final seeding and planting.
- Pit sites.
- Sites having a winter shut down. In the case of winter shut down, or where soil will remain unworked for several months, PAM should be used together with mulch.

Design and Installation Specifications

PAM may be applied with water in dissolved form. The preferred application method is the dissolved form.

PAM is to be applied at a maximum rate of 2/3 pound PAM per 1,000 gallons water (80 mg/L) per 1 acre of bare soil. [Table 4.1.9](#) 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 4.1.9
PAM and Water Application Rates**

Disturbed Area (ac)	PAM (lbs)	Water (gal)
0.50	0.33	500
1.00	0.66	1,000
1.50	1.00	1,500
2.00	1.32	2,000
2.50	1.65	2,500
3.00	2.00	3,000
3.50	2.33	3,500
4.00	2.65	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/1000 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 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 lbs. per acre. This must be applied on a day that is dry. For areas less than 5-10 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 powdered PAM:

- Powdered 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.
- When the total drainage area is greater than or equal to 5 acres, PAM treated areas shall drain to a sediment pond.
- Areas less than 5 acres shall drain to sediment control BMPs, such as a minimum of 3 check dams per acre. The total number of check dams used shall be maximized to achieve the greatest amount of settlement of sediment prior to discharging from the site. Each check dam shall be spaced evenly in the drainage channel through which stormwater flows are discharged off-site.
- On all sites, the use of silt fence shall be maximized to limit the discharges of sediment from the 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 three 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.
- Some PAMs are more toxic and carcinogenic than others. Only the most environmentally safe PAM products should be used.

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." 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 local permitting authority. ~~The Washington State Department of Transportation (WSDOT) has listed approved PAM products on their web page.~~

- PAM designated for these uses should be "water soluble" or "linear" or "non-crosslinked". Cross-linked or water absorbent PAM, polymerized in highly acidic (pH<2) conditions, are used to maintain soil moisture content.
- The PAM anionic charge density may vary from 2-30 percent; a value of 18 percent is typical. Studies conducted by the United States Department of Agriculture (USDA)/ARS demonstrated that soil stabilization was optimized by using very high molecular weight (12-15 mg/mole), highly anionic (>20% hydrolysis) PAM.
- 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 0.5-1 lb. per 1000 gallons of water in a hydromulch machine. Some tackifier product instructions say to use at a rate of 3 –5 lbs. per acre,

which can be too much. In addition, pump problems can occur at higher rates due to increased viscosity.

Maintenance Standards

- 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 two 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](#).

BMP C130: Surface Roughening

Purpose

Surface roughening aids in the establishment of vegetative cover, reduces runoff velocity, increases infiltration, and provides for sediment trapping through the provision of a rough soil surface. Horizontal depressions are 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.

- ~~Areas with grades steeper than 3:1 should be roughened to a depth of 2 to 4 inches prior to seeding.~~

Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding.

Conditions for Use

- All slopes steeper than 3H:1V and greater than 5 vertical feet require surface roughening 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.

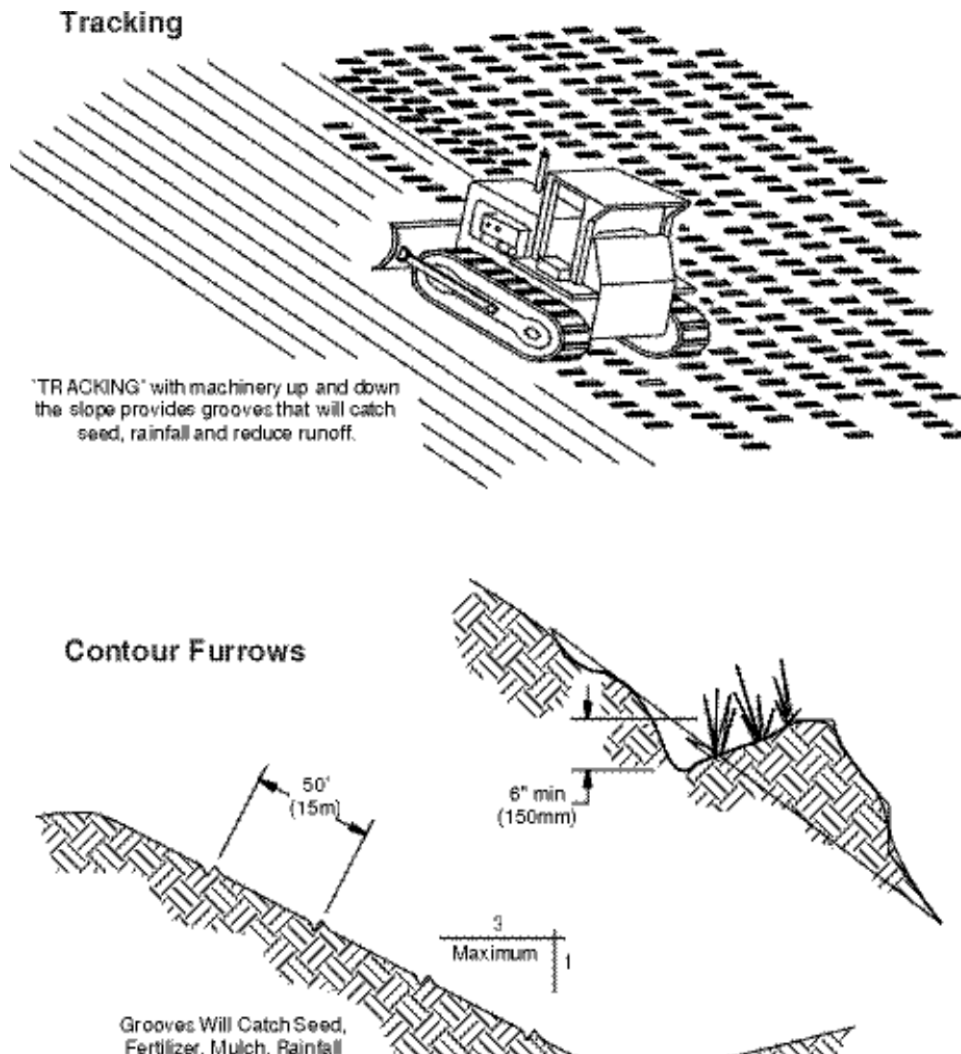
Design and Installation Specifications

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, contour furrows, and tracking. See [Figure 4.1.5](#) for tracking and contour furrows. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling.

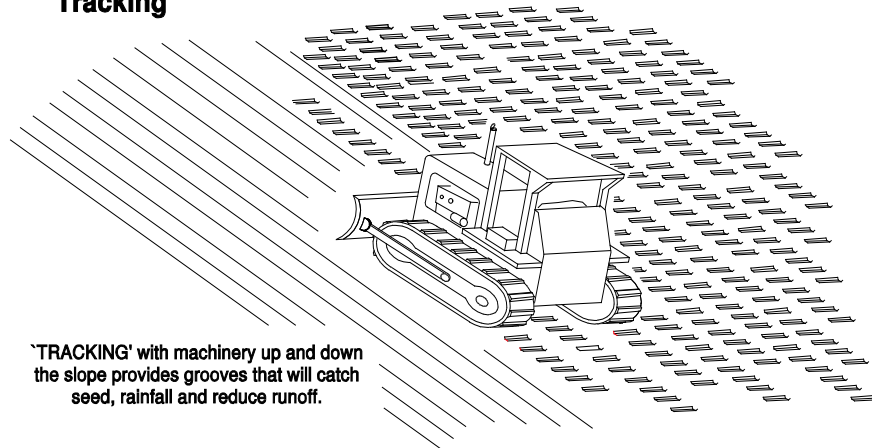
- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.

- 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. Stair steps must be on contour or gullies will form on the slope.
- Areas that will be mowed (these areas should have slopes less steep than $3\text{H}:1\text{V}$) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes greater steeper than $3\text{H}:1\text{V}$ but less than $2\text{H}:1\text{V}$ should be roughened before seeding. 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.
- Tracking is done by operating equipment up and down the slope to leave horizontal depressions in the soil.
- Areas that are 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.

Maintenance Standards



Tracking



Contour Furrows

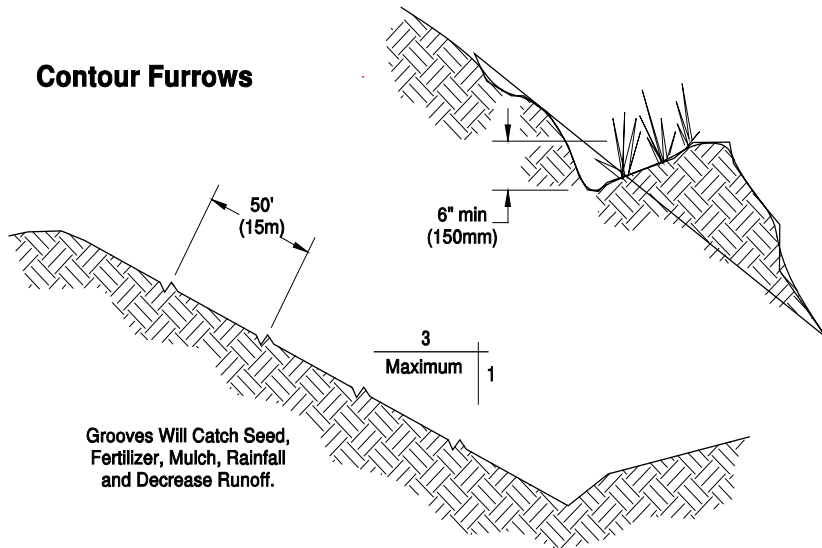


Figure 4.61.5 – Surface Roughening by Tracking and Contour Furrows

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BMP C131: Gradient Terraces

Purpose

Gradient terraces reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a non-erosive velocity.

Conditions of Use

- 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. See [Figure 4.1.6](#) for gradient terraces.

Design and Installation Specifications

- The maximum vertical spacing of gradient terraces should be determined by the following method:

$$VI = (0.8)s + y$$

Where: VI = vertical interval in feet

s = land rise per 100 feet, expressed in feet

y = a soil and cover variable with values from 1.0 to 4.0

Values of “y” are influenced by soil erodibility and cover practices. The lower values are applicable to erosive soils where little to no residue is left on the surface. The higher value is applicable only to erosion-resistant soils where a large amount of residue (1½ tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section should meet the design dimensions.
- The top of the constructed ridge should not be lower at any point than the design elevation plus the specified overfill for ~~settlement~~ settlement. The opening at the outlet end of the terrace should have a cross section equal to that specified for the terrace channel.
- Channel grades may be either uniform or variable with a maximum grade of 0.6 feet per 100 feet length ~~– (0.6%)~~. For short distances, terrace grades may be increased to improve alignment. The channel ~~velocity~~ velocity should not exceed that which is nonerosive for the soil type ~~with the planned treatment~~.
- 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.
- 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.

- 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. The drainage area above the ~~top~~terrace should not exceed the area that would be drained by a terrace with normal spacing.
- The terrace should have enough capacity to handle the peak runoff expected from a 2-year, 24-hour design storm without overtopping.
- 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 ~~eat-~~vehicle.
- Maintenance should be performed as needed. Terraces should be inspected regularly; at least once a year, and after large storm events.

Maintenance Standards

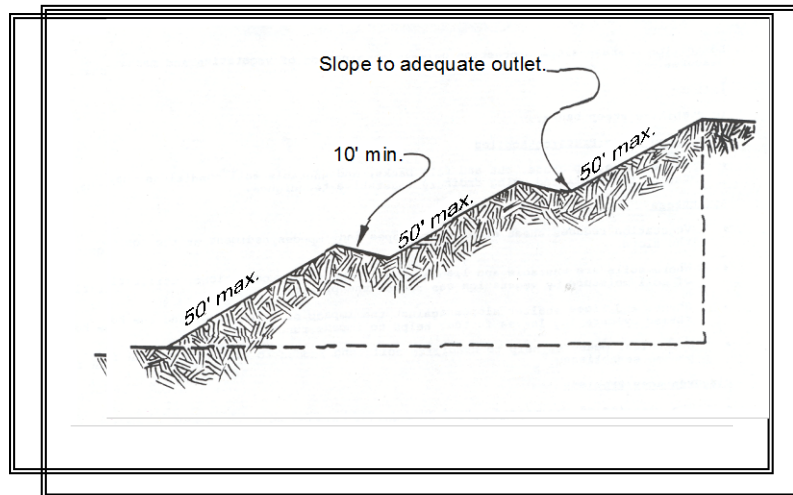


Figure 4.7-1.6 – Gradient Terraces

BMP C140: Dust Control

Purpose	Dust control prevents wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters.
Conditions of Use	<ul style="list-style-type: none">• In areas (including roadways) subject to surface and air movement of dust where on-site and off-site impacts to roadways, drainage ways, or surface waters are likely.
Design and Installation Specifications	<ul style="list-style-type: none">• Vegetate or mulch areas that will not receive vehicle traffic. In areas where planting, mulching, or paving is impractical, apply gravel or landscaping rock.• Limit dust generation by clearing only those areas where immediate activity will take place, leaving the remaining area(s) in the original condition if stable. Maintain the original ground cover as long as practical.• 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 C105 (BMP C105)).• Irrigation water can be used for dust control. Irrigation systems should be installed as a first step on sites where dust control is a concern.• Spray exposed soil areas with a dust palliative, following the manufacturer's instructions and cautions regarding handling and application. Used oil is prohibited from use as a dust suppressant. Local governments may approve other dust palliatives such as calcium chloride or PAM.• PAM (BMP C126 (BMP C126)) added to water at a rate of 0.5 lbs. per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to the increased infiltration of water into the soil and reduced evaporation. In addition, small soil particles are bonded together and are not as easily transported by wind. Adding PAM may actually reduce the quantity of water needed for dust control, especially in eastern Washington. Since the wholesale cost. Use of PAM is about \$ 4.00 per pound, this is an extremely <u>could be a</u> cost-effective dust control method. <p>Techniques that can be used for unpaved roads and lots include:</p> <ul style="list-style-type: none">• Lower speed limits. High vehicle speed increases the amount of dust stirred up from unpaved roads and lots.• Upgrade the road surface strength by improving particle size, shape, and mineral types that make up the surface and base materials.

- Add surface gravel to reduce the source of dust emission. Limit the amount of fine particles (those smaller than .075 mm) to 10 to 20 percent.
- Use geotextile fabrics to increase the strength of new roads or roads undergoing reconstruction.
- Encourage the use of alternate, paved routes, if available.
- Restrict use of paved roadways by tracked vehicles and heavy trucks to prevent damage to road surface and base.
- Apply chemical dust suppressants using the admix method, blending the product with the top few inches of surface material. Suppressants may also be applied as surface treatments.
- Pave unpaved permanent roads and other trafficked areas.
- Use vacuum street sweepers.
- Remove mud and other dirt promptly so it does not dry and then turn into dust.
- Limit dust-causing work on windy days.
- Contact your local Air Pollution Control Authority for guidance and training on other dust control measures. Compliance with the local Air Pollution Control Authority constitutes compliance with this BMP.

Maintenance Standards

Respray area as necessary to keep dust to a minimum.

BMP C150: Materials on Hand

Purpose

Keep quantities of erosion prevention and sediment control materials ~~can be kept~~ on the project site at all times to be used for regular maintenance and emergency situations such as unexpected heavy summer rains. Having these materials on-site reduces the time needed to implement BMPs when inspections indicate that existing BMPs are not meeting the Construction SWPPP requirements. In addition, contractors can save money by buying some materials in bulk and storing them at their office or yard.

Conditions of Use

- Construction projects of any size or type can benefit from having materials on hand. A small commercial development project could have a roll of plastic and some gravel available for immediate protection of bare soil and temporary berm construction. A large earthwork project, such as highway construction, might have several tons of straw, several rolls of plastic, flexible pipe, sandbags, geotextile fabric and steel “T” posts.
- Materials are stockpiled and readily available before any site clearing, grubbing, or earthwork begins. A large contractor or developer could keep a stockpile of materials that are available ~~to be used~~ for use on several projects.

- If storage space at the project site is at a premium, the contractor could maintain the materials at their office or yard. The office or yard must be less than an hour from the project site.

***Design and
Installation
Specifications***

Depending on project type, size, complexity, and length, materials and quantities will vary. A good minimum list of items that will cover numerous situations includes:

Material
Clear Plastic, 6 mil
Drainpipe, 6 or 8 inch diameter
Sandbags, filled
Straw Bales for mulching,
Quarry Spalls
Washed Gravel
Geotextile Fabric
Catch Basin Inserts
Steel "T" Posts
Silt fence material
Straw Wattles

***Maintenance
Standards***

- All materials with the exception of the quarry spalls, steel "T" posts, and gravel should be kept covered and out of both sun and rain.
- Re-stock materials used as needed.

BMP C151: Concrete Handling

Purpose

Concrete work can generate process water and slurry that contain fine particles and high pH, both of which can violate water quality standards in the receiving water. Concrete spillage or concrete discharge to surface waters of the State is prohibited. Use this BMP to minimize and eliminate concrete, concrete process water, and concrete slurry from entering waters of the state.

Conditions of Use

Any time concrete is used, utilize these management practices. Concrete construction projects include, but are not limited to, the following:

- Curbs
- Sidewalks
- Roads
- Bridges
- Foundations
- Floors

**Design and
Installation
Specifications**

- Runways
- Wash out concrete truck chutes, pumps, and internals into formed areas only. Assure that washout of concrete trucks is performed off-site or in designated concrete washout areas. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams. Refer to [BMP C154](#) for information on concrete washout areas.
- Return unused concrete remaining in the truck and pump to the originating batch plant for recycling. Do not dump excess concrete on site, except in designated concrete washout areas.
- ~~Wash off~~ hand tools including, but not limited to, screeds, shovels, rakes, floats, and trowels ~~shall be washed off only into formed areas awaiting installation of concrete or asphalt only.~~
- ~~Equipment that cannot be easily moved~~Wash equipment difficult to move, such as concrete pavers, ~~shall only be washed~~ in areas that do not directly drain to natural or constructed stormwater conveyances.
- ~~Do not allow~~ washdown from areas, such as concrete aggregate driveways ~~shall not, to~~ drain directly to natural or constructed stormwater conveyances.
- ~~When no formed areas are available, Contain~~ washwater and leftover product ~~shall be contained~~ in a lined container. ~~when no formed areas are available.. Dispose of~~ contained concrete ~~shall be disposed of~~ in a manner that does not violate ~~groundwater~~ground water or surface water quality standards.
- Always use forms or solid barriers for concrete pours, such as pilings, within 15-feet of surface waters.
- Refer to [BMPs C252](#) and [C253](#) for pH adjustment requirements.
- Refer to the Construction Stormwater General Permit for pH monitoring requirements if the project involves one of the following activities:
 - Significant concrete work (greater than 1,000 cubic yards poured concrete or recycled concrete used over the life of a project).
 - The use of engineered soils amended with (but not limited to) Portland cement-treated base, cement kiln dust or fly ash.
 - Discharging stormwater to segments of water bodies on the 303(d) list (Category 5) for high pH.

**Maintenance
Standards**

Check containers for holes in the liner daily during concrete pours and repair the same day.

BMP C152: Sawcutting and Surfacing Pollution Prevention

Purpose	Sawcutting and surfacing operations generate slurry and process water that contains fine particles and high pH (concrete cutting), both of which can violate the water quality standards in the receiving water. Concrete spillage or concrete discharge to surface waters of the State is prohibited. Use this BMP to minimize and eliminate process water and slurry created through sawcutting or surfacing from entering waters of the State.
Conditions of Use	Utilize these management practices anytime sawcutting or surfacing operations take place. Sawcutting and surfacing operations include, but are not limited to, the following: <ul style="list-style-type: none">• Sawing• Coring• Grinding• Roughening• Hydro-demolition• Bridge and road surfacing
Design and Installation Specifications	<ul style="list-style-type: none">• Vacuum slurry and cuttings during cutting and surfacing operations.• Slurry and cuttings shall not remain on permanent concrete or asphalt pavement overnight.• Slurry and cuttings shall not drain to any natural or constructed drainage conveyance <u>including stormwater systems. This may require temporarily blocking catch basins.</u>• <u>Dispose of</u> collected slurry and cuttings shall be disposed of in a manner that does not violate groundwater<u>ground water</u> or surface water quality standards.• <u>Do not allow</u> process water that is generated during hydro-demolition, surface roughening or similar operations shall not<u>to</u> drain to any natural or constructed drainage conveyance and shall be disposed of including stormwater systems. <u>Dispose process water</u> in a manner that does not violate groundwater<u>ground water</u> or surface water quality standards.• <u>Handle and dispose</u> 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~~ Dispose of sweeping material from a pick-up sweeper, ~~the material must be hauled out of the area to at~~ an appropriate disposal site.

Maintenance Standards

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

BMP C153: Material Delivery, Storage and Containment

Purpose

Prevent, reduce, or eliminate the discharge of pollutants to the stormwater system or watercourses from material delivery and storage. Minimize the storage of hazardous materials on-site, store materials in a designated area, and install secondary containment.

Conditions of Use

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

Design and Installation Specifications

The following steps should 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 (Oct 1 – April 30), consider storing materials in a covered area.
- Materials should be stored in secondary containments, such as earthen dike, horse trough, or even a children's wading pool for non-reactive

materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in “bus boy” trays or concrete mixing trays.

- Do not store chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet and, when possible, and within 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.

Material Storage Areas and Secondary Containment Practices:

- Liquids, petroleum products, and substances listed in 40 CFR Parts 110, 117, or 302 shall be stored in approved containers and drums and shall not be overfilled. Containers and drums shall be stored in temporary secondary containment facilities.
- Temporary secondary containment facilities shall provide for a spill containment volume able to contain 10% of the total enclosed container volume of all containers, or 110% of the capacity of the largest container within its boundary, whichever is greater.
- Secondary containment facilities shall be impervious to the materials stored therein for a minimum contact time of 72 hours.
- 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.
- Sufficient separation should be provided between stored containers to allow for spill cleanup and emergency response access.
- During the wet weather season (Oct 1 – April 30), each secondary containment facility shall be covered during non-working days, prior to and during rain events.
- Keep material storage areas clean, organized and equipped with an ample supply of appropriate spill clean-up material (spill kit).
- The spill kit should include, at a minimum:
 - 1-Water Resistant Nylon Bag
 - 3-Oil Absorbent Socks 3”x 4’
 - 2-Oil Absorbent Socks 3”x 10’
 - 12-Oil Absorbent Pads 17”x19”
 - 1-Pair Splash Resistant Goggles

- 3-Pair Nitrile Gloves
- 10-Disposable Bags with Ties
- Instructions

BMP C154: Concrete Washout Area

Purpose Prevent or reduce the discharge of pollutants to stormwater from concrete waste by conducting washout off-site, or performing on-site washout in a designated area to prevent pollutants from entering surface waters or ground water.

Conditions of Use Concrete washout area best management practices are implemented on construction projects where:

- Concrete is used as a construction material
- It is not possible to dispose of all concrete wastewater and washout off-site (ready mix plant, etc.).
- Concrete trucks, pumpers, or other concrete coated equipment are washed on-site.
- Note: If less than 10 concrete trucks or pumpers need to be washed out on-site, the washwater may be disposed of in a formed area awaiting concrete or an upland disposal site where it will not contaminate surface or ground water. The upland disposal site shall be at least 50 feet from sensitive areas such as storm drains, open ditches, or water bodies, including wetlands.

Design and Installation Specifications

Implementation

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

- Perform washout of concrete trucks off-site or in designated concrete washout areas only.
- Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams.
- Do not allow excess concrete to be dumped on-site, except in designated concrete washout areas.
- Concrete washout areas may be prefabricated concrete washout containers, or self-installed structures (above-grade or below-grade).
- Prefabricated containers are most resistant to damage and protect against spills and leaks. Companies may offer delivery service and provide regular maintenance and disposal of solid and liquid waste.
- If self-installed concrete washout areas are used, below-grade structures are preferred over above-grade structures because they are less prone to spills and leaks.
- Self-installed above-grade structures should only be used if excavation is not practical.

Education

- Discuss the concrete management techniques described in this BMP with the ready-mix concrete supplier before any deliveries are made.
- Educate employees and subcontractors on the concrete waste management techniques described in this BMP.
- Arrange for contractor's superintendent or Certified Erosion and Sediment Control Lead (CESCL) to oversee and enforce concrete waste management procedures.
- A sign should be installed adjacent to each temporary concrete washout facility to inform concrete equipment operators to utilize the proper facilities.

Contracts

Incorporate requirements for concrete waste management into concrete supplier and subcontractor agreements.

Location and Placement

- Locate washout area at least 50 feet from sensitive areas such as storm drains, open ditches, or water bodies, including wetlands.
- Allow convenient access for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access washout, prevent track-out with a pad of rock or quarry spalls (see [BMP C105](#)). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.
- The number of facilities you install should depend on the expected demand for storage capacity.
- On large sites with extensive concrete work, washouts should be placed in multiple locations for ease of use by concrete truck drivers.

On-site Temporary Concrete Washout Facility, Transit Truck Washout Procedures:

- Temporary concrete washout facilities shall be located a minimum of 50 ft from sensitive areas including storm drain inlets, open drainage facilities, and watercourses. See [Figures 4.1.7](#) and [4.1.8](#).
- Concrete washout facilities shall be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.
- Approximately 7 gallons of wash water are used to wash one truck chute.
- Approximately 50 gallons are used to wash out the hopper of a concrete pump truck.

- Washout of concrete trucks shall be performed in designated areas only.
- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated washout area or properly disposed of off-site.
- Once concrete wastes are washed into the designated area and allowed to harden, the concrete should be broken up, removed, and disposed of per applicable solid waste regulations. Dispose of hardened concrete on a regular basis.
- Temporary Above-Grade Concrete Washout Facility
 - Temporary concrete washout facility (type above grade) should be constructed as shown on the details below, with a recommended minimum length and minimum width of 10 ft, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.
 - Plastic lining material should be a minimum of 10 mil polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.
- Temporary Below-Grade Concrete Washout Facility
 - Temporary concrete washout facilities (type below grade) should be constructed as shown on the details below, with a recommended minimum length and minimum width of 10 ft. The quantity and volume should be sufficient to contain all liquid and concrete waste generated by washout operations.
 - Lath and flagging should be commercial type.
 - Plastic lining material shall be a minimum of 10 mil polyethylene sheeting and should be free of holes, tears, or other defects that compromise the impermeability of the material.
 - Liner seams shall be installed in accordance with manufacturers' recommendations.
 - Soil base shall be prepared free of rocks or other debris that may cause tears or holes in the plastic lining material.

Maintenance Standards

Inspection and Maintenance

- Inspect and verify that concrete washout BMPs are in place prior to the commencement of concrete work.
- During periods of concrete work, inspect daily to verify continued performance.
 - Check overall condition and performance.
 - Check remaining capacity (% full).

- If using self-installed washout facilities, verify plastic liners are intact and sidewalls are not damaged.
- If using prefabricated containers, check for leaks.
- Washout facilities shall be maintained to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Washout facilities must be cleaned, or new facilities must be constructed and ready for use once the washout is 75% full.
- If the washout is nearing capacity, vacuum and dispose of the waste material in an approved manner.
 - Do not discharge liquid or slurry to waterways, storm drains or directly onto ground.
 - Do not use sanitary sewer without local approval.
 - Place a secure, non-collapsing, non-water collecting cover over the concrete washout facility prior to predicted wet weather to prevent accumulation and overflow of precipitation.
 - Remove and dispose of hardened concrete and return the structure to a functional condition. Concrete may be reused on-site or hauled away for disposal or recycling.
- When you remove materials from the self-installed concrete washout, build a new structure; or, if the previous structure is still intact, inspect for signs of weakening or damage, and make any necessary repairs. Re-line the structure with new plastic after each cleaning.

Removal of Temporary Concrete Washout Facilities

- When temporary concrete washout facilities are no longer required for the work, the hardened concrete, slurries and liquids shall be removed and properly disposed of.
- Materials used to construct temporary concrete washout facilities shall be removed from the site of the work and disposed of or recycled.
- Holes, depressions or other ground disturbance caused by the removal of the temporary concrete washout facilities shall be backfilled, repaired, and stabilized to prevent erosion.

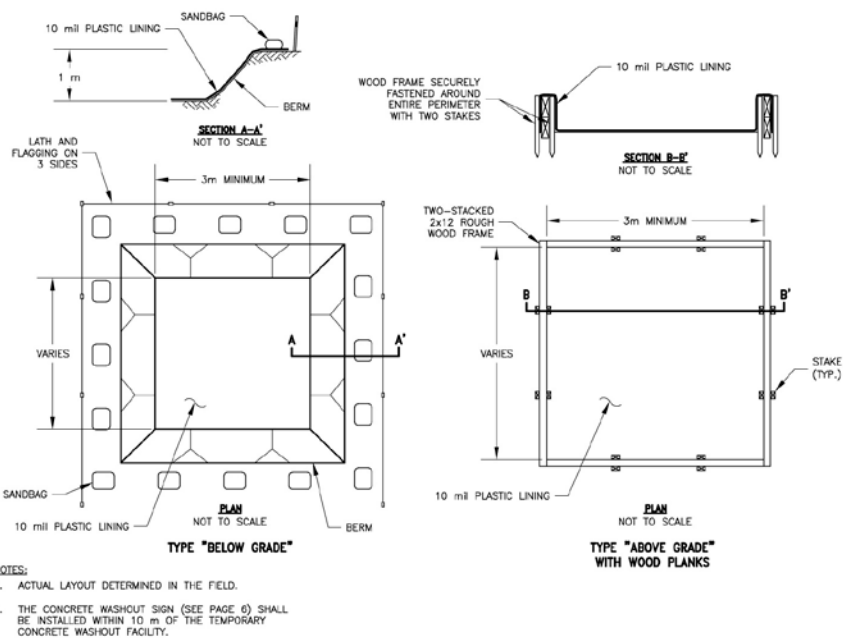
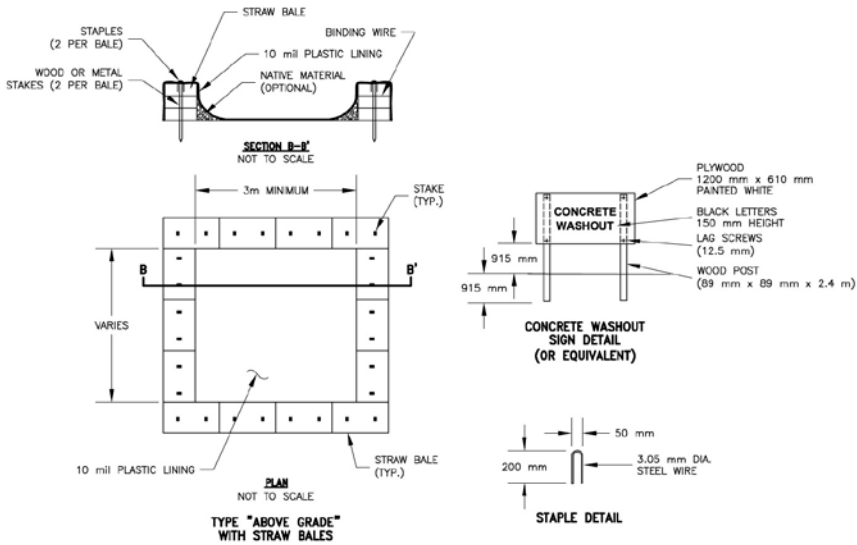


Figure 4.1.7a – Concrete Washout Area



NOTES:

1. ACTUAL LAYOUT DETERMINED IN THE FIELD.
2. THE CONCRETE WASHOUT SIGN (SEE FIG. 4-15) SHALL BE INSTALLED WITHIN 10 m OF THE TEMPORARY CONCRETE WASHOUT FACILITY.

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Figure 4.1.7b – Concrete Washout Area

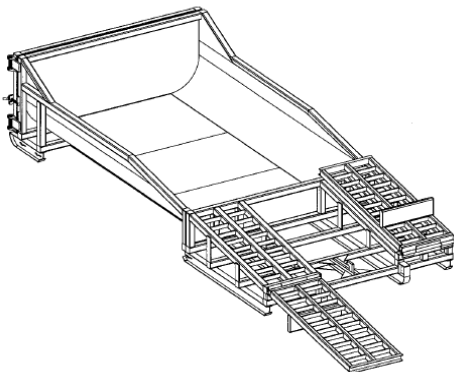


Figure 4.1.8 – Prefabricated Concrete Washout Container w/Ramp

BMP C160: Certified Erosion and Sediment Control Lead

Purpose	The project proponent designates at least one person as the responsible representative in charge of erosion and sediment control (ESC), and water quality protection. The designated person shall be the Certified Erosion and Sediment Control Lead (CESCL) who is responsible for ensuring compliance with all local, state, and federal erosion and sediment control and water quality requirements.
Conditions of Use	<p>A CESCL shall be made available on projects one acre or larger that discharge stormwater to surface waters of the state. Sites less than one acre may have a person without CESCL certification conduct inspections; sampling is not required on sites that disturb less than an acre.</p> <ul style="list-style-type: none">• The CESCL shall:<ul style="list-style-type: none">• 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 (see details below).<p>Ecology will maintain a list of ESC training and certification providers at: http://www.ecy.wa.gov/programs/wq/stormwater/cescl.html</p><p>OR</p><ul style="list-style-type: none">• Be a Certified Professional in Erosion and Sediment Control (CPESC); for additional information go to: www.cpesc.net
Specifications	<ul style="list-style-type: none">• Certification shall remain valid for three years.• The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, <u>or</u> on-call, 24 hours per day throughout the period of construction.• The Construction SWPPP shall include the name, telephone number, fax number, and address of the designated CESCL.• A CESCL may provide inspection and compliance services for multiple construction projects in the same geographic region. <p>Duties and responsibilities of the CESCL shall include, but are not limited to the following:</p> <ul style="list-style-type: none">• Maintaining permit file on site at all times which includes the <u>Construction</u> SWPPP and any associated permits and plans.• Directing BMP installation, inspection, maintenance, modification, and removal.

- Updating all project drawings and the Construction SWPPP with changes made.
- Completing any sampling requirements including reporting results using WebDMR.
- 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:
 1. ~~1)~~ Locations of BMPs inspected.
 2. ~~2)~~ Locations of BMPs that need maintenance.
 3. ~~3)~~ Locations of BMPs that failed to operate as designed or intended, ~~and~~.
 4. ~~4)~~ Locations of where additional or different BMPs are required.
 - 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.

Minimum Requirements for ESC Training and Certification Courses

General Requirements

1. ~~The course shall teach the construction stormwater pollution prevention guidance provided in the most recent version of:~~
 - a. ~~The Washington State Dept. of Ecology~~ **Stormwater Management Manual for Western Washington**,
 - b. ~~Other equivalent stormwater management manuals approved by Ecology.~~
2. ~~Upon completion of course, each attendee shall receive documentation of certification, including, at a minimum, a wallet-sized card that certifies completion of the course. Certification shall remain valid for three years. Recertification may be obtained by completing the 8-hour refresher course or by taking the initial 16-hour training course again.~~
3. ~~The initial certification course shall be a minimum of 16 hours (with a reasonable time allowance for lunch, breaks, and travel to and from field) and include a field element and test.~~
 - a. ~~The field element must familiarize students with the proper installation, maintenance and inspection of common erosion and sediment control BMPs including, but not limited to, blankets, check dams, silt fence, straw mulch, plastic, and seeding.~~
 - b. ~~The test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.~~
4. ~~The refresher course shall be a minimum of 8 hours and include a test.~~
 - a. ~~The refresher course shall include:~~
 - i. ~~Applicable updates to the Stormwater Management Manual that is used to teach the course, including new or updated BMPs; and~~
 - ii. ~~Applicable changes to the NPDES General Permit for Construction Activities.~~
 - b. ~~The refresher course test shall be open book and a passing score is not required for certification. Upon completion of the test, the correct answers shall be provided and discussed.~~
 - c. ~~The refresher course may be taught using an alternative format (e.g. internet, CD ROM, etc.) if the module is approved by Ecology.~~

Required Course Elements

1. ~~Erosion and Sedimentation Impacts~~
 - a. ~~Examples/Case studies~~

|

~~2. Erosion and Sedimentation Processes~~

- ~~a. Definitions~~
- ~~b. Types of erosion~~
- ~~c. Sedimentation~~
 - ~~i. Basic settling concepts~~
 - ~~ii. Problems with clays/turbidity~~

~~3. Factors Influencing Erosion Potential~~

- ~~a. Soil~~
- ~~b. Vegetation~~
- ~~c. Topography~~
- ~~d. Climate~~

~~4. Regulatory Requirements~~

- ~~a. NPDES Construction Stormwater General Permit~~
- ~~b. Local requirements and permits~~
- ~~c. Other regulatory requirements~~

~~5. Stormwater Pollution Prevention Plan (SWPPP)~~

- ~~a. SWPPP is a living document—should be revised as necessary~~
- ~~b. 12 Elements of a SWPPP; discuss suggested BMPs (with examples)~~
 - ~~1. Mark Clearing Limits~~
 - ~~2. Establish Construction Access~~
 - ~~3. Control Flow Rates~~
 - ~~4. Install Sediment Controls~~
 - ~~5. Stabilize Soils~~
 - ~~6. Protect Slopes~~
 - ~~7. Protect Drain Inlets~~
 - ~~8. Stabilize Channels and Outlets~~
 - ~~9. Control Pollutants~~
 - ~~10. Control De-watering~~
 - ~~11. Maintain BMPs~~
 - ~~12. Manage the Project~~

~~6. Monitoring/Reporting/Recordkeeping~~

- ~~a. Site inspections/visual monitoring~~
 - ~~i. Disturbed areas~~
 - ~~ii. BMPs~~
 - ~~iii. Stormwater discharge points~~
- ~~b. Water quality sampling/analysis~~
 - ~~i. Turbidity~~
 - ~~ii. pH~~
- ~~c. Monitoring frequency~~
 - ~~i. Set by NPDES permit~~
 - ~~ii. Inactive sites—reduced frequency~~

- d. ~~Adaptive Management~~
 - i. ~~When monitoring indicates problem, take appropriate action (e.g. install/maintain BMPs)~~
 - ii. ~~Document the corrective action(s) in SWPPP~~
- e. ~~Reporting~~
 - i. ~~Inspection reports/checklists~~
 - ii. ~~Discharge Monitoring Reports (DMR)~~
 - iii. ~~Non-compliance notification~~

~~Instructor Qualifications~~

1. ~~Instructors must be qualified to effectively teach the required course elements.~~
2. ~~At a minimum, instructors must have:~~
 - a. ~~Current certification as a Certified Professional in Erosion and Sediment Control (CPESC), or~~
 - b. ~~Completed a training program for teaching the required course elements, or~~
 - e. ~~The academic credentials and instructional experience necessary for teaching the required course elements.~~
3. ~~Instructors must demonstrate competent instructional skills and knowledge of the applicable subject matter.~~

BMP C161: Payment of Erosion Control Work

Several effective means for payment of erosion control work are described below. These include:

- ~~Temporary Erosion and Sediment Control (TESC) Lump Sum.~~
- ~~TESC Force Account.~~
- ~~Unit Prices.~~
- ~~Lump Sum.~~

TESC Lump Sum

One good method for achieving effective erosion and sediment control is to set up a Progress Payment system whereby the contract spells out exactly what is expected and allows for monthly payments over the life of the contract.

For example, an Item called “TESC Lump Sum” is listed in the Bid Schedule of Unit Prices. An amount, such as \$10,000, is written in both the Unit Price and Amount columns. This requires all bidders to bid \$10,000 for the item. If \$10,000 is not shown in the Amount column, each contractor bids the amount. Often this is under bid, which can cause compliance difficulties later. In this example, the contractor is required to revise the project Construction SWPPP by developing a Contractor’s Erosion and Sediment Control Plan (CESCP) that is specific to their operations.

Next, the following language is included in the TESC specification Payment section:

Based upon lump sum Bid Item “TESC Lump Sum”, payments will be made as follows:

- A. ~~Upon receipt of the Contractor’s CESCP, 25 percent.~~
- B. ~~After Notice To Proceed and before Substantial Completion, 50 percent will be pro-rated and paid monthly for compliance with the CESCP. Non-compliance will result in withholding of payment for the month of non-compliance.~~
- C. ~~At Final Payment, 25 percent for a clean site.~~

~~Payment for “TESC Lump Sum” will be full compensation for furnishing all labor, equipment, materials and tools to implement the CESCP, install, inspect, maintain, and remove temporary erosion and sediment controls as detailed in the drawings and specified herein, with the exception of those items measured and paid for separately.~~

TESC Force Account

~~One good method for ensuring that contingency money is available to address unforeseen erosion and sediment control problems is to set up an~~

item called “TESC Force Account”. For example, an amount such as \$15,000 is written in both the Unit Price and Amount columns for the item. This requires all bidders to bid \$15,000 for the item.

The Force Account is used only at the discretion of the contracting agency or developer. If there are no unforeseen erosion problems, the money is not used. If there are unforeseen erosion problems, the contracting agency would direct the work to be done and pay an agreed-upon amount for the work (such as predetermined rates under a Time and Materials setting).

Contract language for this item could look like this:

Measurement and Payment for “TESC Force Account” will be on a Force Account basis in accordance with _____ (include appropriate section of the Contract Specifications). The amount entered in the Schedule of Unit Prices is an estimate.

Unit Prices

When the material or work can be quantified, it can be paid by Unit Prices. For example, the project designer knows that 2 acres will need to be hydroseeded and sets up an Item of Work for Hydroseed, with a Bid Quantity of 2, and a Unit for Acre. The bidder writes in the unit Prices and Amount.

Unit Price items can be used in conjunction with TESC Force Account and TESC Lump Sum.

Lump Sum

In contracts where all the work in a project is paid as a Lump Sum, erosion control is usually not paid as a separate item. In order to ensure that appropriate amounts are bid into the contract, the contracting agency can request a Schedule of Values and require that all erosion control costs be identified.

BMP C162: Scheduling

Purpose	Sequencing a construction project reduces the amount and duration of soil exposed to erosion by wind, rain, runoff, and vehicle tracking.
Conditions of Use	<p>The construction sequence schedule is an orderly listing of all major land-disturbing activities together with the necessary erosion and sedimentation control measures planned for the project. This type of schedule guides the contractor on work to be done before other work is started so that serious erosion and sedimentation problems can be avoided.</p> <p>Following a specified work schedule that coordinates the timing of land-disturbing activities and the installation of control measures is perhaps the most cost-effective way of controlling erosion during construction. The</p>

removal of surface ground cover leaves a site vulnerable to accelerated erosion. Construction procedures that limit land clearing, provide timely installation of erosion and sedimentation controls, and restore protective cover quickly can significantly reduce the erosion potential of a site.

***Design
Considerations***

- Minimize construction during rainy periods.
- Schedule projects to disturb only small portions of the site at any one time. Complete grading as soon as possible. Immediately stabilize the disturbed portion before grading the next portion. Practice staged seeding in order to revegetate cut and fill slopes as the work progresses.

4.2 Runoff Conveyance and Treatment BMPs

This section contains the standards and specifications for Runoff Conveyance and Treatment BMPs. [Table 4.2.1](#)—

BMP C180: Small Project, below, shows the relationship of the BMPs in Section 4.2 to the Construction Stormwater Pollution Prevention Plan (SWPPP) Elements

Purpose — To prevent the discharge of sediment and other pollutants to the maximum extent practicable from small construction projects.

Conditions of Use — On small construction projects, those adding or replacing less than 2,000 square feet of impervious surface or clearing less than 7,000 square feet.

Soil shall be managed described in Section 3.3a a manner that does not permanently compact or deteriorate the final soil and landscape system. If disturbance and/or compaction occur the impact must be corrected at the end of the construction activity. This shall include restoration of soil depth, soil quality, permeability, and percent organic matter. Construction practices must not cause damage to or compromise the design of permanent landscape or infiltration areas. 3.

- ~~Locate excavated basement soil a reasonable distance behind the curb, such as in the backyard or side yard area. This will increase the distance eroded soil must travel to reach the storm sewer system. Soil piles should be covered until the soil is either used or removed. Piles should be situated so that sediment does not run into the street or adjoining yards.~~
- ~~Backfill basement walls as soon as possible and rough grade the lot. This will eliminate large soil mounds, which are highly erodible, and prepares the lot for temporary cover, which will further reduce erosion potential.~~
- ~~Remove excess soil from the site as soon as possible after backfilling. This will eliminate any sediment loss from surplus fill.~~
- ~~If a lot has a soil bank higher than the curb, a trench or berm should be installed moving the bank several feet behind the curb. This will reduce the occurrence of gully and rill erosion while providing a storage and settling area for stormwater.~~
- ~~The construction entrance should be stabilized where traffic will be leaving the construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.~~
- ~~Provide for periodic street cleaning to remove any sediment that may have been tracked out. Sediment should be removed by shoveling or sweeping and carefully removed to a suitable disposal area where it will not be re-eroded.~~
- ~~Utility trenches that run up and down slopes must be backfilled within seven days. Cross slope trenches may remain open throughout~~

~~construction to provide runoff interception and sediment trapping, provided that they do not convey turbid runoff off site.~~

Table 4.2.1 Runoff Conveyance and Treatment BMPs by SWPPP Element

BMP or Element Name	Element #1 Preserve Vegetation/Mark Clearing Limits	Element #2 Establish Construction Access	Element #5 Stabilize Soils	Element #6 Protect Slopes	Element #8 Stabilize Channels and Outlets	Element #9 Control Pollutants	Element #11 Maintain BMPs	Element #12 Manage the Project	Element #13 Protect Low Impact Development
BMP C101: Preserving Natural Vegetation	✓								
BMP C102: Buffer Zones	✓								✓
BMP C103: High Visibility Plastic or Metal Fence	✓								✓
BMP C105: Stabilized Construction Entrance / Exit		✓							
BMP C106: Wheel Wash		✓							
BMP C107: Construction Road/Parking Area Stabilization		✓							
BMP C120: Temporary and Permanent Seeding			✓	✓					
BMP C121: Mulching			✓	✓					
BMP C122: Nets and Blankets			✓	✓	✓				
BMP C123: Plastic Covering			✓						
BMP C124: Sodding			✓						
BMP C125: Topsoiling / Composting			✓						
BMP C126: Polyacrylamide for Soil Erosion Protection			✓						
BMP C130: Surface Roughening			✓	✓					
BMP C131: Gradient Terraces			✓	✓					
BMP C140: Dust Control			✓						
BMP C150: Materials On Hand							✓	✓	
BMP C151: Concrete Handling						✓			
BMP C152: Sawcutting and Surfacing Pollution Prevention						✓			
BMP C153: Material Delivery, Storage and Containment						✓			
BMP C154: Concrete Washout Area						✓			
BMP C160: Certified Erosion and Sediment Control Lead							✓	✓	
BMP C162: Scheduling								✓	

BMP C200: Interceptor Dike and Swale

Purpose	Provide a ridge of compacted soil, or a ridge with an upslope swale, at the top or base of a disturbed slope or along the perimeter of a disturbed construction area to convey stormwater. Use the dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled. This can prevent storm runoff from entering the work area or sediment-laden runoff from leaving the construction site.										
Conditions of Use	<p>Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control facility which can safely convey the stormwater.</p> <ul style="list-style-type: none">• Locate upslope of a construction site to prevent runoff from entering disturbed area.• When placed horizontally across a disturbed slope, it reduces the amount and velocity of runoff flowing down the slope.• Locate downslope to collect runoff from a disturbed area and direct itwater to a sediment basin.										
Design and Installation Specifications	<ul style="list-style-type: none">• Dike and/or swale and channel must be stabilized with temporary or permanent vegetation or other channel protection during construction.• Channel requires a positive grade for drainage; steeper grades require channel protection and check dams.• Review construction for areas where overtopping may occur.• Can be used at top of new fill before vegetation is established.• May be used as a permanent diversion channel to carry the runoff.• Sub-basin tributary area should be one acre or less.• Design capacity for the peak flow from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution, for temporary facilities. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model. For facilities that will also serve on a permanent basis, consult the local government's drainage requirements. <p>Interceptor dikes shall meet the following criteria:</p> <table><tr><td>Top Width</td><td>2 feet minimum.</td></tr><tr><td>Height</td><td>1.5 feet minimum on berm.</td></tr><tr><td>Side Slope</td><td>2:12H:1V or flatter.</td></tr><tr><td>Grade</td><td>Depends on topography, however, dike system minimum is 0.5%, and maximum is 1%.</td></tr><tr><td>Compaction</td><td>Minimum of 90 percent ASTM D698 standard proctor.</td></tr></table>	Top Width	2 feet minimum.	Height	1.5 feet minimum on berm.	Side Slope	2:1 2H:1V or flatter.	Grade	Depends on topography, however, dike system minimum is 0.5%, and maximum is 1%.	Compaction	Minimum of 90 percent ASTM D698 standard proctor.
Top Width	2 feet minimum.										
Height	1.5 feet minimum on berm.										
Side Slope	2:1 2H:1V or flatter.										
Grade	Depends on topography, however, dike system minimum is 0.5%, and maximum is 1%.										
Compaction	Minimum of 90 percent ASTM D698 standard proctor.										

Horizontal Spacing of Interceptor Dikes:

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

Stabilization depends on velocity and reach

Slopes <5% Seed and mulch applied within 5 days of dike construction (see [BMP C121, Mulching](#) ~~BMP C121, Mulching~~).

Slopes 5 - 40% Dependent on runoff velocities and dike materials. Stabilization should be done immediately using either sod or riprap or other measures to avoid erosion.

- 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.
- Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.

Interceptor swales shall meet the following criteria:

Bottom Width 2 feet minimum; the [cross-section](#) bottom shall be level.

Depth 1-foot minimum.

Side Slope [2:1H:1V](#) or flatter.

Grade Maximum 5 percent, with positive drainage to a suitable outlet (such as a sediment pond).

Stabilization Seed as per [BMP C120](#) ~~BMP C120~~, *Temporary and Permanent Seeding*, or [BMP C202](#) ~~BMP C202~~, *Channel Lining*, 12 inches thick ~~of~~ riprap pressed into the bank and extending at least 8 inches vertical from the bottom.

- Inspect diversion dikes and interceptor swales once a week and after every rainfall. Immediately remove sediment from the flow area.
- Damage caused by construction traffic or other activity must be repaired before the end of each working day.

Check outlets and make timely repairs as needed to avoid gully formation. When the area below the temporary diversion dike is permanently stabilized, remove the dike and fill and stabilize the channel to blend with the natural surface.

BMP C201: Grass-Lined Channels

Purpose To provide a channel with a vegetative lining for conveyance of runoff. See [Figure 4.2.1](#) ~~Figure 4.7~~ for typical grass-lined channels.

Conditions of Use 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 5 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 blankets 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 blankets.

Design and Installation Specifications Locate the channel where it can conform to the topography and other features such as roads.

- Locate them to use natural drainage systems to the greatest extent possible.
- Avoid sharp changes in alignment or bends and changes in grade.
- Do not reshape the landscape to fit the drainage channel.
- The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 5 feet/second. The channel shall not be overtopped by the peak runoff from a 10-year, 24-hour storm, assuming a Type 1A rainfall distribution." Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model to determine a flow rate which the channel must contain.

~~• Avoid sharp changes in alignment or bends and changes in grade.~~

~~• Do not reshape the landscape to fit the drainage channel.~~

~~• The maximum design velocity shall be based on soil conditions, type of vegetation, and method of revegetation, but at no times shall velocity exceed 5 feet/second. The channel shall not be overtopped by~~

~~the peak runoff from a 10-year, 24-hour storm, assuming a Type I-A rainfall distribution." Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model to determine a flow rate which the channel must contain.~~

- Where the grass-lined channel will also function as a permanent stormwater conveyance facility, ~~consultant~~consult the drainage conveyance requirements of the local government with jurisdiction.
- An established grass or vegetated lining is required before the channel can be used to convey stormwater, unless stabilized with nets or blankets.
- If design velocity of a channel to be vegetated by seeding exceeds 2 ft/sec, a temporary channel liner is required. Geotextile or special mulch protection such as fiberglass roving or straw and netting ~~provide~~provides stability until the vegetation is fully established. See Figure 4.2.2~~Figure 4.9.~~
- 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.
- 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 that are subject to prolonged wet conditions due to long duration flows or a high water table.
- Provide outlet protection at culvert ends and at channel intersections.
- Grass channels, at a minimum, should carry peak runoff for temporary construction drainage facilities from the 10-year, 24-hour storm without eroding. Where flood hazard exists, increase the capacity according to the potential damage.
- Grassed channel side slopes generally are constructed ~~3:1~~3H:1V or flatter to aid in the establishment of vegetation and for maintenance.

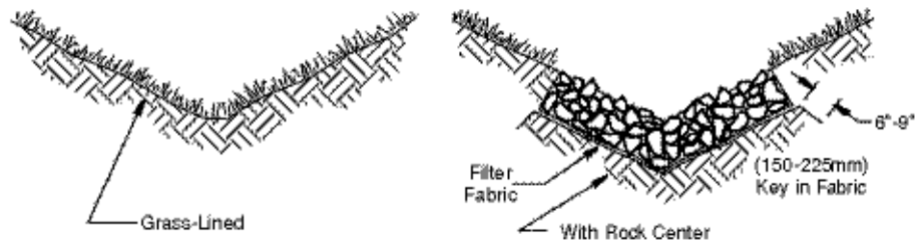
***Maintenance
Standards***

- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

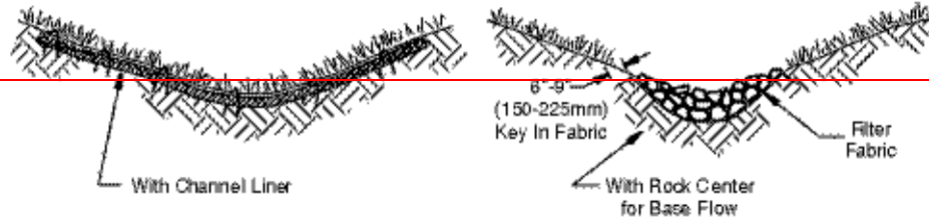
During the establishment period, check grass-lined channels after every rainfall.

- 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.

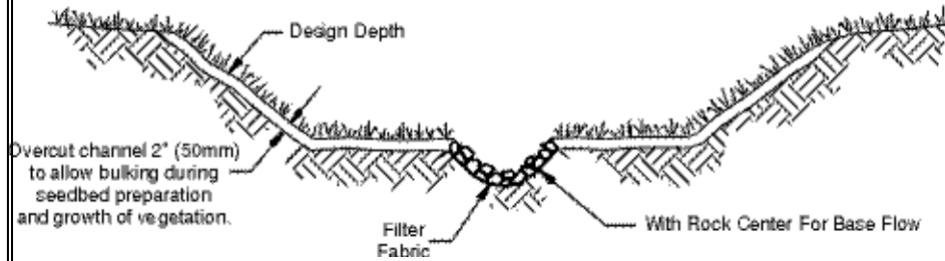
Typical V-Shaped Channel Cross-section



Typical Parabolic Channel Cross-Section



Typical Trapezoidal Channel Cross-Section



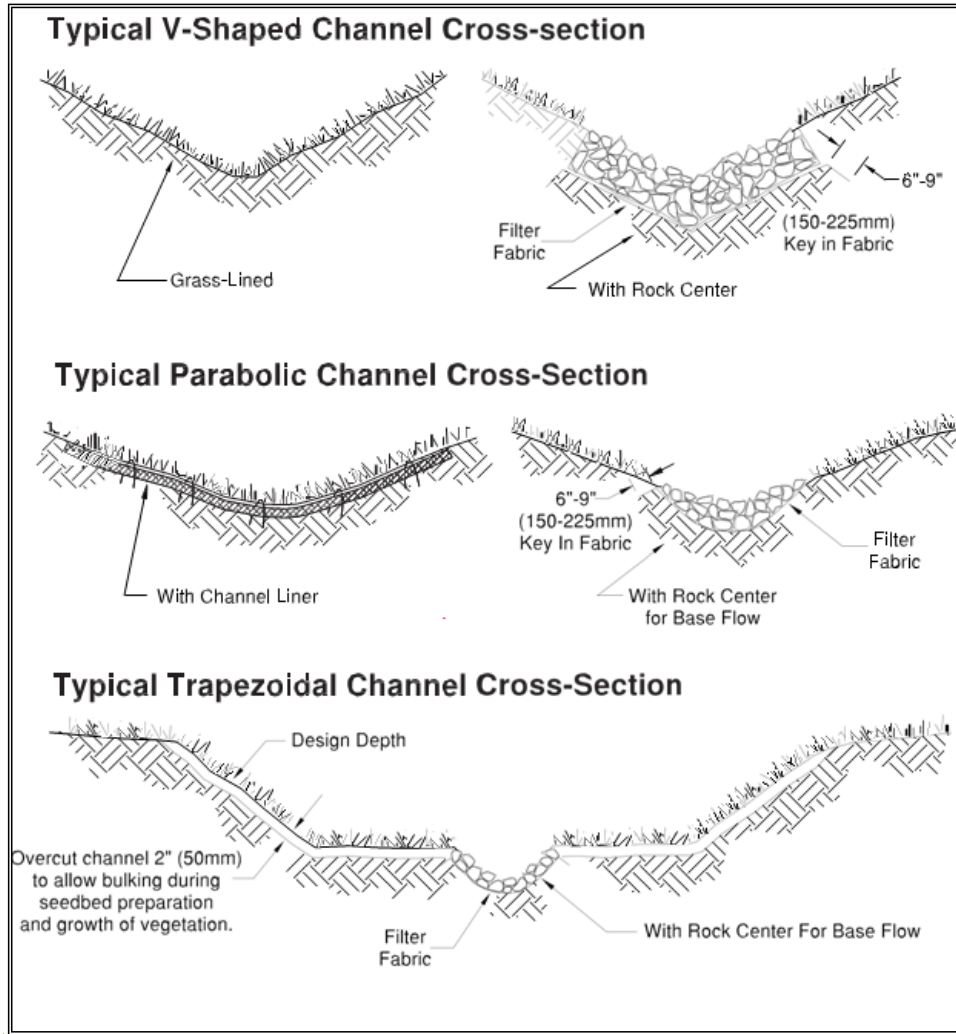
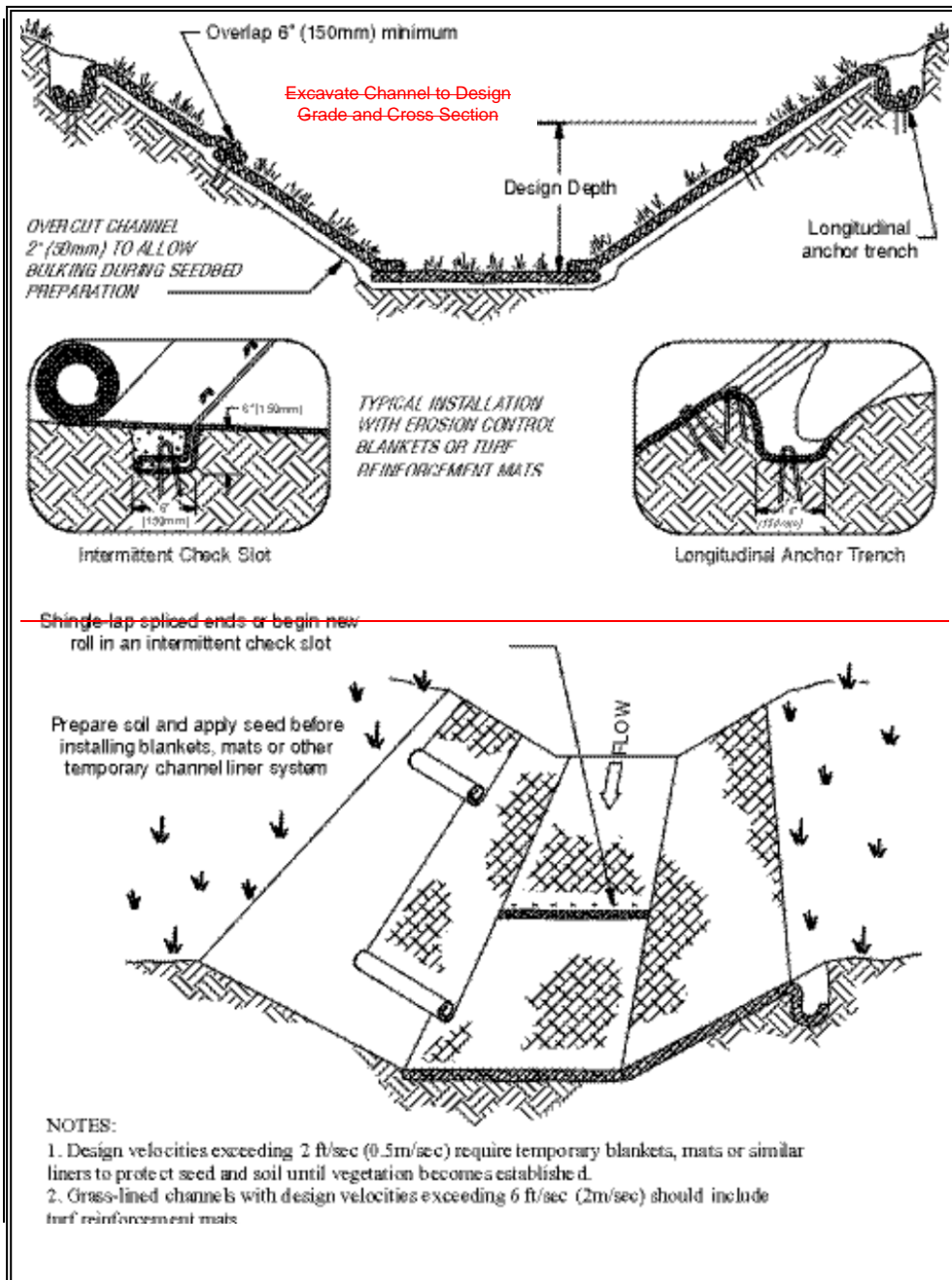
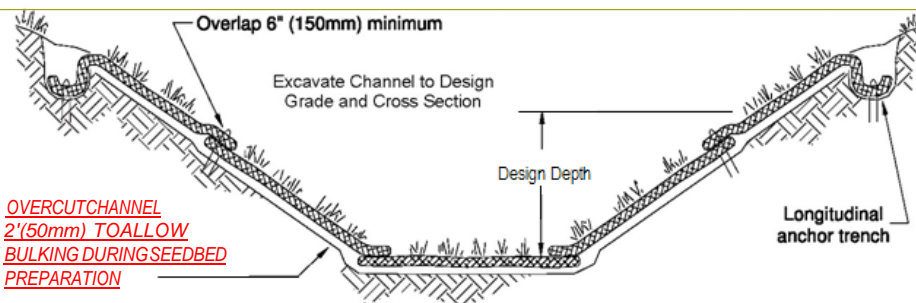
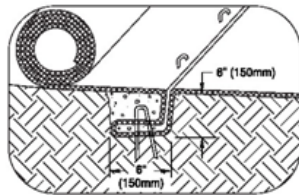


Figure 4.82.1 – Typical Grass-Lined Channels



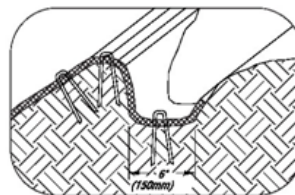


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Intermittent Check Slot

TYPICAL INSTALLATION WITH EROSION CONTROL BLANKETS OR TURF REINFORCEMENT MATS

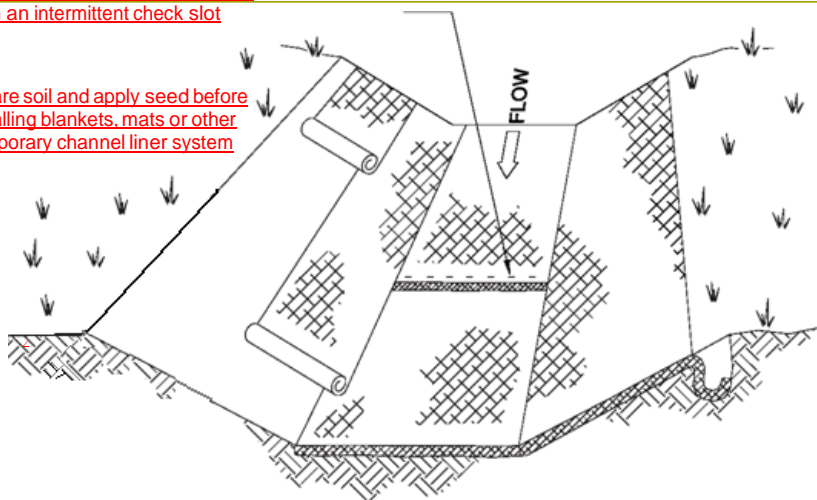


Longitudinal Anchor Trench

Shingle-lap spliced ends or begin new roll in an intermittent check slot

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Prepare soil and apply seed before installing blankets, mats or other temporary channel liner system



NOTES:

- 1 Design velocities exceeding 2 ft/sec (0.5m/sec) require temporary blankets, mats or similar liners to protect seed and soil until vegetation becomes established.
- 2 Grass-lined channels with design velocities exceeding 6 ft/sec (2m/sec) should include turf reinforcement mats.

Figure 4.92.2 – Temporary Channel Liners

BMP C202: Channel Lining

Purpose	To protect erodible channels by providing a channel liner using either blankets or riprap.
Conditions of Use	<p>When natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.</p> <ul style="list-style-type: none">• When a permanent ditch or pipe system is to be installed and a temporary measure is needed.• 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 lbs/ft².
Design and Installation Specifications	<p>See BMP C122 for information on blankets.</p> <p>Since riprap is used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.</p> <ul style="list-style-type: none">• Disturbance of areas where riprap is to be placed should be undertaken only when final preparation and placement of the riprap can follow immediately behind the initial disturbance. Where riprap is used for outlet protection, the riprap should be placed before or in conjunction with the construction of the pipe or channel so that it is in place when the pipe or channel begins to operate.• 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. The possibility of drainage structure damage by children shall be considered in selecting a riprap size, especially if there is nearby water or a gully in which to toss the stones.• 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 requirement of this standard and specification.~~
- 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 1-1/2:~~2H:1V~~2H:1V 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.

BMP C203: Water Bars

Purpose

A small ditch or ridge of material is constructed diagonally across a road or right-of-way to divert stormwater runoff from the road surface, wheel tracks, or a shallow road ditch. [See Figure 4.2.3.](#)

Conditions of use

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.

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

Design and Installation Specifications

Height: 8-inch minimum measured from the channel bottom to the ridge top.

- Side slope of channel: 2H:1V maximum; 3H:1V or flatter when vehicles will cross.
- Base width of ridge: 6-inch minimum.
- Locate them to use natural drainage systems and to discharge into well vegetated stable areas.
- Guideline for Spacing:

Slope %	Spacing (ft)
< 5	125
5 - 10	100
10 - 20	75

20 - 35	50
> 35	Use rock lined ditch

- ~~Side slope of channel: 2:1 maximum; 3:1 or flatter when vehicles will cross.~~
- ~~Base width of ridge: 6 inch minimum.~~
- ~~Locate them to use natural drainage systems and to discharge into well vegetated stable areas.~~
- ~~Guideline for Spacing:~~
 - 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 that are not subject to traffic. Gravel the areas crossed by vehicles.

Maintenance Standards

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 ~~dikedikes~~ and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.

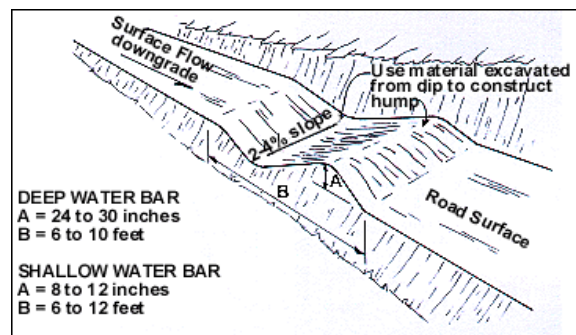


Figure 4.2.3 – Water Bar

BMP C204: Pipe Slope Drains

Purpose

To use a pipe to convey stormwater anytime water needs to be diverted away from or over bare soil to prevent gullies, channel erosion, and saturation of slide-prone soils.

Conditions of Use

Pipe slope drains should be used when a temporary or permanent stormwater conveyance is needed to move the water down a steep slope to avoid erosion ([Figure 4.2.4\(Figure 4.10\)-.](#)).

On highway projects, ~~they~~[pipe slope drains](#) should be used at bridge ends to collect runoff and pipe it to the base of the fill slopes along bridge approaches. These can be designed into a project and included as bid items. Another use on road projects is to collect runoff from pavement and pipe it away from side slopes. These are useful because there is generally a time lag between having the first lift of asphalt installed and the curbs, gutters, and permanent drainage installed. Used in conjunction with sand bags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Water can be collected, channeled with sand bags, Triangular Silt Dikes, berms, or other material, and piped to temporary sediment ponds.

Pipe slope drains can be:

- Connected to new catch basins and used temporarily until all permanent piping is installed;
- Used to drain water collected from aquifers exposed on cut slopes and take it to the base of the slope;
- Used to collect clean runoff from plastic sheeting and direct it away from exposed soil;
- Installed in conjunction with silt fence to drain collected water to a controlled area;
- Used to divert small seasonal streams away from construction. They have been used successfully on culvert replacement and extension jobs. Large flex pipe can be used on larger streams during culvert removal, repair, or replacement; and,
- Connected to existing down spouts and roof drains and used to divert water away from work areas during building renovation, demolition, and construction projects.

There are now several commercially available collectors that are attached to the pipe inlet and help prevent erosion at the inlet.

***Design and
Installation
Specifications***

Size the pipe to convey the flow. The capacity for temporary drains shall be sufficient to handle the peak flow from a 10-year, 24-hour storm event, assuming a Type 1A rainfall distribution. Alternatively, use 1.6 times the 10-year, 1-hour flow indicated by an approved continuous runoff model.

Consult local drainage requirements for sizing permanent pipe slope drains.

- Use care in clearing vegetated slopes for installation.
- Re-establish cover immediately on areas disturbed by installation.
- Use temporary drains on new cut or fill slopes.
- Use diversion dikes or swales to collect water at the top of the slope.
- Ensure that the entrance area is stable and large enough to direct flow into the pipe.
- Piping of water through the berm at the entrance area is a common failure mode.
- 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. Sand bags may also be used at pipe entrances as a temporary measure.
- 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, fused or have gasketed watertight fittings, and shall be securely anchored into the soil.
- Thrust blocks should be installed anytime 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 10-20 feet of pipe length or so, depending on the size of the pipe and quantity of water to ~~diverted~~divert.
- Interceptor 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.
- The area below the outlet must be stabilized with a riprap apron (see [BMP C209](#)~~BMP C209~~ Outlet Protection, for the appropriate outlet material).

Maintenance Standards

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.
- Materials specifications for any permanent piped system shall be set by the local government.

Check inlet and outlet points regularly, especially after storms.

The inlet should be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall should be reinforced with compacted earth or sand bags.

- The outlet point should be free of erosion and installed with appropriate outlet protection.
- 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.

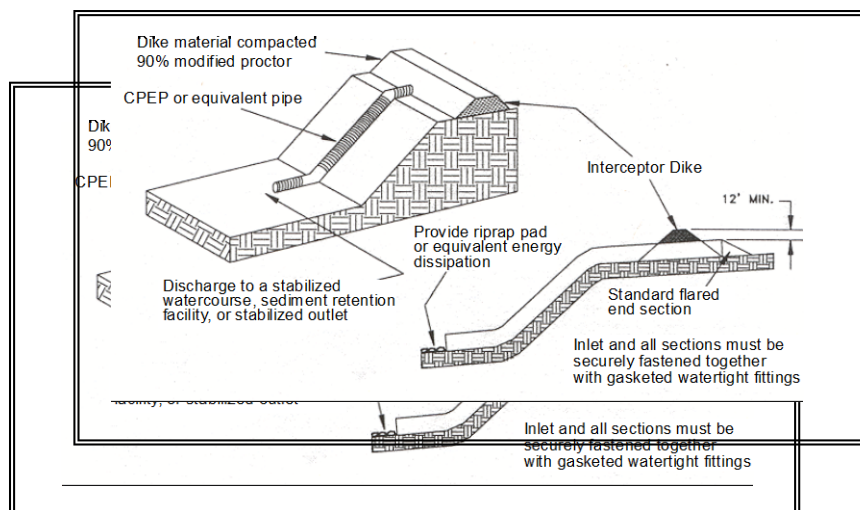


Figure 4.10-2.4 – Pipe Slope Drain

BMP C205: Subsurface Drains

Purpose	To intercept, collect, and convey ground water to a satisfactory outlet, using a perforated pipe or conduit below the ground surface. Subsurface drains are also known as “french drains.” The perforated pipe provides a dewatering mechanism to drain excessively wet soils, provide a stable base for construction, improve stability of structures with shallow foundations, or to reduce hydrostatic pressure to improve slope stability.
Conditions of Use	Use when excessive water must be removed from the soil. The soil permeability, depth to water table and impervious layers are all factors which may govern the use of subsurface drains.
Design and Installation Specifications	<p>Relief drains are used either to lower the water table in large, relatively flat areas, improve the growth of vegetation, or to remove surface water.</p> <p>TheRelief drains are installed along a slope and drain in the direction of the slope.</p> <p>They can be installed in a grid pattern, a herringbone pattern, or a random pattern.</p> <ul style="list-style-type: none">• Interceptor drains are used to remove excess ground water from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated. <p>TheInterceptor drains are installed perpendicular to a slope and drain to the side of the slope.</p> <p>They usually consist of a single pipe or series of single pipes instead of a patterned layout.</p> <ul style="list-style-type: none">• Depth and spacing of interceptor drains --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 be accounted for in the receiving stream (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 complete subsurface investigations, including hydraulic conductivity of the soil, before designing a subsurface drainage system.

- **Size of drain**--Size subsurface drains to carry the required capacity without pressure flow. Minimum diameter for a subsurface drain is 4 inches.
- The minimum velocity required to prevent silting is 1.4 ft./sec. The line shall be graded to achieve this velocity at a minimum. 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 pond through a catch basin. If free of sediment, it can then empty into a receiving channel, swale, or stable vegetated area adequately protected from erosion and undermining.
- 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.
- 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 drain pipe is not displaced or damaged.
- Do not install permanent drains near trees to avoid the tree roots that tend to clog the line. Use solid pipe with watertight connections where it is necessary to pass a subsurface drainage system through a stand of trees.
- **Outlet**--Ensure that the outlet of a drain empties into a channel or other watercourse above the normal water level.
- 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 stream, outlet protection must be provided.

Maintenance Standards

Subsurface drains shall be checked periodically to ensure that they are free-flowing and not clogged with sediment or roots.

- 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 drains are crossed by heavy vehicles, the line shall be checked to ensure that it is not crushed.

BMP C206: Level Spreader

Purpose

To provide a temporary outlet for dikes and diversions consisting of an excavated depression constructed at zero grade across a slope. To convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation or an engineered filter strip.

Conditions of Use

Used when a concentrated flow of water needs to be dispersed over a large area with existing stable vegetation.

- Items to consider are:
 1. What is the risk of erosion or damage if the flow may become concentrated?
 2. Is an easement required if discharged to adjoining property?
 3. Most of the flow should be as ground water and not as surface flow.
 4. Is there an unstable area downstream that cannot accept additional ground water?
- Use only where the slopes are gentle, the water volume is relatively low, and the soil will adsorb most of the low flow events.

Design and Installation Specifications

Use above undisturbed areas that are stabilized by existing vegetation.

If the level spreader has any low points, flow will concentrate, create channels and may cause erosion.

- Discharge area below the outlet must be uniform with a slope of ~~less~~ flatter than 5H:1V.
- Outlet to be constructed level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not ~~reconcentrate~~ re-concentrate after release unless intercepted by another downstream measure.

- The grade of the channel for the last 20 feet of the dike or interceptor entering the level spreader shall be less than or equal to 1 percent. The grade of the level spreader shall be 0 percent to ensure uniform spreading of storm runoff.
- A 6-inch high gravel berm placed across the level lip shall consist of washed crushed rock, 2- to 4-inch or 3/4-inch to 1½-inch size.
- The spreader length shall be determined by estimating the peak flow expected from the 10-year, 24-hour design storm. The length of the spreader shall be a minimum of 15 feet for 0.1 cfs and shall be increased by 10 feet for each 0.1 cfs thereafter to a maximum of 0.5 cfs per spreader. Use multiple spreaders for higher flows.
- The width of the spreader should be at least 6 feet.
- The depth of the spreader as measured from the lip should be at least 6 inches and it should be uniform across the entire length.
- Level spreaders shall be setback from the property line unless there is an easement for flow.
- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sand bags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figures 4.2.5, Figure 4.2.6, and Figure 4.2.7 provide a cross-section and a detail of a level spreader. A capped perforated pipe could also be used as a spreader.

Maintenance Standards

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 the structure and should prevent construction traffic from crossing over the structure.
- If the spreader is damaged by construction traffic, it shall be immediately repaired.

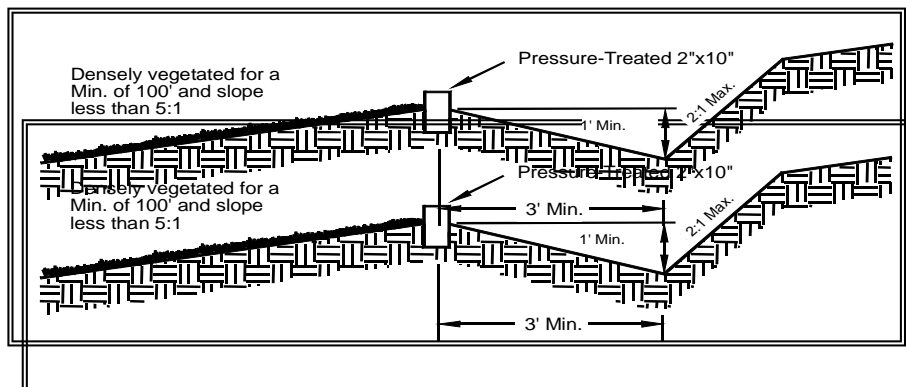
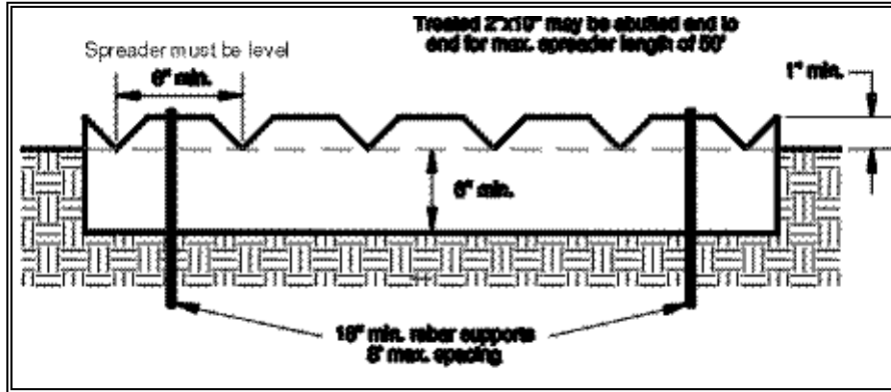
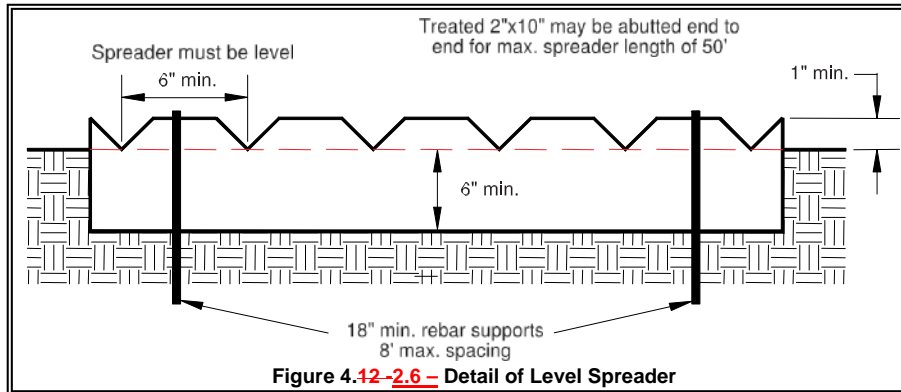


Figure 4.142.5 – Cross Section of Level Spreader





BMP C207: Check Dams

Purpose Construction of small dams across a swale or ditch reduces the velocity of concentrated flow and dissipates energy at the check dam.

Conditions of Use Where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, and/or velocity checks are required.

- Check dams may not be placed in streams unless approved by the State Department of Fish and Wildlife. Check dams may not be placed in wetlands without approval from a permitting agency.

~~Figure 4.12 – Cross Section of Level Spreader~~

- Do not place check dams ~~shall not be placed~~ below the expected backwater from any salmonid bearing water between October 1 and May 31 to ensure that there is no loss of high flow refuge habitat for overwintering juvenile salmonids and emergent salmonid fry.
- Construct rock check dams from appropriately sized rock. The rock used must be large enough to stay in place given the expected design flow through the channel. The rock must be placed by hand or by mechanical means (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.
- Check dams may also be constructed of either rock or pea-gravel filled bags. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.
- Place check dams perpendicular to the flow of water.
- The dam should form a triangle when viewed from the side. This prevents undercutting as water flows over the face of the dam rather than falling directly onto the ditch bottom.

- Before installing check dams impound and bypass upstream water flow away from the work area. Options for bypassing include pumps, siphons, or temporary channels.
- Check dams in association with sumps work more effectively at slowing flow and retaining sediment than just a check dam alone. A deep sump should be provided immediately upstream of the check dam.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading. They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to prevent further sediment from leaving the site.
- ~~Check dams can be constructed of either rock or pea gravel filled bags. Numerous new products are also available for this purpose. They tend to be re-usable, quick and easy to install, effective, and cost efficient.~~
- ~~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.
- Keep the maximum height at 2 feet at the center of the dam.
- Keep the center of the check dam at least 12 inches lower than the outer edges at natural ground elevation.
- Keep the side slopes of the check dam at 2:1H:1V or flatter.
- Key the stone into the ditch banks and extend it beyond the abutments a minimum of 18 inches to avoid washouts from overflow around the dam.
- Use filter fabric foundation under a rock or sand bag check dam. If a blanket ditch liner is used, ~~this filter fabric~~ is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- ~~Rock check dams shall be constructed of appropriately sized rock. The rock must be placed by hand or by mechanical means (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.~~ In the case of grass-lined ditches and swales, all 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.

***Maintenance
Standards***

- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones. [Figure 4.2.7](#) ~~Figure 4.13~~ depicts a typical rock check dam.

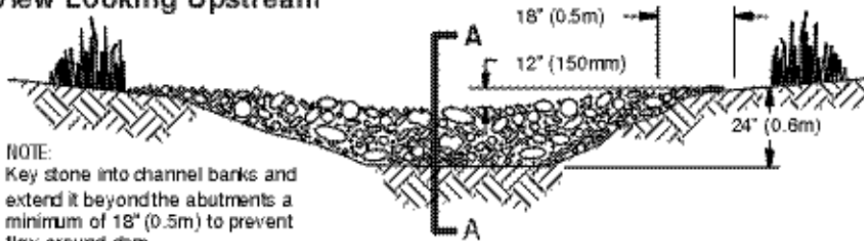
Check dams shall be monitored for performance and sediment accumulation during and after each runoff producing rainfall. Sediment shall be removed when it reaches one half the sump depth.

- Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam.
- If significant erosion occurs between dams, install a protective riprap liner in that portion of the channel.

***Approved as
Equivalent***

Ecology has approved products as able to meet the requirements of [BMP C207](#). The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology’s website at <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html>

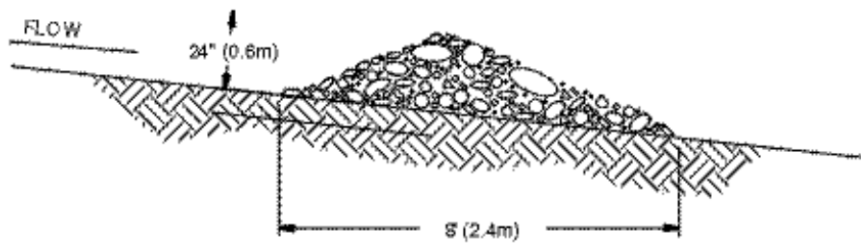
View Looking Upstream



NOTE:

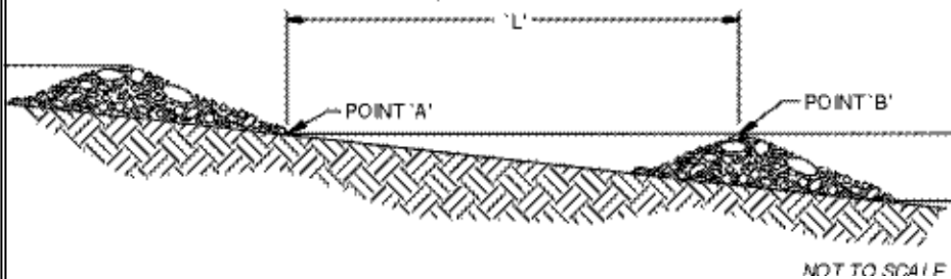
Key stone into channel banks and extend it beyond the abutments a minimum of 18" (0.5m) to prevent flow around dam.

Section A - A



Spacing Between Check Dams

"L" = the distance such that points "A" and "B" are of equal elevation.



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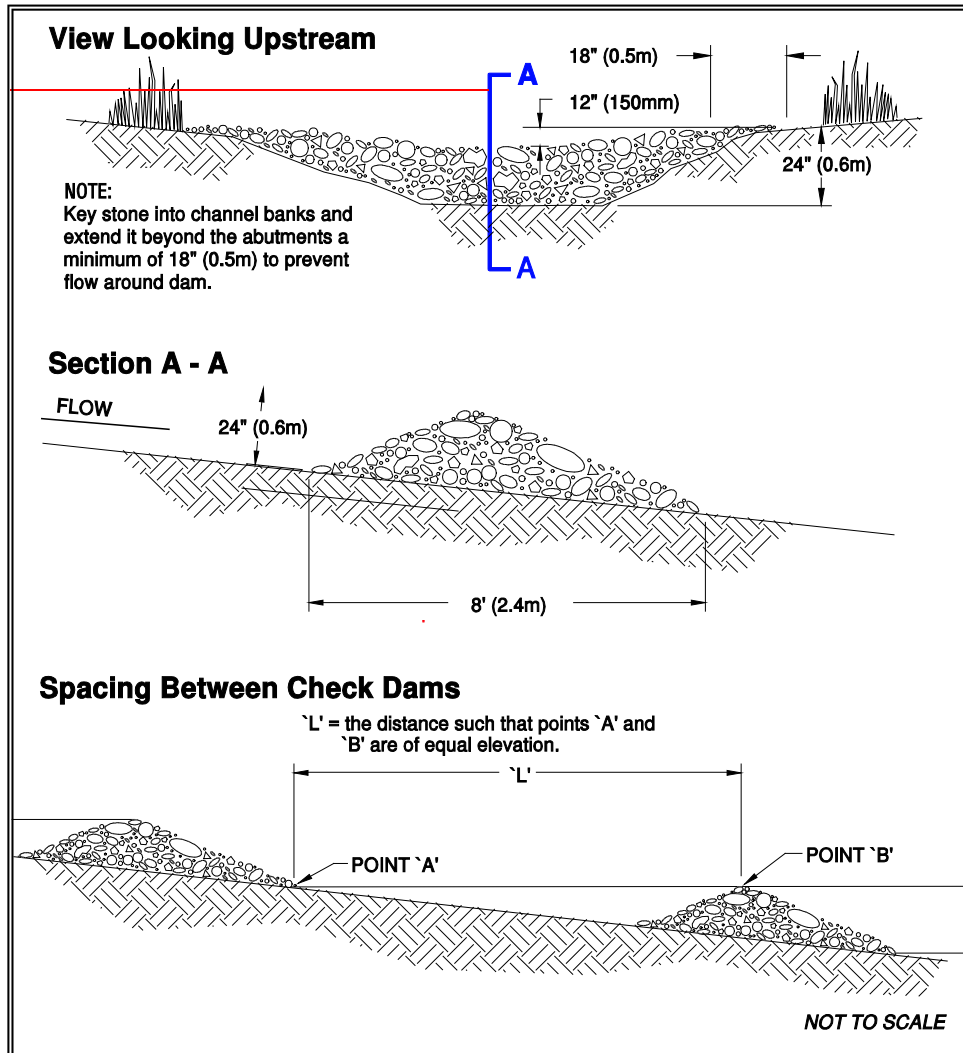


Figure 4.13-2.7 – Rock Check Dams

BMP C208: Triangular Silt Dike (TSD) (Geotextile-Encased Check Dam)

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 interceptor dike.
Conditions of use	<ul style="list-style-type: none">• May be used on soil or pavement with adhesive or staples.• May be used on soil or pavement with adhesive or staples.• TSDs have been used to build temporary:<ol style="list-style-type: none">1. sediment ponds;2. diversion ditches;3. concrete wash out facilities;4. curbing;5. water bars;6. level spreaders; and,7. berms.
Design and Installation Specifications	<p>Made of urethane foam sewn into a woven geosynthetic fabric.</p> <p>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.</p> <ul style="list-style-type: none">• 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 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.• Check dams should be located and installed as soon as construction will allow.• Check dams should be placed perpendicular to the flow of water.• When used as check dams, the leading edge must be secured with rocks, sandbags, or a small key slot and staples.• 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.

Maintenance Standards

- Triangular silt dams shall be inspected 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.
- Anticipate submergence and deposition above the triangular silt dam and erosion from high flows around the edges of the dam. Immediately repair any damage or any undercutting of the dam.

BMP C209: Outlet Protection

Purpose

Outlet protection prevents scour at conveyance outlets and minimizes the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Conditions of use

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

Design and Installation Specifications

The receiving channel at the outlet of a culvert shall be protected from erosion by rock lining a minimum of 6 feet downstream and extending up the channel sides a minimum of 1-foot above the maximum tailwater elevation or 1-foot above the crown, whichever is higher. For large pipes (more than 18 inches in diameter), the outlet protection lining of the channel is lengthened to four times the diameter of the culvert.

- Standard wingwalls, and tapered outlets and paved channels should also be considered when appropriate for permanent culvert outlet protection. (See WSDOT Hydraulic Manual, available through WSDOT Engineering Publications).
- Organic or synthetic erosion blankets, with or without vegetation, are usually more effective than rock, cheaper, and easier to install. Materials can be chosen using manufacturer product specifications. ASTM test results are available for most products and the designer can choose the correct material for the expected flow.
- With low flows, vegetation (including sod) can be effective.
- The following guidelines shall be used for riprap outlet protection:
 1. If the discharge velocity at the outlet is less than 5 fps (pipe slope less than 1 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1-foot.
 2. For 5 to 10 fps discharge velocity at the outlet (pipe slope less than 3 percent), use 24-inch to ~~4-foot~~48-inch riprap. Minimum thickness is 2 feet.
 3. For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), an engineered energy dissipater shall be used.

- Filter fabric or erosion control blankets should always be used under riprap to prevent scour and channel erosion.
- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over-widened to the upstream side, from the outfall. Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a HPA. See Volume V for more information on outfall system design.

Maintenance Standards

- Inspect and repair as needed.
- Add rock as needed to maintain the intended function.
- Clean energy dissipater if sediment builds up.

BMP C220: Storm Drain Inlet Protection

Purpose

~~To prevent~~ Storm drain inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

~~Where~~ Use storm drain inlet protection at inlets ~~that are to be made~~ operational before permanent stabilization of the disturbed drainage area. ~~Protection should be provided~~ Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless ~~the conveying runoff that enters the~~ entering catch ~~basin will be~~ conveyed ~~basins~~ to a sediment pond or trap. ~~Inlet protection may be used anywhere to protect the drainage system. It is likely that the drainage system will still require cleaning.~~

Table 4.9 ~~Also consider inlet protection for lawn and yard drains on new home construction. These small and numerous drains coupled with lack of gutters in new home construction can add significant amounts of sediment into the roof drain system. If possible delay installing lawn and yard drains until just before landscaping or cap these drains to prevent sediment from entering the system until completion of landscaping. Provide 18-inches of sod around each finished lawn and yard drain.~~

Table 4.2.2 lists several options for inlet protection. All of the methods for storm drain inlet protection ~~are prone to~~ end to plugging ~~plug~~ and require a high frequency of maintenance. Limit drainage areas ~~should be limited to~~ one acre or less. Possibly provide emergency overflows ~~may be required with additional end-of-pipe treatment~~ where stormwater ponding would cause a hazard. ~~If an emergency overflow is provided, additional end-of-pipe treatment may be required.~~

Table 4.2.2 Storm Drain Inlet Protection			
Type of Inlet Protection	Emergency Overflow	Applicable for Paved/ Earthen Surfaces	Conditions of Use
Drop Inlet Protection			
Excavated drop inlet protection	Yes, temporary flooding will occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area Requirement: 30' X 30'/acre
Block and gravel drop inlet protection	Yes	Paved or Earthen	Applicable for heavy concentrated flows. Will not pond.
Gravel and wire drop inlet protection	No		Applicable for heavy concentrated flows. Will pond. Can withstand traffic.
Catch basin filters	Yes	Paved or Earthen	Frequent maintenance required.
Curb Inlet Protection			
Curb inlet protection with a wooden weir	Small capacity overflow	Paved	Used for sturdy, more compact installation.
Block and gravel curb inlet protection	Yes	Paved	Sturdy, but limited filtration.
Culvert Inlet Protection			
Culvert inlet sediment trap			18 month expected life.

Design and Installation Specifications

Excavated Drop Inlet Protection - An excavated impoundment around the storm drain. Sediment settles out of the stormwater prior to entering the storm drain.

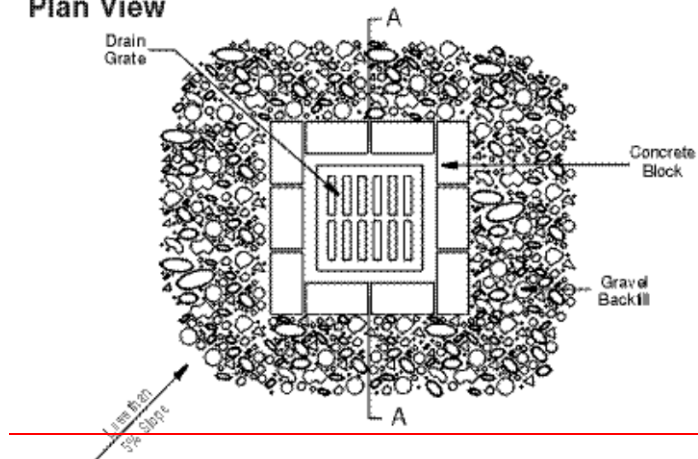
- ~~Depth~~ Provide a depth of 1-2 ft as measured from the crest of the inlet structure.
- ~~Side Slopes~~ Slope sides of excavation no steeper than ~~2:1~~ 2H:1V.
- Minimum volume of excavation 35 cubic yards.
- Shape basin to fit site with longest dimension oriented toward the longest inflow area.
- Install provisions for draining to prevent standing water problems.
- Clear the area of all debris.
- Grade the approach to the inlet uniformly.
- Drill weep holes into the side of the inlet.
- Protect weep holes with screen wire and washed aggregate.
- Seal weep holes when removing structure and stabilizing area.

- ~~It may be necessary to~~ Build a temporary dike, if necessary, to the down slope side of the structure to prevent bypass flow.

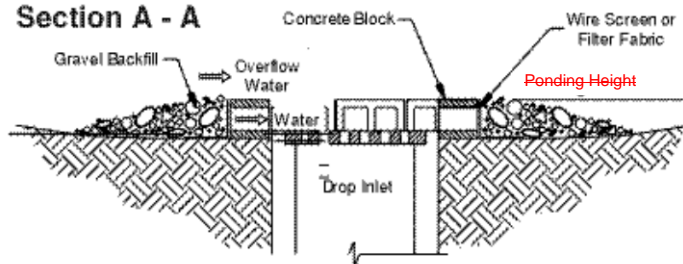
Block and Gravel Filter - A barrier formed around the storm drain inlet with standard concrete blocks and gravel. See [Figure 4.2.8](#). ~~Figure 4.14.~~

- ~~Height~~ Provide a height of 1 to 2 feet above inlet.
- Recess the first row 2-inches into the ground for stability.
- Support subsequent courses by placing a 2x4 through the block opening.
- Do not use mortar.
- Lay some blocks in the bottom row on their side for dewatering the pool.
- Place hardware cloth or comparable wire mesh with ½-inch openings over all block openings.
- Place gravel just below the top of blocks on slopes of ~~2:1~~ 2H:1V or flatter.
- An alternative design is a gravel donut.
- Provide an inlet slope of ~~3:1~~ 3H:1V.
- Provide an outlet slope of ~~2:1~~ 2H:1V.
- ~~4~~ Provide a 1-foot wide level stone area between the structure and the inlet.
- Use inlet slope stones 3 inches in diameter or larger.
- ~~Outlet slope~~ Use gravel ½- to ¾-inch at a minimum thickness of 1-foot for the outlet slope.

Plan View



Section A - A



Notes:

1. Drop inlet sediment barriers are to be used for small, nearly level drainage areas. (less than 5%)
2. Excavate a basin of sufficient size adjacent to the drop inlet.
3. The top of the structure (poning height) must be well below the ground elevation downslope to prevent runoff from bypassing the inlet. A temporary dike may be necessary on the downslope side of the structure.

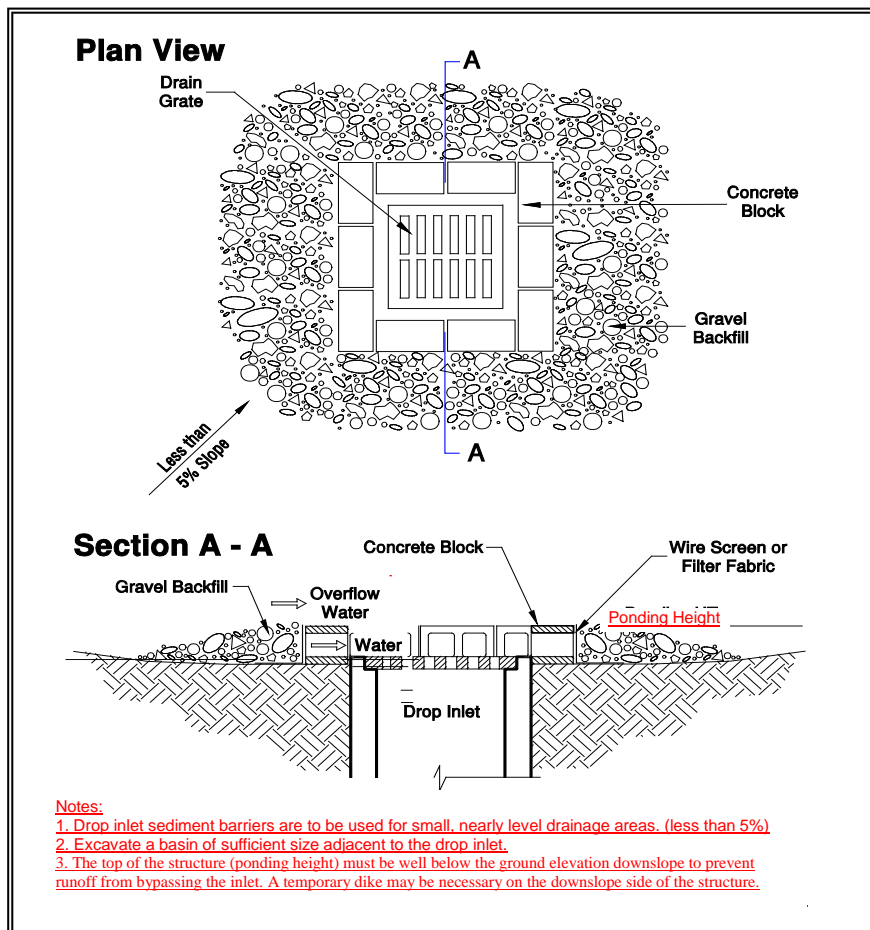


Figure 4.142.8 – Block and Gravel Filter

Gravel and Wire Mesh Filter - A gravel barrier placed over the top of the inlet. This structure does not provide an overflow.

- Use a hardware cloth or comparable wire mesh with ½-inch openings.
- Use coarse aggregate.
- Provide a height 1-foot or more, 18-inches wider than inlet on all sides.
- Place wire mesh over the drop inlet so that the wire extends a minimum of 1-foot beyond each side of the inlet structure.

- Overlap the strips if more than one strip of mesh is necessary, ~~overlap the strips.~~
- Place coarse aggregate over the wire mesh.
- ~~The~~Provide at least a 12-inch depth of ~~the~~ gravel ~~should be at least 12 inches~~ over the entire inlet opening and extend at least 18 inches on all sides.

Catchbasin Filters ~~Inserts should be~~ Use inserts designed by ~~the manufacturer~~manufacturers for use at construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. ~~The~~To reduce maintenance requirements ~~can be reduced by combining~~combine a catchbasin filter with another type of inlet protection. This type of inlet protection provides flow bypass without overflow and therefore may be a better method for inlets located along active rights-of-way.

- Provides 5 cubic feet of storage.
- Requires dewatering provisions.
- Provides a high-flow bypass that will not clog under normal use at a construction site.
- Insert the catchbasin filter ~~is inserted~~ in the catchbasin just below the grating.

Curb Inlet Protection with Wooden Weir – Barrier formed around a curb inlet with a wooden frame and gravel.

- Use wire mesh with ½-inch openings.
- Use extra strength filter cloth.
- Construct a frame.
- Attach the wire and filter fabric to the frame.
- Pile coarse washed aggregate against wire/fabric.
- Place weight on frame anchors.

Block and Gravel Curb Inlet Protection – Barrier formed around a curb inlet with concrete blocks and gravel. See [Figure 4.2.9](#).

- Use wire mesh with ½-inch openings.
- Place two concrete blocks on their sides abutting the curb at either side of the inlet opening. These are spacer blocks.
- Place a 2x4 stud 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 over the outside vertical face.
- Pile coarse aggregate against the wire to the top of the barrier.

Curb and Gutter Sediment Barrier – Sandbag or rock berm (riprap and aggregate) 3 feet high and 3 feet wide in a horseshoe shape. See [Figure 4.2.10](#).

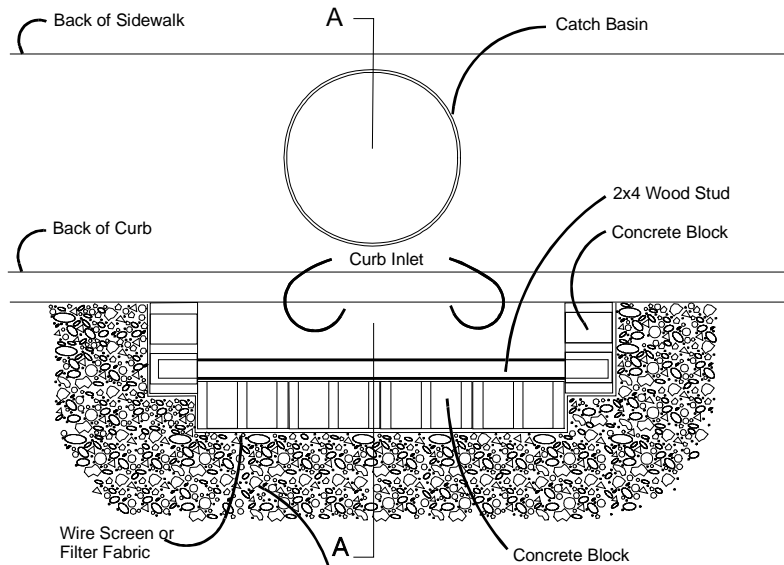
- Construct a horseshoe shaped berm, faced with coarse aggregate if using riprap, 3 feet high and 3 feet wide, at least 2 feet from the inlet.
- Construct a horseshoe shaped sedimentation trap on the outside of the berm sized to sediment trap standards for protecting a culvert inlet.
- Inspect catch basin filters frequently, especially after storm events. Clean and replace clogged inserts. For systems with clogged stone filters: pull away the stones from the inlet and clean or replace. An alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.
- ~~For systems using stone filters: If the stone filter becomes clogged with sediment, the stones must be pulled away from the inlet and cleaned or replaced. Since cleaning of gravel at a construction site may be difficult, an alternative approach would be to use the clogged stone as fill and put fresh stone around the inlet.~~
- 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.

Maintenance Standards

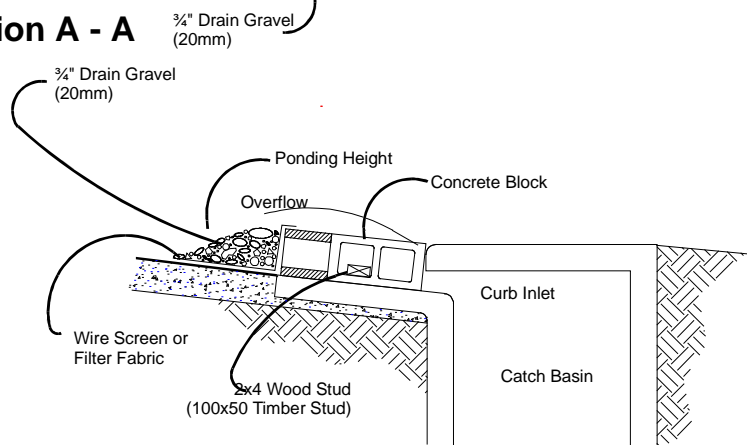
Approved as Equivalent

Ecology has approved products as able to meet the requirements of [BMP C220](#). The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology's website at <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html>

Plan View



Section A - A

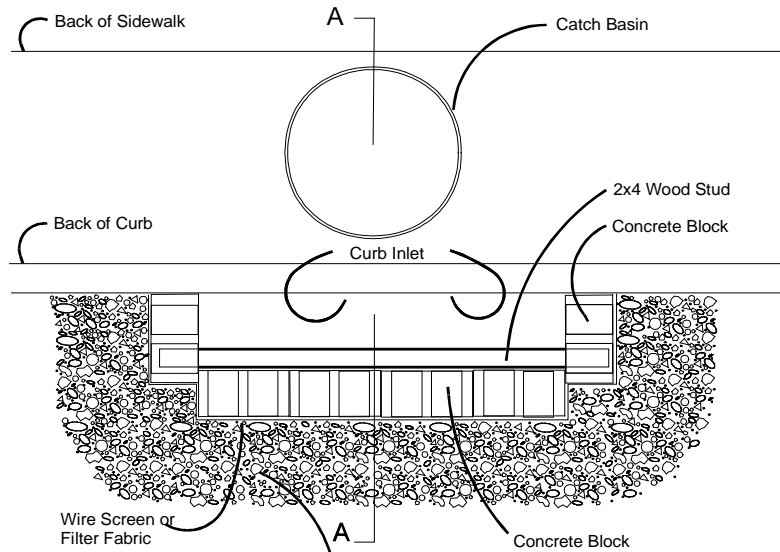


NOTES:

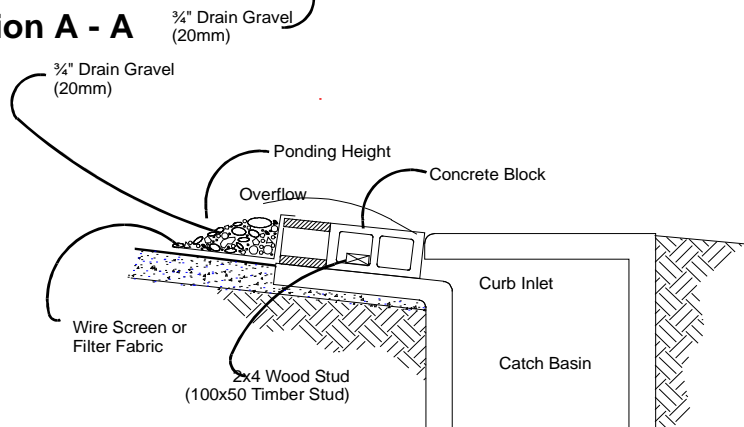
1. Use block and gravel type sediment barrier when curb inlet is located in gently sloping street segment, where water can pond and allow sediment to separate from runoff.
2. Barrier shall allow for overflow from severe storm event.
3. Inspect barriers and remove sediment after each storm event. Sediment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

Figure 4.152.9 – Block and Gravel Curb Inlet Protection

Plan View



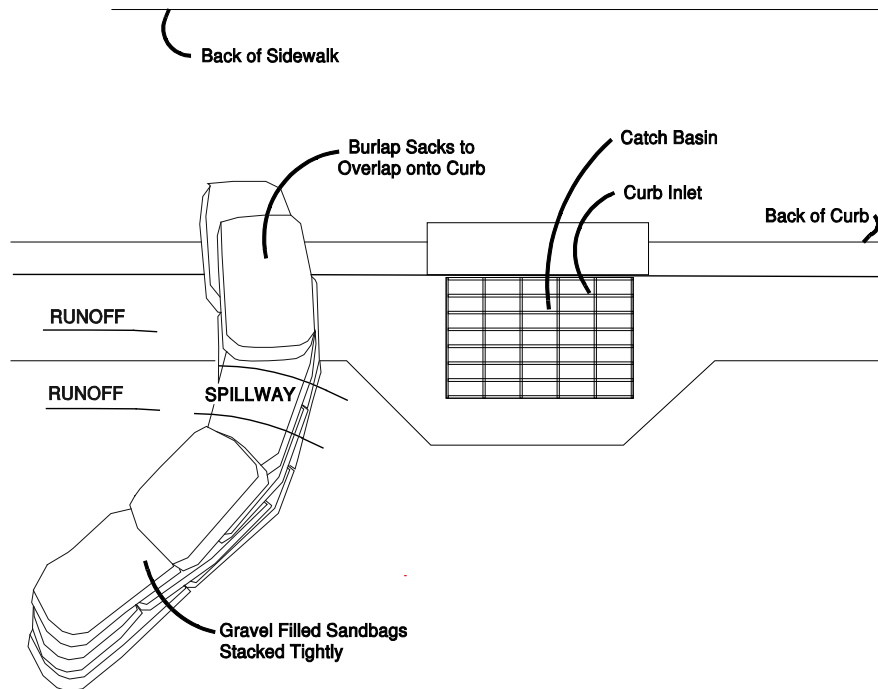
Section A - A



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.

Plan View



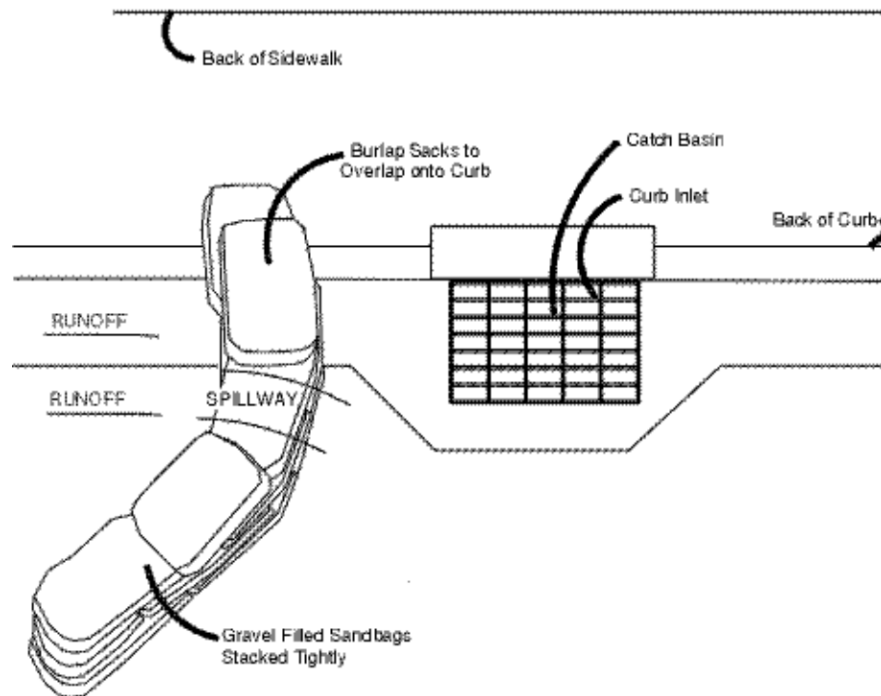
NOTES:

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 sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

Figure 4.162.10 – Curb and Gutter Barrier

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Plan View



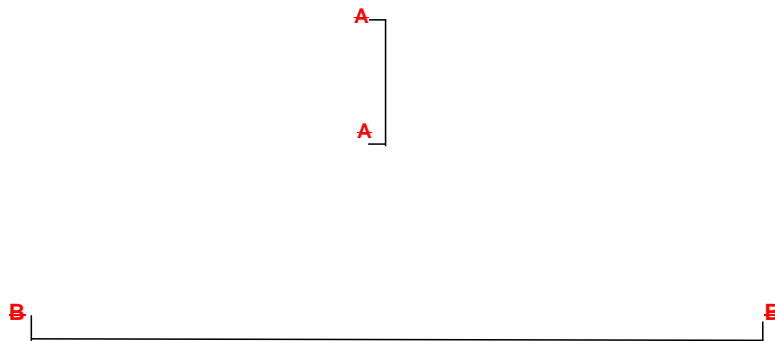
NOTES:

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 sediment after each storm event. Sediment and gravel must be removed from the traveled way immediately.

BMP C230: Straw Bale Barrier

- Purpose** — To decrease the velocity of sheet flows and intercept and detain small amounts of sediment from disturbed areas of limited extent, preventing sediment from leaving the site. See Figure 4.17 for details on straw bale barriers.
- ~~Straw bales are among the most used and least effective BMPs. The best use of a straw bale is hand spread on the site.~~
 - ~~Where the size of the drainage area is no greater than 1/4 acre per 100 feet of barrier length; the maximum slope length behind the barrier is 100 feet; and the maximum slope gradient behind the barrier is 2:1.~~
 - ~~Where effectiveness is required for less than three months.~~
 - ~~Under no circumstances should straw bale barriers be constructed in streams, channels, or ditches.~~
 - ~~Straw bale barriers should not be used where rock or hard surfaces prevent the full and uniform anchoring of the barrier.~~
 - ~~The barrier shall be entrenched and backfilled. A trench shall be excavated the width of a bale and the length of the proposed barrier to a minimum depth of 4 inches. The trench must be deep enough to remove all grass and other material that might allow underflow. After the bales are staked and chinked (filled by wedging), the excavated soil shall be backfilled against the barrier. Backfill soil shall conform to the ground level on the downhill side and shall be built up to 4 inches against the uphill side of the barrier.~~
 - ~~Each bale shall be securely anchored by at least two stakes or re-bars driven through the bale. The first stake in each bale shall be driven toward the previously laid bale to force the bales together. Stakes or re-bars shall be driven deep enough into the ground to securely anchor the bales. Stakes should not extend above the bales but instead should be driven in flush with the top of the bale for safety reasons.~~
 - ~~The gaps between the bales shall be chinked (filled by wedging) with straw to prevent water from escaping between the bales. Loose straw scattered over the area immediately uphill from a straw bale barrier tends to increase barrier efficiency. Wedging must be done carefully in order not to separate the bales.~~
 - ~~Close attention shall be paid to the repair of damaged bales, end runs, and undercutting beneath bales.~~
 - ~~Necessary repairs to barriers or replacement of bales shall be accomplished promptly.~~
 - ~~Sediment deposits should be removed after each runoff-producing rainfall. They must be removed when the level of deposition reaches approximately one-half the height of the barrier.~~

- Any sediment deposits remaining in place after the straw bale barrier is no longer required shall be dressed to conform to the existing grade, prepared and seeded.
- Straw bales used as a temporary straw bale barrier shall be removed after project completion and stabilization to prevent sprouting of unwanted vegetation.



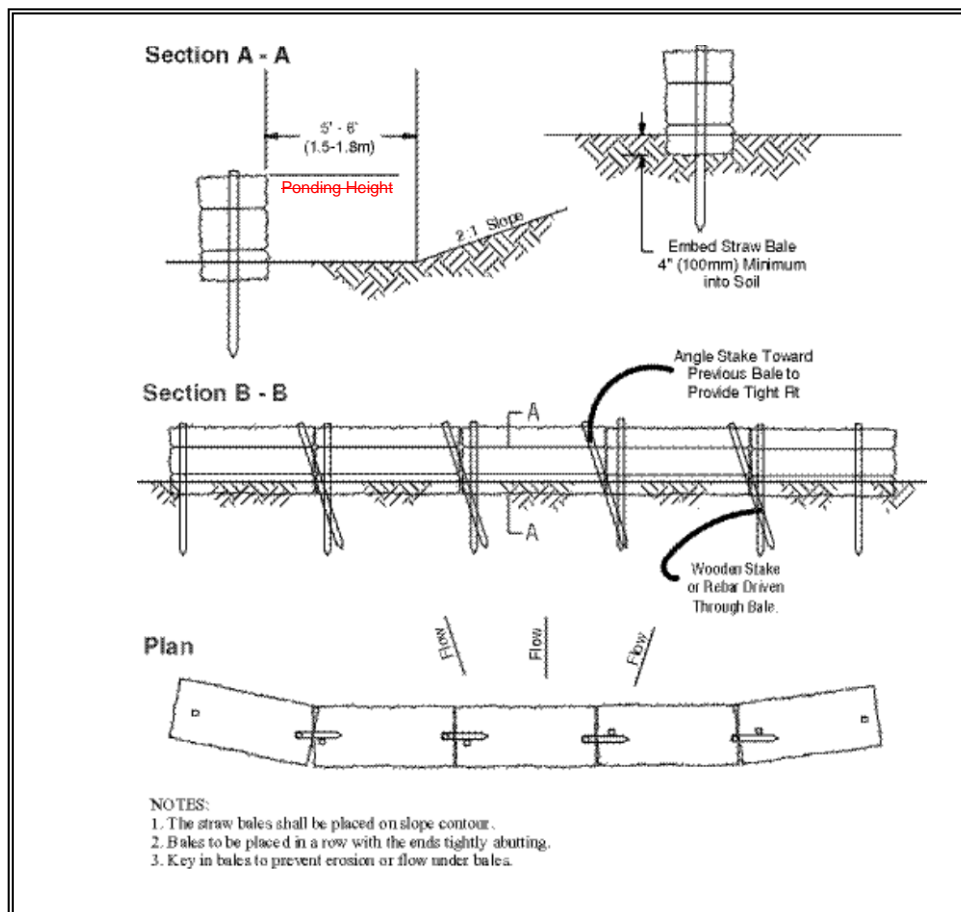


Figure 4.17 Straw Bale Barrier

BMP C231: Brush Barrier

Purpose

The purpose of brush barriers is to 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.

Conditions of Use

- Brush barriers may be used downslope of all disturbed areas of less than one-quarter acre.
- Brush barriers 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 brush barrier, rather than by a sediment pond, is when the area draining to the barrier is small.
- Brush barriers should only be installed on contours.

Design and Installation Specifications

- Height 2 feet (minimum) to 5 feet (maximum).
- Width 5 feet at base (minimum) to 15 feet (maximum).
- Filter fabric (geotextile) may be anchored over the brush berm to enhance the filtration ability of the barrier. Ten-ounce burlap is an adequate alternative to filter fabric.
- Chipped site vegetation, composted mulch, or wood-based mulch (hog fuel) can be used to construct brush barriers.
- A 100 percent biodegradable installation can be constructed using 10-ounce burlap held in place by wooden stakes. [Figure 4.2.11](#) ~~Figure 4.18~~ depicts a typical brush barrier.

Maintenance Standards

- There shall be no signs of erosion or concentrated runoff under or around the barrier. If concentrated flows are bypassing the barrier, it must be expanded or augmented by toed-in filter fabric.
- The dimensions of the barrier must be maintained.

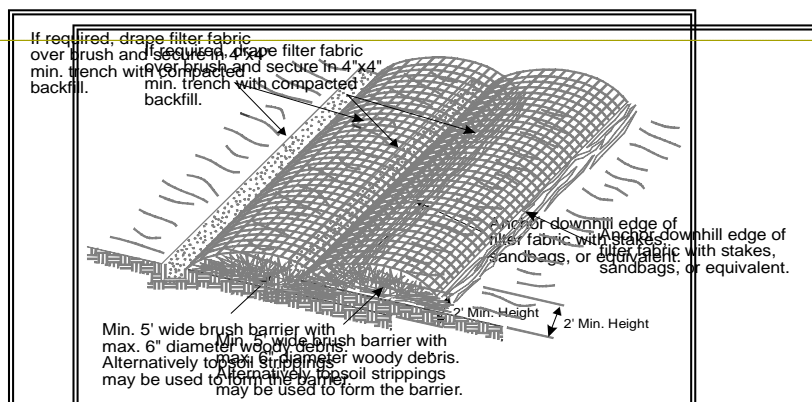


Figure 4.182.11 – Brush Barrier

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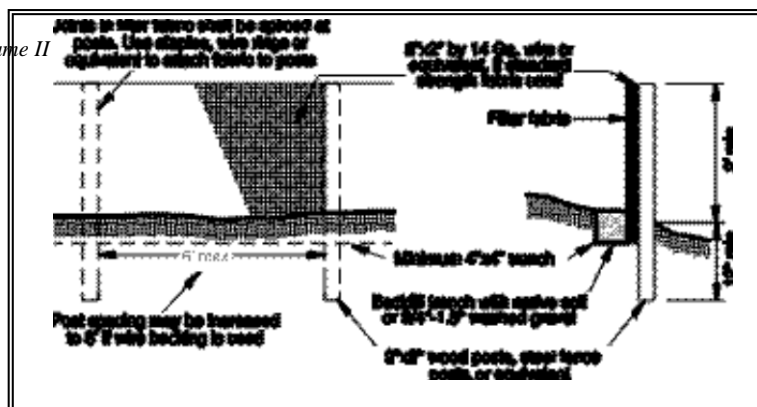
BMP C232: Gravel Filter Berm

Purpose	A gravel filter berm is constructed on rights-of-way or traffic areas within a construction site to retain sediment by using a filter berm of gravel or crushed rock.
Conditions of Use	Where a temporary measure is needed to retain sediment from rights-of-way or in traffic areas on construction sites.
Design and Installation Specifications	<ul style="list-style-type: none">Berm material shall be $\frac{3}{4}$ to 3 inches in size, washed well-grade gravel or crushed rock with less than 5 percent fines.Spacing of berms:<ul style="list-style-type: none">Every 300 feet on slopes less than 5 percentEvery 200 feet on slopes between 5 percent and 10 percentEvery 100 feet on slopes greater than 10 percentBerm dimensions:<ul style="list-style-type: none">1 foot high with 3:1<u>3H:1V</u> side slopes8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm
Maintenance Standards	<ul style="list-style-type: none">Regular inspection is required. Sediment shall be removed and filter material replaced as needed.

BMP C233: Silt Fence

Purpose	Use of a silt fence reduces 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. See Figure 4.2.12 Figure 4.19 for details on silt fence construction.
Conditions of Use	<u>Silt fence may be used downslope of all disturbed areas.</u> <ul style="list-style-type: none"><u>Silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.</u>Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. <u>Convey</u> 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 silt fence, rather than by a sediment pond, is when the area draining to the fence is one acre or less and flow rates are less than 0.5 cfs.Silt fences should<u>Do not be constructed</u> construct silt fences in streams or used<u>use</u> in V-shaped ditches. They are<u>Silt fences do not provide</u> an

Volume II



adequate method of silt control for anything deeper than sheet or overland flow.

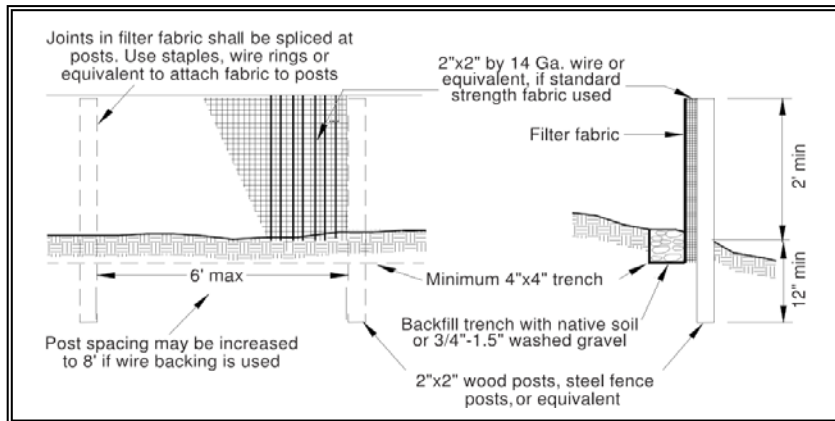


Figure 4.192.12 – Silt Fence

**Design and
Installation
Specifications**

- Use in combination with sediment basins or other BMPs.
- Maximum slope steepness (normal (perpendicular) to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- ~~No~~**Do not allow** flows greater than 0.5 cfs.
- The geotextile used shall meet the following standards. All geotextile properties listed below are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in [Table 4.2.3](#) ~~Table 4.10~~):

Table 4.2.3 Geotextile Standards	
Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for slit film woven (#30 sieve). 0.30 mm maximum for all other geotextile types (#50 sieve). 0.15 mm minimum for all fabric types (#100 sieve).
Water Permittivity (ASTM D4491)	0.02 sec ⁻¹ minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. Minimum for extra strength fabric. 100 lbs minimum for standard strength fabric.
Grab Tensile Strength (ASTM D4632)	30% maximum
Ultraviolet Resistance (ASTM D4355)	70% minimum

- **Support** standard strength fabrics ~~shall be supported~~ with wire mesh, chicken wire, 2-inch x 2-inch wire, safety fence, or jute mesh to

increase the strength of the fabric. Silt fence materials are available that have synthetic mesh backing attached.

- Filter fabric material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of six months of expected usable construction life at a temperature range of 0°F. to 120°F.
- ~~400~~One-hundred percent biodegradable silt fence is available that is strong, long lasting, and can be left in place after the project is completed, if permitted by local regulations.
- Refer to Figure 4.2.12 for standard silt fence details. Include the following standard Notes for silt fence on construction plans and specifications ~~follow. Refer to Figure 4.19 for standard silt fence details.~~

1. The contractor shall install and maintain temporary silt fences at the locations shown in the Plans. ~~The~~

~~1.2.~~ Construct silt fences ~~shall be constructed in the~~ areas of clearing, grading, or drainage prior to starting those activities.

~~A silt fence shall not be considered temporary if The silt fence must function beyond the life of the contract. The Silt fence shall prevent soil carried by runoff water from going beneath, through, or over the top of the silt fence, but shall allow the water to pass through the fence.~~

~~2.3.~~ The minimum shall have a 2-feet min. and a 2½-feet max. height of the top of silt fence shall be 2 feet and the maximum height shall be 2½ feet above the original ground surface.

~~3.4.~~ The geotextile filter fabric shall be sewn together at the point of manufacture, ~~or at an approved location as determined by the Engineer,~~ to form geotextile filter fabric lengths as required. Locate all sewn seams ~~shall be located at a support post.~~ posts. Alternatively, two sections of silt fence can be overlapped, provided the Contractor can demonstrate, to the satisfaction of the Engineer, that the overlap is long enough and that the adjacent fence sections are close enough together to prevent silt laden water from escaping through the fence at the overlap.

5. ~~The geotextile shall be attached~~ Attach the filter fabric on the up-slope side of the posts and ~~support system~~ secure with staples, wire, or in accordance with the manufacturer's recommendations. ~~The geotextile shall be attached~~ Attach the filter fabric to the posts in a manner that reduces the potential for geotextile-tearing at the staples, wire, or other connection device. ~~Silt fence back-up support for the geotextile in.~~

~~4.6.~~ Support the form of a filter fabric with wire or plastic mesh ~~is,~~ dependent on the properties of the geotextile selected for use. If

wire or plastic ~~back-up~~ mesh is used, fasten the mesh ~~shall be fastened~~ securely to the up-slope side of the posts with the ~~geotextile being filter fabric~~ up-slope of the mesh ~~back-up support~~.

7. Mesh support, if used, shall consist of steel wire with a maximum mesh spacing of 2-inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 lbs. grab tensile strength. The geotextile at The polymeric mesh must be as resistant to the same level of ultraviolet radiation as the filter fabric it supports.

5.8. Bury the bottom of the ~~fence shall be buried in a trench to a minimum depth of filter fabric 4-inches min.~~ below the ground surface. ~~The trench shall be backfilled~~ Backfill and ~~the~~ tamp soil ~~tamped~~ in place over the buried portion of the ~~geotextile, such filter fabric, so~~ that no flow can pass beneath the fence and scouring ~~can not~~ occur. When wire or polymeric back-up support mesh is used, the wire or polymeric mesh shall extend into the ~~trench a minimum of ground 3-inches min.~~

6.9. Drive or place the fence posts ~~shall be placed or driven a minimum of into the ground 18-inches- min.~~ A ~~minimum 12-inch min.~~ depth ~~of 12-inches~~ is allowed if topsoil or other soft subgrade soil is not present and ~~a minimum depth of 18-18-inches~~ cannot be reached. Increase fence post min. depths ~~shall be increased~~ by 6 inches if the fence is located on slopes of ~~3:1~~ 3H:1V or steeper and the slope is perpendicular to the fence. If required post depths cannot be obtained, the posts shall be adequately secured by bracing or guying to prevent overturning of the fence due to sediment loading.

10. Use wood, steel or equivalent posts. The spacing of the support posts shall be a maximum of 6-feet. Posts shall consist of either:

- Wood with dimensions of 2-inches by 2-inches wide min. and a 3-feet min. length. Wood posts shall be free of defects such as knots, splits, or gouges.
- No. 6 steel rebar or larger.
- ASTM A 120 steel pipe with a minimum diameter of 1-inch.
- U, T, L, or C shape steel posts with a minimum weight of 1.35 lbs./ft.
- Other steel posts having equivalent strength and bending resistance to the post sizes listed above.

7.11. Locate silt fences ~~shall be located~~ on contour as much as possible, except at the ends of the fence, where the fence shall be turned uphill such that the silt fence captures the runoff water and prevents water from flowing around the end of the fence.

12. If the fence must cross contours, with the exception of the ends of the fence, place gravel check dams ~~placed~~ perpendicular to the back of the fence ~~shall be used~~ to minimize concentrated flow and erosion ~~along the back. The slope~~ of the fence. ~~The line where contours must be crossed shall not be steeper than 3H:1V.~~

- Gravel check dams shall be approximately 1-foot deep at the back of the fence. ~~It Gravel check dams~~ shall be continued perpendicular to the fence at the same elevation until the top of the check dam intercepts the ground surface behind the fence.
- ~~The~~ Gravel check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. ~~The~~ Gravel check dams shall be located every 10 feet along the fence where the fence must cross contours. ~~The slope of the fence line where contours must be crossed shall not be steeper than 3:1.~~

~~Wood, steel or equivalent posts shall be used. Wood posts shall have minimum dimensions of 2 inches by 2 inches by 3 feet minimum length, and shall be free of defects such as knots, splits, or gouges. Steel posts shall consist of either size No. 6 rebar or larger, ASTM A 120 steel pipe with a minimum diameter of 1 inch, U, T, L, or C shape steel posts with a minimum weight of 1.35 lbs./ft. or other steel posts having equivalent strength and bending resistance to the post sizes listed. The spacing of the support posts shall be a maximum of 6 feet.~~

~~Fence back-up support, if used, shall consist of steel wire with a maximum mesh spacing of 2 inches, or a prefabricated polymeric mesh. The strength of the wire or polymeric mesh shall be equivalent to or greater than 180 lbs. grab tensile strength. Refer to Figure 4.2.13. The polymeric mesh must be as resistant to ultraviolet radiation as the geotextile it supports.~~

- for slicing method details. Silt fence installation using the slicing method ~~specification details follow. Refer to Figure 4.20 for slicing method details, specifications:~~
 1. The base of both end posts must be at least 2 to 4 inches above the top of the silt fence~~filter~~ fabric on the middle posts for ditch checks to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.
 2. Install posts 3 to 4 feet apart in critical retention areas and 6 to 7 feet apart in standard applications.
 3. Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the filter fabric, enabling posts to support the filter fabric from upstream water pressure.

4. Install posts with the nipples facing away from the ~~silt fence~~filter fabric.
5. Attach the filter fabric to each post with three ties, all spaced within the top 8-inches of the filter fabric. Attach each tie diagonally 45 degrees through the filter fabric, with each puncture at least 1-inch vertically apart. ~~In addition,~~ Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.
6. Wrap approximately 6-inches of fabric around the end posts and secure with 3 ties.
7. No more than 24-inches of a 36-inch filter fabric is allowed above ground level.

~~The rope lock system must be used in all ditch check applications.~~

~~The installation should be checked and corrected for any deviation before compaction. Use a flat bladed shovel to tuck fabric deeper into the ground if necessary.~~

~~Compaction is vitally important for effective results.~~ Compact the soil immediately next to the ~~silt fence~~filter fabric with the front wheel of the tractor, skid steer, or roller exerting at least 60 pounds per square inch. Compact the upstream side first and then each side twice for a total of four trips. Check and correct the silt fence installation for any deviation before compaction. Use a flat-bladed shovel to tuck fabric deeper into the ground if necessary.

It is important to

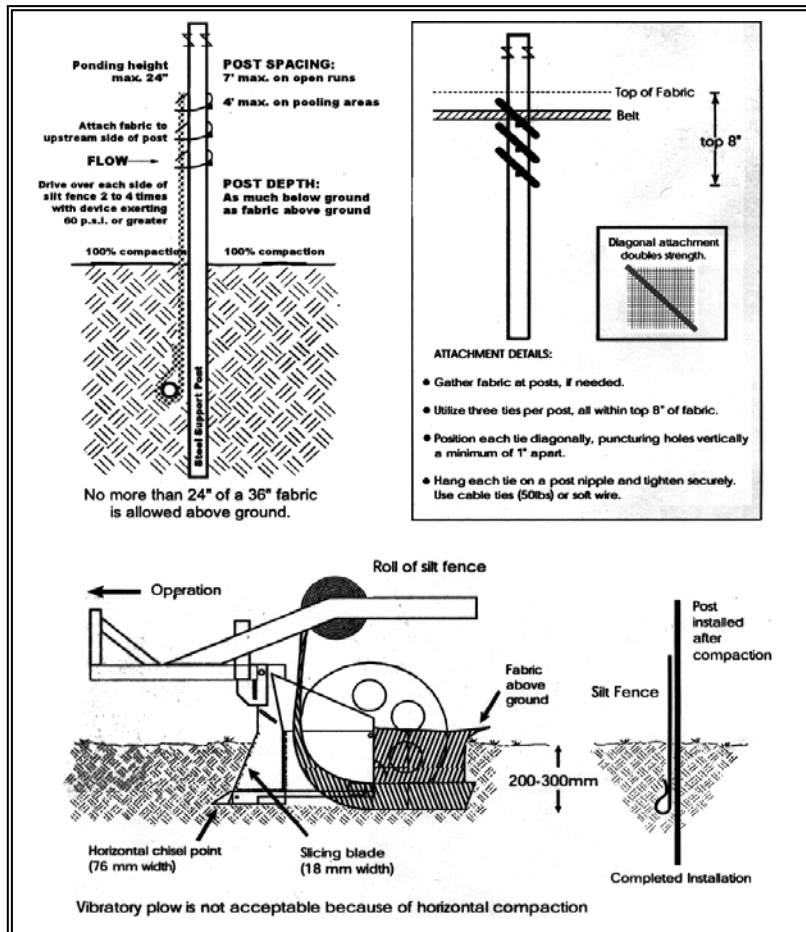
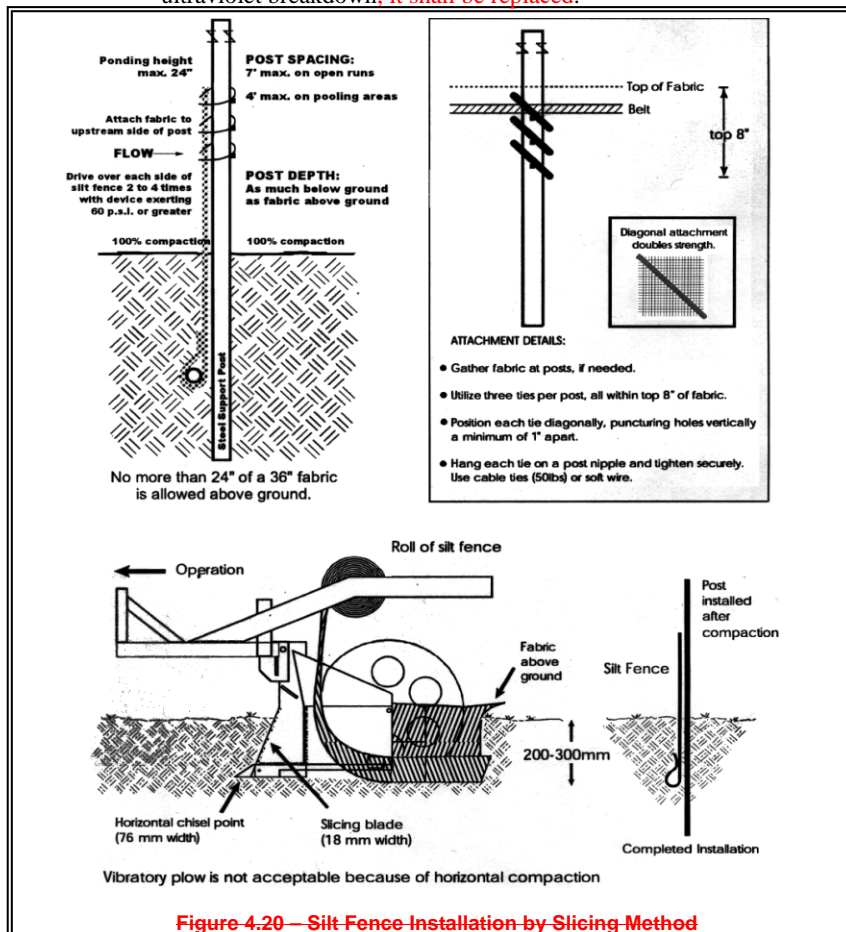


Figure 4.2.13 – Silt Fence Installation by Slicing Method

Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the silt fence to a sediment pond.
- Check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.

- Remove sediment deposits ~~shall either be removed~~ when the deposit reaches approximately one-third the height of the silt fence, or install a second silt fence ~~shall be installed~~.
- If the Replace filter fabric (geotextile) ~~that~~ has deteriorated due to ultraviolet breakdown, ~~it shall be replaced~~.



BMP C234: Vegetated Strip

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.

Conditions of Use

- Vegetated strips may be used downslope of all disturbed areas.
- 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 criteria are met (see [Table 4.2.4](#) ~~Table 4.11~~):

Table 4.2.4 Contributing Drainage Area for Vegetated Strips		
Average Contributing area Slope	Average Contributing area Percent Slope	Max Contributing area Flowpath Length
1.5H:1V or flatter	67% or flatter	100 feet
2H:1V or flatter	50% or flatter	115 feet
4H:1V or flatter	25% or flatter	150 feet
6H:1V or flatter	16.7% or flatter	200 feet
10H:1V or flatter	10% or flatter	250 feet

Design and Installation Specifications

- The vegetated strip shall consist of a minimum of a 25-foot flowpath length continuous strip of dense vegetation with 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 4H:1V.
- The uphill boundary of the vegetated strip shall be delineated with clearing limits.

Maintenance Standards

- 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.

BMP C235: ~~Straw~~ Wattles

Purpose

~~Straw~~ Wattles are temporary erosion and sediment control barriers consisting of straw, compost, or other material that is wrapped in biodegradable tubular plastic or similar encasing material. 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. See [Figure 4.2.14](#) ~~Figure 4.21~~ for typical construction details. WSDOT Standard Plan I-30.30-00 also provides information on Wattles (<http://www.wsdot.wa.gov/Design/Standards/Plans.htm#SectionI>)

Conditions of Use

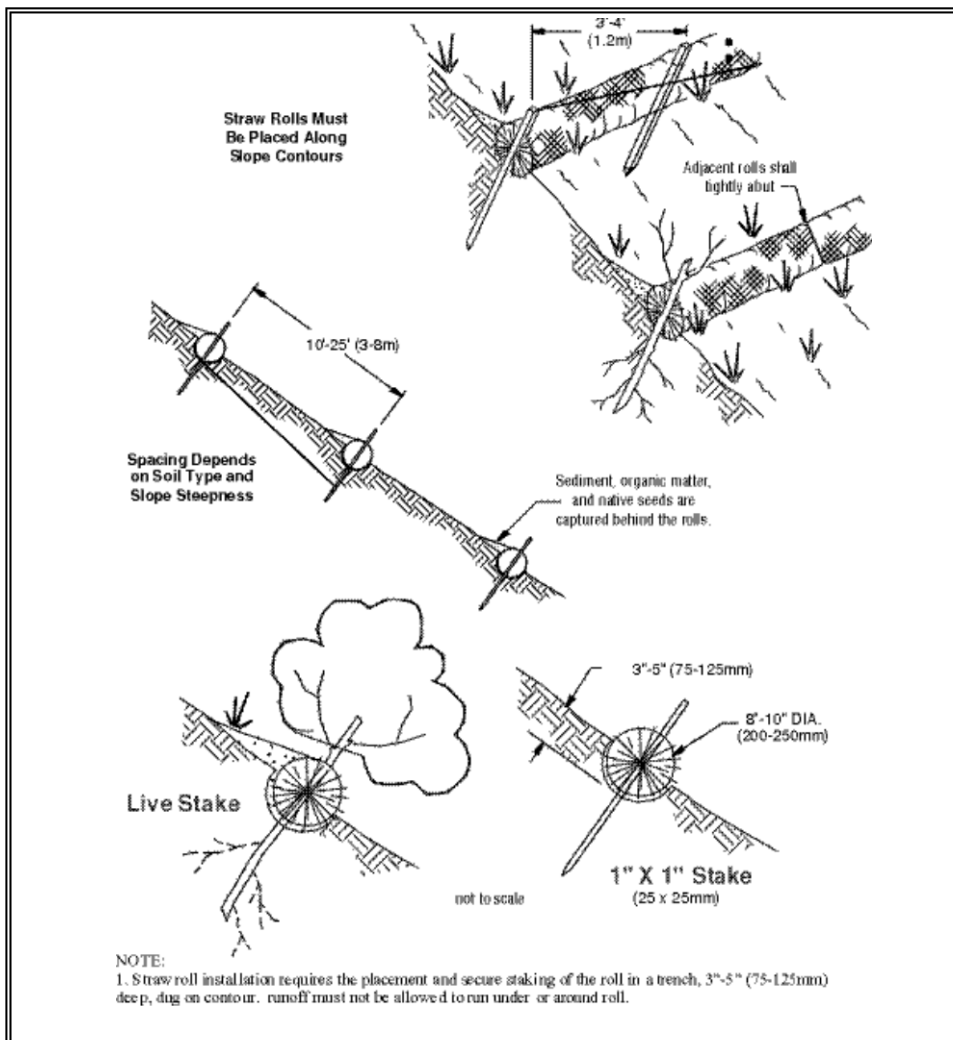
- Use wattles:
 - In disturbed areas that require immediate erosion protection.
 - On exposed soils during the period of short construction delays, or over winter months.
 - On slopes requiring stabilization until permanent vegetation can be established.
- ~~Straw~~ The material used dictates the effectiveness period of the wattle. Generally, Wattles are typically effective for one to two seasons.
- ~~If conditions are appropriate, wattles can be staked to the ground using willow cuttings for added revegetation.~~
- ~~Rilling can occur~~ Prevent rilling beneath wattles ~~if not~~ properly entrenched ~~entrenching~~ and ~~water can pass~~ abutting wattles together to prevent water from passing between ~~wattles if not tightly abutted together~~ them.

Design Criteria

- Install wattles perpendicular to the flow direction and parallel to the slope contour.
- 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. 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.
- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material ~~should be spread~~ evenly along the uphill slope and compacted using hand tamping or other methods.
- Construct trenches at ~~contour~~ intervals of 310- to 30-25- feet ~~apart~~ depending on the steepness of the slope, soil type, and rainfall. The steeper the slope the closer together the trenches.
- Install the 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.
- ~~At a minimum,~~ Wooden stakes should be approximately 3/4 x 3/4 x 24 inches— min. Willow cuttings or 3/8-inch rebar can also be used for stakes.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.
- Wattles may require maintenance to ensure they are in contact with soil and thoroughly entrenched, especially after significant rainfall on steep sandy soils.

Maintenance Standards



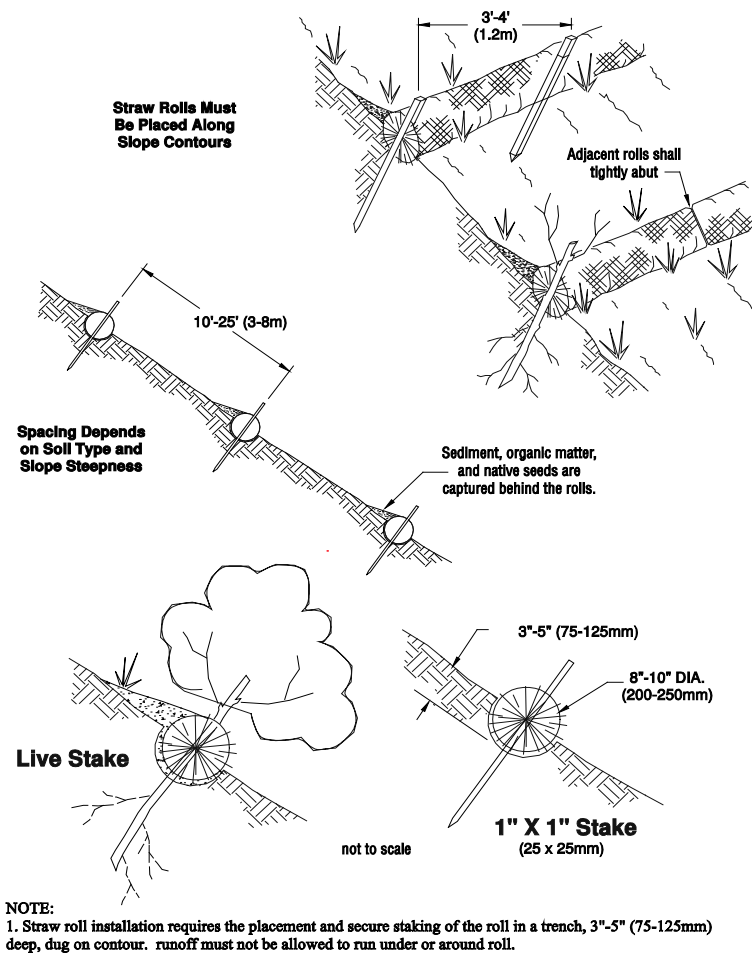


Figure 4.2.14 – Wattles

- Inspect the slope after significant storms and repair any areas where wattles are not tightly abutted or water has scoured beneath the wattles.

Approved as Equivalent

Ecology has approved products as able to meet the requirements of [BMP C235](#). The products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. Local jurisdictions may choose not to accept this product approved as equivalent, or may require additional testing prior to consideration for local use. The products are available for review on Ecology’s website at <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/equivalent.html>

BMP C236: Vegetative Filtration

Purpose Vegetative Filtration may be used in conjunction with [BMP C241 Temporary Sediment Ponds](#), [BMP C206 Level Spreader](#) and a pumping system with surface intake to improve turbidity levels of stormwater discharges by filtering through existing vegetation where undisturbed forest floor duff layer or established lawn with thatch layer are present. Vegetative Filtration can also be used to infiltrate dewatering waste from foundations, vaults, and trenches as long as runoff does not occur.

Conditions of Use

- For every five acre of disturbed soil use one acre of grass field, farm pasture, or wooded area. Reduce or increase this area depending on project size, ground water table height, and other site conditions.
- Wetlands shall not be used for filtration.
- Do not use this BMP in areas with a high ground water table, or in areas that will have a high seasonal ground water table during the use of this BMP.
- This BMP may be less effective on soils that prevent the infiltration of the water, such as hard till.
- Using other effective source control measures throughout a construction site will prevent the generation of additional highly turbid water and may reduce the time period or area need for this BMP.
- Stop distributing water into the vegetated area if standing water or erosion results.

Design Criteria

- Find land adjacent to the project that has a vegetated field, preferably a farm field, or wooded area.
- If the project site does not contain enough vegetated field area consider obtaining permission from adjacent landowners (especially for farm fields).
- Install a pump and downstream distribution manifold depending on the project size. Generally, the main distribution line should reach 100 to 200-feet long (many large projects, or projects on tight soil, will

require systems that reach several thousand feet long with numerous branch lines off of the main distribution line).

- The manifold should have several valves, allowing for control over the distribution area in the field.
- Install several branches of 4" schedule 20, swaged-fit common septic tight-lined sewer line, or 6" fire hose, which can convey the turbid water out to various sections of the field. See [Figure 4.2.15](#).
- Determine the branch length based on the field area geography and number of branches. Typically, branches stretch from 200-feet to several thousand feet. Always, lay branches on contour with the slope.
- On uneven ground, sprinklers perform well. Space sprinkler heads so that spray patterns do not overlap.
- On relatively even surfaces, a level spreader using 4-inch perforated pipe may be used as an alternative option to the sprinkler head setup. Install drain pipe at the highest point on the field and at various lower elevations to ensure full coverage of the filtration area. Pipe should be placed with the holes up to allow for a gentle weeping of stormwater evenly out all holes. Leveling the pipe by staking and using sandbags may be required.
- To prevent the over saturation of the field area, rotate the use of branches or spray heads. Do this as needed based on monitoring the spray field.
- Monitor the spray field on a daily basis to ensure that over saturation of any portion of the field doesn't occur at any time. The presence of standing puddles of water or creation of concentrated flows visually signify that over saturation of the field has occurred.
- Since the operator is handling contaminated water, physically monitor the vegetated spray field all the way down to the nearest surface water, or furthest spray area, to ensure that the water has not caused overland or concentrated flows, and has not created erosion around the spray nozzle.
- Monitoring usually needs to take place 3-5 times per day to ensure sheet-flow into state waters. Do not exceed water quality standards for turbidity.
- Ecology strongly recommends that a separate inspection log be developed, maintained and kept with the existing site logbook to aid the operator conducting inspections. This separate "Field Filtration Logbook" can also aid the facility in demonstrating compliance with permit conditions.
- Inspect the spray nozzles daily, at a minimum, for leaks and plugging from sediment particles.

***Maintenance
Standards***

- If erosion, concentrated flows, or over saturation of the field occurs, rotate the use of branches or spray heads or move the branches to a new field location.
- Check all branches and the manifold for unintended leaks.

Flowpath Guidelines for Vegetative Filtration		
Average Slope	Average Area % Slope	Estimated Flowpath Length (ft)
1.5H:1V	67%	250
2H:1V	50%	200
4H:1V	25%	150
6H:1V	16.7%	115
10H:1V	10%	100

Figure 4.21 – Straw Wattles



Figure 4.2.15 – Manifold and Braches in a wooded, vegetated spray field

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BMP C240: Sediment Trap

Purpose

A sediment trap is a small temporary ponding area with a gravel outlet used to collect and store sediment from sites cleared and/or graded during construction. Sediment traps, along with other perimeter controls, shall be installed before any land disturbance takes place in the drainage area.

Conditions of Use

Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or trap or other appropriate sediment removal best management practice. Non-engineered sediment traps may be used on-site prior to an engineered sediment trap or sediment pond to provide additional sediment removal capacity.

It is intended for use on sites where the tributary drainage area is less than 3 acres, with no unusual drainage features, and a projected build-out time of six months or less. The sediment trap is a temporary measure (with a design life of approximately 6 months) and shall be maintained until the site area is permanently protected against erosion by vegetation and/or structures.

Sediment traps and ponds are only effective in removing sediment down to about the medium silt size fraction. Runoff with sediment of finer grades (fine silt and clay) will pass through untreated, emphasizing the need to control erosion to the maximum extent first.

Whenever possible, sediment-laden water shall be discharged into ~~onsite~~^{on-site}, relatively level, vegetated areas (see [BMP C234 – Vegetated Strip](#)~~BMP C234 – Vegetated Strip~~). This is the only way to effectively remove fine particles from runoff unless chemical treatment or filtration is used. This can be particularly useful after initial treatment in a sediment trap or pond. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it, because of the possibility of pump failure or runoff volume in excess of pump capacity.

All projects that are constructing permanent facilities for runoff quantity control should use the rough-graded or final-graded permanent facilities for traps and ponds. This includes combined facilities and infiltration facilities. When permanent facilities are used as temporary sedimentation facilities, the surface area requirement of a sediment trap or pond must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the trap or pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds.

**Design and
Installation
Specifications**

Either a permanent control structure or the temporary control structure (described in [BMP C241](#), Temporary Sediment Pond) can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond. A shut-off valve may be added to the control structure to allow complete retention of stormwater in emergency situations. In this case, an emergency overflow weir must be added.

A skimmer may be used for the sediment trap outlet if approved by the Local Permitting Authority.

- See [Figures 4.2.16](#) and [4.2.17](#) for details.
- If permanent runoff control facilities are part of the project, they should be used for sediment retention.
- To determine the sediment trap geometry, first calculate the design surface area (SA) of the trap, measured at the invert of the weir. Use the following equation:

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

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. If no hydrologic analysis is required, the Rational Method may be used.

V_s = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm³ has been selected as the particle of interest and has a settling velocity (V_s) of 0.00096 ft/sec.

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

Therefore, the equation for computing surface area becomes:

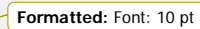
$$SA = 2 \times Q_2 / 0.00096 \text{ or}$$

2080 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.

- 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.

- ## Maintenance Standards



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BMP C241: Temporary Sediment Pond

Purpose	Sediment ponds remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to remove sediment no smaller than medium silt (0.02 mm). Consequently, they usually reduce turbidity only slightly.
Conditions of Use	<p>Prior to leaving a construction site, stormwater runoff must pass through a sediment pond or other appropriate sediment removal best management practice.</p> <p>A sediment pond shall be used where the contributing drainage area is 3 acres or more. Ponds must be used in conjunction with erosion control practices to reduce the amount of sediment flowing into the basin.</p>
Design and Installation Specifications	<ul style="list-style-type: none">• Sediment basins 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. Compliance with local ordinances regarding health and safety must be addressed. If fencing of the pond is required, the type of fence and its location shall be shown on the ESC plan.• Structures having a maximum storage capacity at the top of the dam of 10 acre-ft (435,600 ft³) or more are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC (Chapter 173-175 WAC)).• See Figures 4.2.18, 4.2.19, Figure 4.24, Figure 4.25, and 4.2.20 Figure 4.26 for details.• If permanent runoff control facilities are part of the project, they should be used for sediment retention. The surface area requirements of the sediment basin must be met. This may require <u>temporarily enlarging the permanent basin to comply with the surface area requirements. If aThe permanent control structure is used, it may must be advisabletemporarily replaced with a control structure that only allows water to partially restrict leave the lower orifice with gravel to increase residence time while still allowing dewatering of pond from the basin surface or by pumping. The permanent control structure must be installed after the site is fully stabilized.</u>• Use of infiltration facilities for sedimentation basins during construction tends to clog the soils and reduce their capacity to infiltrate. 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.

- 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. If no hydrologic analysis is required, the Rational Method may be used.

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

$$SA = 2 \times Q_2 / 0.00096 \quad \text{or} \\ 2080 \text{ square feet per cfs of inflow}$$

See [BMP C240](#) ~~BMP C240~~ for more information on the derivation of the surface area calculation.

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 ~~3:1~~[3H:1V](#) interior side slopes and maximum ~~2:1~~[2H:1V](#) exterior slopes. The interior slopes can be increased to a maximum of ~~2:1~~[2H:1V](#) 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 Minimum Requirement #7: Flow Control. 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 4.2.21](#) [Figure 4.28](#) for riser inflow curves.

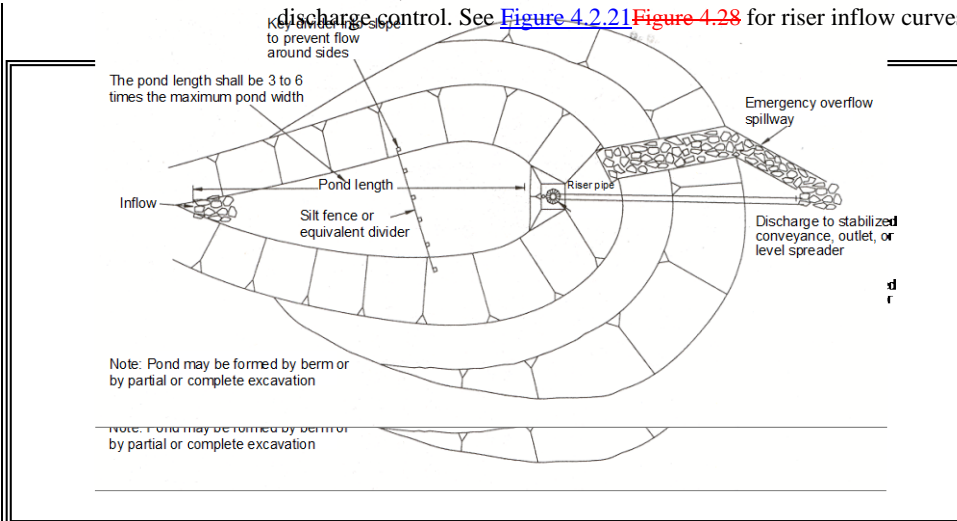


Figure 4.26 – Sediment Pond Riser Detail

Figure 4.24.18 – Sediment Pond Plan View

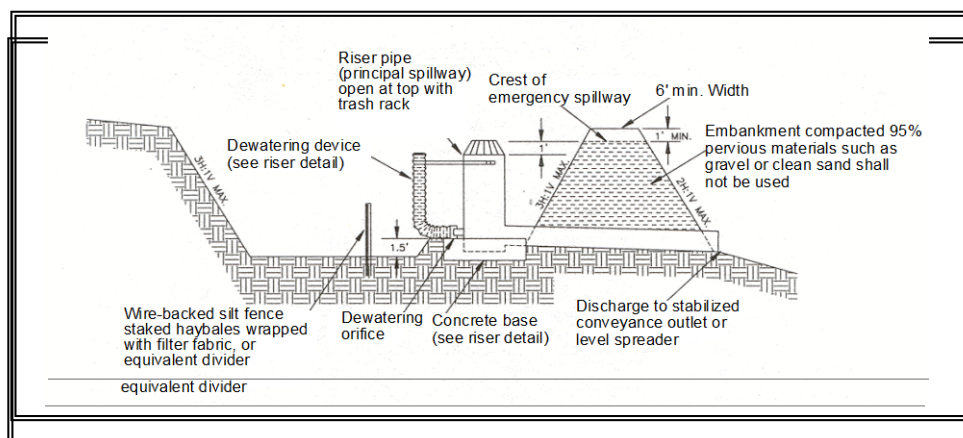
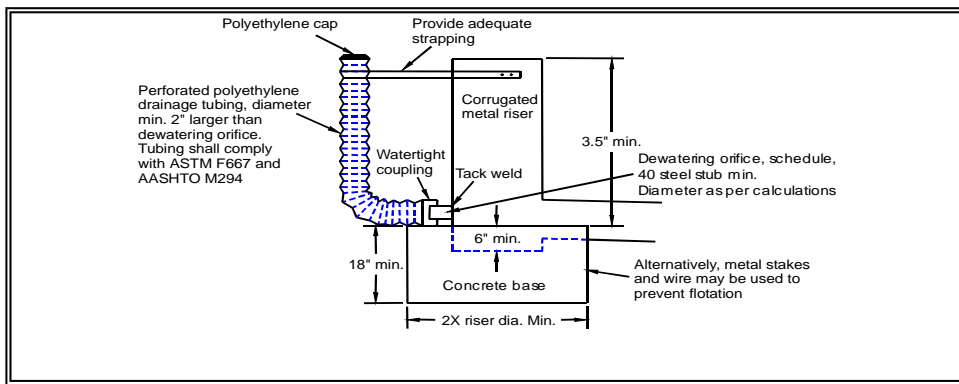


Figure 4.252.19 – Sediment Pond Cross Section



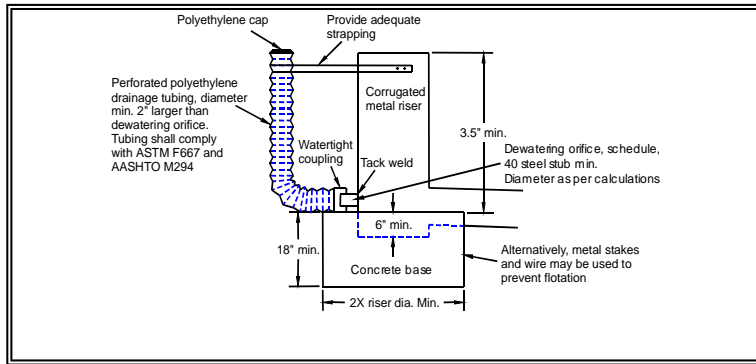


Figure 4.2.20 – Sediment Pond Riser Detail

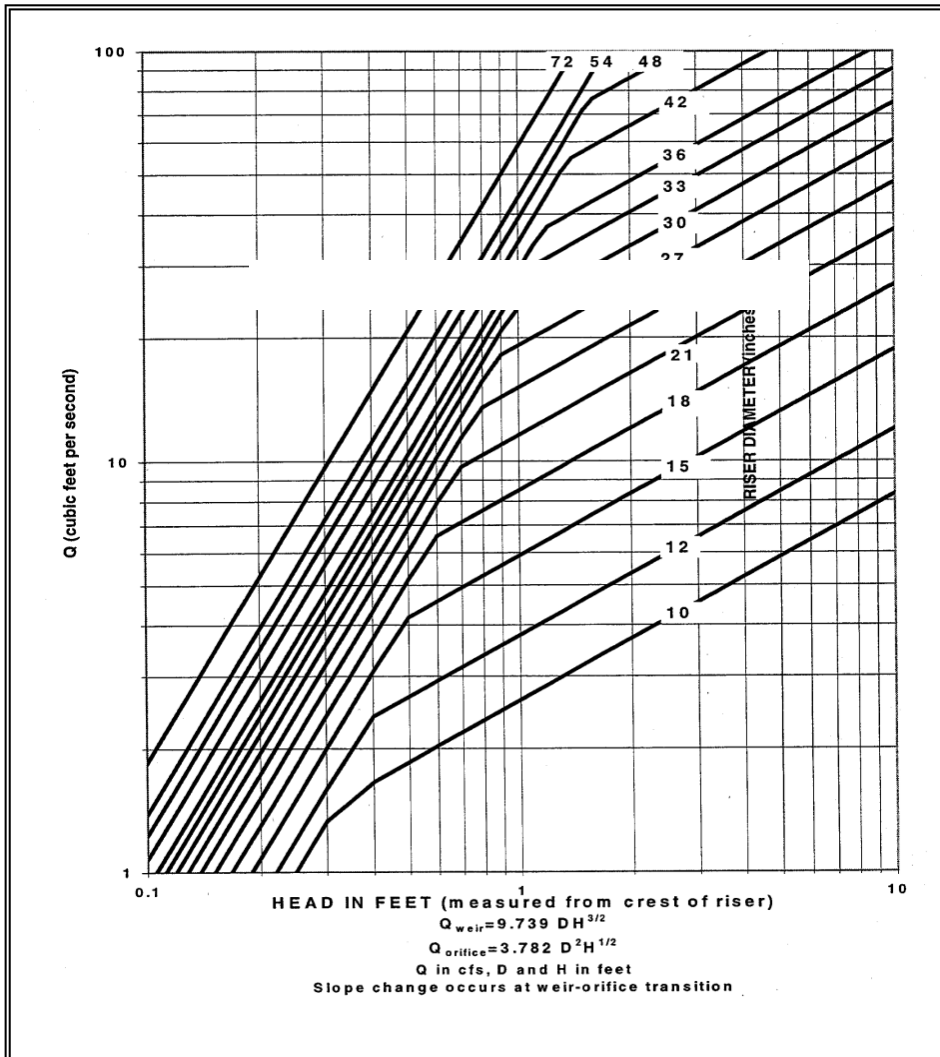
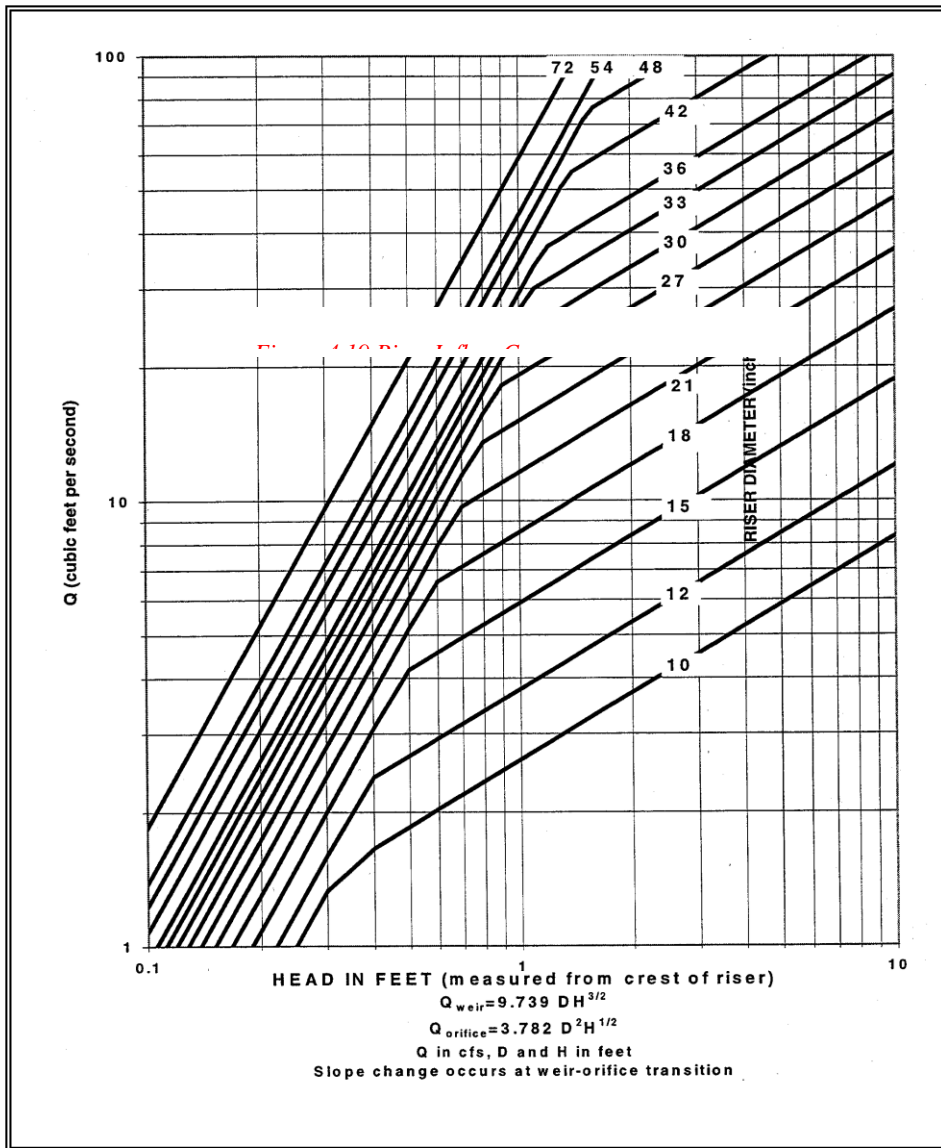


Figure 4.26— Sediment Pond Riser Detail

Figure 4.272.21 – 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 site's 15-minute, 10-year peak flow rate. If using the Western Washington Hydrology Model (WWHM), Version 2 or 3, design flow (Q_{10}) is the 10-year (1 hour) flow for the developed (unmitigated) site, multiplied by a factor of 1.6. Use Figure 4.282.21 to determine this 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 using the method contained in Volume III.

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:

$$A_o = \frac{A_s (2h)^{0.5}}{0.6 \times 3600 T g^{0.5}}$$

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/second²)

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

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

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 one foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric supported by treated 4"x4"s 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, one-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 criteria contained in Volume III regarding dam safety for detention BMPs.

- 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:

1. Tight connections between riser and barrel and other pipe connections.
2. Adequate anchoring of riser.
3. Proper soil compaction of the embankment and riser footing.
4. Proper construction of anti-seep devices.

Maintenance Standards

- 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.

BMP C250: Construction Stormwater Chemical Treatment

~~Purpose~~ **Purpose** This BMP applies when using stormwater chemicals in batch treatment or flow-through treatment.

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~~ Traditional erosion and sediment no smaller than medium silt (0.02 mm). Chemical ~~treatment~~ control BMPs may not be used to reduce ~~adequate to ensure compliance with the water quality standards for turbidity of stormwater runoff in receiving water.~~

Conditions of Use—Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. ~~Very high turbidities can~~

be reduced to levels comparable to what is found in streams during dry weather. 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. Chemical treatment may be required to protect streams from the impact of turbid stormwater discharges. Chemical treatment may be required to meet turbidity stormwater discharge requirements, especially when construction is to proceed through the wet season.

Conditions of Use

Formal written approval from Ecology ~~and the Local Permitting Authority~~ is required for the use of chemical treatment regardless of site size. ~~The intention to use Chemical Treatment shall be indicated on the Notice of Intent for coverage under the General Construction Permit. The Local Permitting Authority may also require review and approval. When approved, the~~ chemical treatment systems ~~should be designed as part of the Construction SWPPP, not after the fact. Chemical treatment may be used to correct problem sites in limited circumstances with formal written approval from Ecology and the Local Permitting Authority.~~

~~The SEPA review authority must be notified at the application phase of the project review (or the time that the SEPA determination on the project is performed) that chemical treatment is proposed. If it is added after this stage, an addendum will be necessary and may result in project approval delay, included in the Construction Stormwater Pollution Prevention Plan (SWPPP).~~

Design and Installation Specifications

See [Appendix II-B](#) for background information on chemical treatment.

Criteria for Chemical Treatment Product Use: Chemically treated stormwater discharged from construction sites must be nontoxic to aquatic organisms. The Chemical Technology Assessment Protocol (CTAPE) must be used to evaluate chemicals proposed for stormwater treatment. Only chemicals approved by Ecology under the CTAPE may be used for stormwater treatment. The approved chemicals, their allowable application techniques (batch treatment or flow-through treatment), allowable application rates, and conditions of use can be found at the Department of Ecology Emerging Technologies website: <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html>.

- ~~— Treatment chemicals must be approved by EPA for potable water use.~~
- ~~— Petroleum-based polymers are prohibited.~~
- ~~— Prior to authorization for field use, jar tests shall be conducted to demonstrate that turbidity reduction necessary to meet the receiving water criteria can be achieved. Test conditions, including but not limited to raw water quality and jar test procedures, should be~~

~~indicative of field conditions. Although these small scale tests cannot be expected to reproduce performance under field conditions, they are indicative of treatment capability.~~

- ~~• Prior to authorization for field use, the chemically treated stormwater shall be tested for aquatic toxicity. Applicable procedures defined in Chapter 173-205 WAC, Whole Effluent Toxicity Testing and Limits, shall be used. Testing shall use stormwater from the construction site at which the treatment chemical is proposed for use or a water solution using soil from the proposed site.~~
- ~~• The proposed maximum dosage shall be at least a factor of five lower than the no observed effects concentration (NOEC).~~
- ~~• The approval of a proposed treatment chemical shall be conditional, subject to full scale bioassay monitoring of treated stormwater at the construction site where the proposed treatment chemical is to be used.~~
- ~~• Treatment chemicals that have already passed the above testing protocol do not need to be reevaluated. Contact the Department of Ecology Regional Office for a list of treatment chemicals that have been evaluated and are currently approved for use.~~

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.~~
- Only Ecology approved chemicals may be used and must follow approved dose rate.
- The pH of the stormwater must be in the proper range for the polymers to be effective, which is typically 6.5 to 8.5
- The coagulant must be mixed rapidly into the water to ~~insure~~ensure 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 that are 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~~Discharge from a batch treatment system should be directed through a physical filter such as a vegetated swale that would catch any unintended floc discharge. Currently, flow-through systems always discharge through the chemically enhanced sand filtration system.

~~**Treatment System Design:** Chemical treatment systems shall be designed as batch treatment systems using either ponds or portable trailer-mounted tanks. Flow-through continuous treatment systems are not allowed at this time.~~

- A system discharge rates must take into account downstream conveyance integrity.

Polymer Batch Treatment Process Description:

A batch 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 batch treatment system shall use a minimum of two lined treatment cells— in addition to an untreated stormwater storage pond. 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 six feet high or which impound more than 10 acre-feet require special engineering analyses. ~~Portable tanks may also be suitable~~ The Ecology Dam Safety Section has specific design criteria for dams in Washington State (see <http://www.ecy.wa.gov/programs/wr/dams/GuidanceDocs.html> some sites).

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater 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 untreated stormwater storage pond. The pH is adjusted by the application of carbon dioxide or a base until the stormwater in the storage pond is within the desired pH range, 6.5 to 8.5. When used, carbon dioxide 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 untreated stormwater 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 (dependant on polymer being used), the stormwater is pumped from the untreated stormwater 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, flocculent chemical concentration, 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.

Polymer Batch Treatment Process Description:

At a minimum, a flow-through chemical treatment system consists of the stormwater collection system (either temporary diversion or the permanent site drainage system), an untreated stormwater storage pond, and the chemically enhanced sand filtration system.

Stormwater is collected at interception point(s) on the site and is diverted by gravity or by pumping to an untreated stormwater storage pond or other untreated stormwater holding area. The stormwater is stored until treatment occurs. It is important that the holding pond be large enough to provide adequate storage.

Stormwater is then pumped from the untreated stormwater storage pond to the chemically enhanced sand filtration system where polymer is added. Adjustments to pH may be necessary before chemical addition. The sand filtration system continually monitors the stormwater for turbidity and pH. If the discharge water is ever out of an acceptable range for turbidity or pH, the water is recycled to the untreated stormwater pond where it can be retreated.

For batch treatment and flow-through treatment, the following equipment should be located in ~~an operations~~ a lockable shed:

- The chemical injector~~;~~
- Secondary containment for acid, caustic, buffering compound, and treatment chemical~~;~~
- Emergency shower and eyewash~~, and~~.

- Monitoring equipment which consists of a pH meter and a turbidimeter.

System Sizing:

Certain sites are required to implement flow control for the developed sites. These sites must also control stormwater release rates during construction. Generally, these are sites that discharge stormwater directly, or indirectly, through a conveyance system, into a fresh water. System sizing is dependent on flow control requirements.

Sizing Criteria— for Batch Treatment Systems for Flow Control Exempt Water Bodies:

~~The combination total volume of the untreated stormwater storage pond or other holding area and treatment capacity should ponds or tanks must be large enough to treat stormwater that is produced during multiple day storm events. It is recommended that at a minimum the untreated stormwater 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, Chapter 2. If no hydrologic analysis is required for the site, the Rational Method may be Worst-case land cover conditions (i.e., producing the most runoff) should be used— for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).~~

Primary settling should be encouraged in the untreated stormwater 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 two 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:~~

- ~~If the discharge is directly or indirectly to a stream, 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.~~
- ~~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.~~

- ~~Discharge to a stream should not increase the stream flow rate by more than 10 percent.~~

~~If the discharge is directly to a lake, a major flow control exempt receiving water listed in Appendix C1-E of Volume I, or to an infiltration system, there is no discharge flow limit.~~

~~Ponds sized for flow control water bodies must at a minimum meet the sizing criteria for flow control exempt waters.~~

Sizing Criteria for Flow-Through Treatment Systems for Flow Control Exempt Water Bodies:

~~When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies, the treatment system capacity should be a factor. The untreated stormwater storage pond or tank should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the treatment system flowrate should be sized using a hydraulic loading rate between 6-8 gpm/ft². Other hydraulic loading rates may be more appropriate for other systems. Bypass should be provided around the chemical treatment system to accommodate extreme storms. Runoff volume shall be calculated using the methods presented in Volume 3, Chapter 2. Worst-case land cover conditions (i.e., producing the most runoff) should be used for analyses (in most cases, this would be the land cover conditions just prior to final landscaping).~~

Sizing Criteria for Flow Control Water Bodies:

~~Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from ½ of the 2-year flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond and treatment cells.~~

~~The following is how WWHM can be used to determine the release rates from the chemical treatment systems:~~

- ~~1. Determine the pre-developed flow durations to be matched by entering the existing land use area under the "Pre-developed" scenario in WWHM. The default flow range is from ½ of the 2-year flow through the 10-year flow.~~
- ~~2. Enter the post developed land use area in the "Developed Unmitigated" scenario in WWHM.~~
- ~~3. Copy the land use information from the "Developed Unmitigated" to "Developed Mitigated" scenario.~~

4. While in the “Developed Mitigated” scenario, add a pond element under the basin element containing the post-developed land use areas. This pond element represents information on the available untreated stormwater storage and discharge from the chemical treatment system. In cases where the discharge from the chemical treatment system is controlled by a pump, a stage/storage/discharge (SSD) table representing the pond must be generated outside WWHM and imported into WWHM. WWHM can route the runoff from the post-developed condition through this SSD table (the pond) and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial SSD table proved to be inadequate, the designer would have to modify the SSD table outside WWHM and re-import in WWHM and route the runoff through it again. The iteration will continue until a pond that complies with the flow duration standard is correctly sized.

Notes on SSD table characteristics:

- The pump discharge rate would likely be initially set at just below ½ of the 2-year flow from the pre-developed condition. As runoff coming into the untreated stormwater storage pond increases and the available untreated stormwater storage volume gets used up, it would be necessary to increase the pump discharge rate above ½ of the 2-year. The increase(s) above ½ of the 2-year must be such that they provide some relief to the untreated stormwater storage needs but at the same time will not cause violations of the flow duration standard at the higher flows. The final design SSD table will identify the appropriate pumping rates and the corresponding stage and storages.
 - When building such a flow control system, the design must ensure that any automatic adjustments to the pumping rates will be as a result of changes to the available storage in accordance with the final design SSD table.
5. It should be noted that the above procedures would be used to meet the flow control requirements. The chemical treatment system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of ½ of the 2-year or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

If the discharge is to a municipal storm drainage system, the allowable discharge rate may be limited by the capacity of the public system. It may be necessary to clean the municipal storm drainage system prior to the start of the discharge to prevent scouring solids from the drainage system.

If the municipal storm drainage system discharges to a water body not on the flow control exempt list, the project site is subject to flow control requirements. Obtain permission from the owner of the collection system before discharging to it.

If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirement. In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt water bodies described earlier except all discharge (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond. If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater storage pond and the post-treatment flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The post-treatment flow control pond's revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

Maintenance Standards

Monitoring: At a minimum, the following monitoring shall be conducted. Test results shall be recorded on a daily log kept on site. Additional testing may be required by the NPDES permit based on site conditions.

- ~~• Runoff rates shall be calculated using the methods presented in Volume 3, Chapter 2 for the predeveloped condition. If no hydrologic analysis is required for the site, the Rational Method may be used.~~
- ~~• pH, conductivity (as a surrogate for alkalinity), turbidity and temperature of the untreated stormwater~~

Operational Monitoring:

- Total volume treated and discharged.
- ~~• Discharge time and flow rate~~
- ~~• Flow must be continuously monitored and recorded at not greater than 15-minute intervals.~~
- Type and amount of chemical used for pH adjustment.
- Amount of polymer used for treatment.
- Settling time.

Compliance Monitoring:

- ~~• pH and turbidity of the treated stormwater~~

- Influent and effluent pH, flocculent chemical concentration, and turbidity must be continuously monitored and recorded at not greater than 15-minute intervals. pH and turbidity of the receiving water.

Biomonitoring:

Treated stormwater ~~shall~~must be non-toxic to aquatic organisms. Treated stormwater must be tested for aquatic toxicity or residual chemicals. Frequency of biomonitoring will be determined by Ecology.

Residual chemical tests must be approved by Ecology prior to their use.

If testing treated stormwater for aquatic toxicity, you must test for acute (lethal) toxicity. Bioassays shall be conducted by a laboratory accredited by Ecology, unless otherwise approved by Ecology. ~~The performance standard for acute toxicity is no statistically significant difference in survival between the control and 100 percent chemically treated stormwater.~~ Acute toxicity tests shall be conducted per the CTAPE protocol.

~~Acute toxicity tests shall be conducted with the following species and protocols:~~

- ~~— Fathead minnow, *Pimephales promelas* (96 hour static renewal test, method: EPA/600/4-90/027F). Rainbow trout, *Oncorhynchus mykiss* (96 hour static renewal test, method: EPA/600/4-90/027F) may be used as a substitute for fathead minnow.~~
- ~~— Daphnid, *Ceriodaphnia dubia*, *Daphnia pulex*, or *Daphnia magna* (48 hour static test, method: EPA/600/4-90/027F).~~

~~All toxicity tests shall meet quality assurance criteria and test conditions in the most recent versions of the EPA test method and Ecology Publication # WQ-R-95-80, Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria.~~

~~Bioassays shall be performed on the first five batches and on every tenth batch thereafter, or as otherwise approved by Ecology. Failure to meet the performance standard shall be immediately reported to Ecology.~~

Discharge Compliance: Prior to discharge, ~~each batch of~~ treated stormwater must be sampled and tested for compliance with pH, flocculent chemical concentration, and turbidity limits. These limits may be established by the ~~water quality standards~~ Construction Stormwater General Permit or a site-specific discharge permit. Sampling and testing for other pollutants may also be necessary at some sites. ~~Turbidity must be within 5 NTUs of the background turbidity. Background is measured in the receiving water, upstream from the treatment process discharge point.~~ pH must be within the range of 6.5 to 8.5 standard units and not cause a change in the pH of the receiving water of more than 0.2 standard

units. ~~It is often possible to discharge treated stormwater that has a lower turbidity than the receiving water and that matches the pH.~~

Treated stormwater samples and measurements shall be taken from the discharge pipe or another location representative of the nature of the treated stormwater discharge. Samples used for determining compliance with the water quality standards in the receiving water shall not be taken from the treatment pond prior to decanting. Compliance with the water quality standards is determined in the receiving water.

Operator Training: Each contractor who intends to use chemical treatment shall be trained by an experienced contractor ~~on an active site for at least 40 hours.~~ Each site using chemical treatment must have an operator trained and certified by an organization approved by Ecology.

Standard BMPs: Surface stabilization BMPs should be implemented on site to prevent significant erosion. All sites shall use a truck wheel wash to prevent tracking of sediment off site.

Sediment Removal and Disposal:

- 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.
- Sediment that is known to be non-toxic may be incorporated into the site away from drainages.

BMP C251: Construction Stormwater Filtration

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

Background Information:

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.

Conditions of Use 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 µm). 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.

~~as long as treatment chemicals are not used. Filtration may also be used in conjunction with polymer treatment in a portable system to assure capture of the flocculated solids.~~

~~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 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 testing under the Chemical Technology Assessment Protocol – Ecology (CTAPE) before it can be initiated. Approval from the appropriate regional Ecology office must be obtained at each site where polymers use is proposed prior to use. For more guidance on stormwater chemical treatment see BMP C250a much larger filter area.~~

Design and Installation Specifications

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 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. 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 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 ~~an untreated stormwater~~ sediment pond or tank for removal of large sediment and storage of the stormwater before it is treated by the filtration system. The ~~untreated~~ 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.

Maintenance

Rapid sand filters typically have automatic backwash systems that are

Standards

triggered by a pre-set pressure drop across the filter. If the backwash water volume is not large or substantially more turbid than the untreated stormwater stored in the holding pond or tank, backwash return to the untreated stormwater pond or tank may be appropriate. However, other means of treatment and disposal may be necessary.

~~If large volumes of concrete are being poured, pH adjustment 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.

Sizing Criteria for Flow-Through Treatment Systems for Flow Control Exempt Water Bodies:

When sizing storage ponds or tanks for flow-through systems for flow control exempt water bodies the treatment system capacity should be a factor. The untreated stormwater storage pond or tank should be sized to hold 1.5 times the runoff volume of the 10-year, 24-hour storm event minus the treatment system flowrate for an 8-hour period. For a chitosan-enhanced sand filtration system, the treatment system flowrate should be sized using a hydraulic loading rate between 6-8 gpm/ft². Other hydraulic loading rates may be more appropriate for other systems. Bypass should be provided around the chemical treatment system to accommodate extreme storms. Runoff volume shall be calculated using the methods presented in Volume 3, Chapter 2. Worst-case conditions (i.e., producing the most runoff) should be used for analyses (most likely conditions present prior to final landscaping).

Sizing Criteria for Flow Control Water Bodies:

Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges shall not exceed the discharge durations of the pre-developed condition for the range of pre-developed discharge rates from 1/2 of the 2-year flow through the 10-year flow as predicted by an approved continuous runoff model. The pre-developed condition to be matched shall be the land cover condition immediately prior to the development project. This restriction on release rates can affect the size of the storage pond, the filtration system, and the flow rate through the filter system.

The following is how WWHM can be used to determine the release rates from the filtration systems:

1. Determine the pre-developed flow durations to be matched by entering the land use area under the "Pre-developed" scenario in WWHM. The

default flow range is from ½ of the 2-year flow through the 10-year flow.

2. Enter the post developed land use area in the “Developed Unmitigated” scenario in WWHM.
3. Copy the land use information from the “Developed Unmitigated” to “Developed Mitigated” scenario.
4. There are two possible ways to model stormwater filtration systems:
 - a. The stormwater filtration system uses an untreated stormwater storage pond/tank and the discharge from this pond/tank is pumped to one or more filters. In-line filtration chemicals would be added to the flow right after the pond/tank and before the filter(s). Because the discharge is pumped, WWHM can’t generate a stage/storage /discharge (SSD) table for this system. This system is modeled the same way as described in [BMP C250](#) and is as follows:

While in the “Developed Mitigated” scenario, add a pond element under the basin element containing the post-developed land use areas. This pond element represents information on the available untreated stormwater storage and discharge from the filtration system. In cases where the discharge from the filtration system is controlled by a pump, a stage/storage/discharge (SSD) table representing the pond must be generated outside WWHM and imported into WWHM. WWHM can route the runoff from the post-developed condition through this SSD table (the pond) and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial SSD table proved to be out of compliance, the designer would have to modify the SSD table outside WWHM and re-import in WWHM and route the runoff through it again. The iteration will continue until a pond that enables compliance with the flow duration standard is designed.

Notes on SSD table characteristics:

- The pump discharge rate would likely be initially set at just below ½ if the 2-year flow from the pre-developed condition. As runoff coming into the untreated stormwater storage pond increases and the available untreated stormwater storage volume gets used up, it would be necessary to increase the pump discharge rate above ½ of the 2-year. The increase(s) above ½ of the 2-year must be such that they provide some relief to the untreated stormwater storage needs but at the same time they will not cause violations of the flow duration standard at the higher flows. The final design SSD table will

identify the appropriate pumping rates and the corresponding stage and storages.

- When building such a flow control system, the design must ensure that any automatic adjustments to the pumping rates will be as a result of changes to the available storage in accordance with the final design SSD table.

b. The stormwater filtration system uses a storage pond/tank and the discharge from this pond/tank gravity flows to the filter. This is usually a slow sand filter system and it is possible to model it in WWHM as a Filter element or as a combination of Pond and Filter element placed in series. The stage/storage/discharge table(s) may then be generated within WWHM as follows:

- (i) While in the “Developed Mitigated” scenario, add a Filter element under the basin element containing the post-developed land use areas. The length and width of this filter element would have to be the same as the bottom length and width of the upstream untreated stormwater storage pond/tank.
- (ii) In cases where the length and width of the filter is not the same as those for the bottom of the upstream untreated stormwater storage tank/pond, the treatment system may be modeled as a Pond element followed by a Filter element. By having these two elements, WWHM would then generate a SSD table for the storage pond which then gravity flows to the Filter element. The Filter element downstream of the untreated stormwater storage pond would have a storage component through the media, and an overflow component for when the filtration capacity is exceeded.

WWHM can route the runoff from the post-developed condition through the treatment systems in 4b and determine compliance with the flow duration standard. This would be an iterative design procedure where if the initial sizing estimates for the treatment system proved to be inadequate, the designer would have to modify the system and route the runoff through it again. The iteration would continue until compliance with the flow duration standard is achieved.

5. It should be noted that the above procedures would be used to meet the flow control requirements. The filtration system must be able to meet the runoff treatment requirements. It is likely that the discharge flow rate of ½ of the 2-year or more may exceed the treatment capacity of the system. If that is the case, the untreated stormwater discharge rate(s) (i.e., influent to the treatment system) must be reduced to allow proper treatment. Any reduction in the flows would likely result in the need for a larger untreated stormwater storage volume.

If system design does not allow you to discharge at the slower rates as described above and if the site has a retention or detention pond that will

serve the planned development, the discharge from the treatment system may be directed to the permanent retention/detention pond to comply with the flow control requirements. In this case, the untreated stormwater storage pond and treatment system will be sized according to the sizing criteria for flow-through treatment systems for flow control exempt waterbodies described earlier except all discharges (water passing through the treatment system and stormwater bypassing the treatment system) will be directed into the permanent retention/detention pond. If site constraints make locating the untreated stormwater storage pond difficult, the permanent retention/detention pond may be divided to serve as the untreated stormwater discharge pond and the post-treatment flow control pond. A berm or barrier must be used in this case so the untreated water does not mix with the treated water. Both untreated stormwater storage requirements, and adequate post-treatment flow control must be achieved. The post-treatment flow control pond's revised dimensions must be entered into the WWHM and the WWHM must be run to confirm compliance with the flow control requirement.

BMP C252: High pH Neutralization Using CO₂

Purpose

When pH levels in stormwater rise above 8.5 it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5, this process is called pH neutralization. pH neutralization involves the use of solid or compressed carbon dioxide gas in water requiring neutralization. Neutralized stormwater may be discharged to surface waters under the General Construction NPDES permit.

Neutralized process water such as concrete truck wash-out, hydro-demolition, or saw-cutting slurry must be managed to prevent discharge to surface waters. Any stormwater contaminated during concrete work is considered process wastewater and must not be discharged to surface waters.

Reason for pH Neutralization:

A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral pH is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

Calcium hardness can contribute to high pH values and cause toxicity that is associated with high pH conditions. A high level of calcium hardness in waters of the state is not allowed.

The water quality standard for pH in Washington State is in the range of 6.5 to 8.5. Ground water standard for calcium and other dissolved solids in Washington State is less than 500 mg/l.

Conditions of Use

Causes of High pH:

High pH at construction sites is most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime containing construction materials. (See [BMP C151: Concrete Handling](#) for more information on concrete handling procedures). The principal caustic agent in cement is calcium hydroxide (free lime).

Advantages of CO₂ Sparging:

- Rapidly neutralizes high pH water.
- Cost effective and safer to handle than acid compounds.
- CO₂ is self-buffering. It is difficult to overdose and create harmfully low pH levels.
- Material is readily available.

**Design and
Installation
Specifications**

The Chemical Process:

When carbon dioxide (CO₂) is added to water (H₂O), carbonic acid (H₂CO₃) is formed which can further dissociate into a proton (H⁺) and a bicarbonate anion (HCO₃⁻) as shown below:



The free proton is a weak acid that can lower the pH. Water temperature has an effect on the reaction as well. The colder the water temperature is the slower the reaction occurs and the warmer the water temperature is the quicker the reaction occurs. Most construction applications in Washington State have water temperatures in the 50°F or higher range so the reaction is almost simultaneous.

Treatment Process:

High pH water may be treated using continuous treatment, continuous discharge systems. These manufactured systems continuously monitor influent and effluent pH to ensure that pH values are within an acceptable range before being discharged. All systems must have fail safe automatic shut off switches in the event that pH is not within the acceptable discharge range. Only trained operators may operate manufactured systems. System manufacturers often provide trained operators or training on their devices.

The following procedure may be used when not using a continuous discharge system:

1. Prior to treatment, the appropriate jurisdiction should be notified in accordance with the regulations set by the jurisdiction.
2. Every effort should be made to isolate the potential high pH water in order to treat it separately from other stormwater on-site.
3. Water should be stored in an acceptable storage facility, detention pond, or containment cell prior to treatment.
4. Transfer water to be treated to the treatment structure. Ensure that treatment structure size is sufficient to hold the amount of water that is to be treated. Do not fill tank completely, allow at least 2 feet of freeboard.
5. The operator samples the water for pH and notes the clarity of the water. As a rule of thumb, less CO₂ is necessary for clearer water. This information should be recorded.
6. In the pH adjustment structure, add CO₂ until the pH falls in the range of 6.9-7.1. Remember that pH water quality standards apply so adjusting pH to within 0.2 pH units of receiving water (background pH) is recommended. It is unlikely that pH can be adjusted to within 0.2 pH units using dry ice. Compressed carbon dioxide gas should be introduced to the water using a carbon dioxide diffuser located near

**Maintenance
Standards**

the bottom of the tank, this will allow carbon dioxide to bubble up through the water and diffuse more evenly.

7. Slowly discharge the water making sure water does not get stirred up in the process. Release about 80% of the water from the structure leaving any sludge behind.

8. Discharge treated water through a pond or drainage system.

9. Excess sludge needs to be disposed of properly as concrete waste. If several batches of water are undergoing pH treatment, sludge can be left in treatment structure for the next batch treatment. Dispose of sludge when it fills 50% of tank volume.

Sites that must implement flow control for the developed site must also control stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

Safety and Materials Handling:

- All equipment should be handled in accordance with OSHA rules and regulations.
- Follow manufacturer guidelines for materials handling.

Operator Records:

Each operator should provide:

- A diagram of the monitoring and treatment equipment.
- A description of the pumping rates and capacity the treatment equipment is capable of treating.

Each operator should keep a written record of the following:

- Client name and phone number.
- Date of treatment.
- Weather conditions.
- Project name and location.
- Volume of water treated.
- pH of untreated water.
- Amount of CO₂ needed to adjust water to a pH range of 6.9-7.1.
- pH of treated water.
- Discharge point location and description.

A copy of this record should be given to the client/contractor who should retain the record for three years.

BMP C253: pH Control for High pH Water

Purpose When pH levels in stormwater rise above 8.5 it is necessary to lower the pH levels to the acceptable range of 6.5 to 8.5, this process is called pH neutralization. Stormwater with pH levels exceeding water quality standards may be treated by infiltration, dispersion in vegetation or compost, pumping to a sanitary sewer, disposal at a permitted concrete batch plant with pH neutralization capabilities, or carbon dioxide sparging. [BMP C252](#) gives guidelines for carbon dioxide sparging.

Reason for pH Neutralization:

A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this pH range is required for the survival of aquatic organisms. Should the pH rise or drop out of this range, fish and other aquatic organisms may become stressed and may die.

Conditions of Use Causes of High pH:

High pH levels at construction sites are most commonly caused by the contact of stormwater with poured or recycled concrete, cement, mortars, and other Portland cement or lime containing construction materials. (See [BMP C151: Concrete Handling](#) for more information on concrete handling procedures). The principal caustic agent in cement is calcium hydroxide (free lime).

Design and Installation Specifications

Disposal Methods:

Infiltration

- Infiltration is only allowed if soil type allows all water to infiltrate (no surface runoff) without causing or contributing to a violation of surface or ground water quality standards.
- Infiltration techniques should be consistent with Volume V, Chapter 7

Dispersion

Use BMP T5.30 Full Dispersion

Sanitary Sewer Disposal

- Local sewer authority approval is required prior to disposal via the sanitary sewer.

Concrete Batch Plant Disposal

- Only permitted facilities may accept high pH water.
- Facility should be contacted before treatment to ensure they can accept the high pH water.

Stormwater Discharge

Any pH treatment options that generate treated water that must be discharged off site are subject to flow control requirements. Sites that must implement flow control for the developed site must also control

stormwater release rates during construction. All treated stormwater must go through a flow control facility before being released to surface waters which require flow control.

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Resource Materials

Association of General Contractors of Washington, Water Quality Manual.

Clark County Conservation District, Erosion and Runoff Control, January 1981.

King County Conservation District, Construction and Erosion Control, December 1981.

King County Department of Transportation Road Maintenance BMP Manual (Final Draft), May 1998.

King County Surface Water Design Manual, September 1998.

Maryland Erosion and Sedimentation Control Manual, 1983.

Michigan State Guidebook for Erosion and Sediment Control, 1975.

Snohomish County Addendum to the 1992 Ecology Stormwater Management Manual for the Puget Sound Basin, September 1998.

University of Washington, by Loren Reinelt, Construction Site Erosion and Sediment Control Inspector Training Manual, Center for Urban Water Resources Management, October 1991.

University of Washington, by Loren Reinelt, Processes, Procedures, and Methods to Control Pollution Resulting from all Construction Activity, Center for Urban Water Resources Management, October 1991.

Virginia Erosion and Sediment Control Handbook, 2nd Edition, 1980.

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Appendix II-A Recommended Standard Notes for Erosion Control Plans

The following standard notes are suggested for use in erosion control plans. Local jurisdictions may have other mandatory notes for construction plans that are applicable. Plans should also identify with phone numbers the person or firm responsible for the preparation of and maintenance of the erosion control plan.

Standard Notes

Approval of this erosion/sedimentation control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g. size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).

The implementation of these ESC plans and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the applicant/contractor until all construction is completed and approved and vegetation/landscaping is established.

The boundaries of the clearing limits shown on this plan shall be clearly flagged in the field prior to construction. During the construction period, no disturbance beyond the flagged clearing limits shall be permitted. The flagging shall be maintained by the applicant/contractor for the duration of construction.

The ESC facilities shown on this plan must be constructed in conjunction with all clearing and grading activities, and in such a manner as to insure that sediment and sediment laden water do not enter the drainage system, roadways, or violate applicable water standards.

The ESC facilities shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and to ensure that sediment and sediment-laden water do not leave the site.

The ESC facilities shall be inspected daily by the applicant/contractor and maintained as necessary to ensure their continued functioning.

The ESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within the 48 hours following a major storm event.

At no time shall more than one foot of sediment be allowed to accumulate within a trapped catch basin. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment laden water into the downstream system.

Stabilized construction entrances shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures may be required to insure that all paved areas are kept clean for the duration of the project.

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Appendix II-B Background Information on Chemical Treatment

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: 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: 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: The final step is the 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: 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.

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 (underdosing) 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.

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.

~~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.~~

Adjustment of the 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.~~

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Volume III Hydrologic Analysis and Flow Control BMPs

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Chapter 1 - Introduction

1.1 Purpose of this Volume

Best Management Practices (BMPs) are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. As described in Volume I of this stormwater manual, BMPs for long-term management of stormwater at developed sites can be divided into three main categories:

- BMPs addressing the volume and timing of stormwater flows;
- BMPs addressing prevention of pollution from potential sources; and
- BMPs addressing treatment of runoff to remove sediment and other pollutants.

This volume of the stormwater manual focuses mainly on the first category. It presents techniques of hydrologic analysis, and BMPs related to management of the amount and timing of stormwater flows from developed sites. The purpose of this volume is to provide guidance on the estimation and control of stormwater runoff quantity.

BMPs for preventing pollution of stormwater runoff and for treating contaminated runoff are presented in Volumes IV and V, respectively.

1.2 Content and Organization of this Volume

Volume III of the stormwater manual contains three chapters. [Chapter 1](#) serves as an introduction. [Chapter 2](#) reviews methods of hydrologic analysis, covers the use of hydrograph methods for designing BMPs, and provides an overview of various computerized modeling methods and analysis of closed depressions. [Chapter 3](#) describes flow control BMPs and provides design specifications for roof downspouts and detention facilities. It also provides design considerations of infiltration facilities for flow control.

This volume includes three appendices. [Appendix A](#) has isopluvial maps for western Washington. [Appendix B](#) has information and assumptions on the Western Washington Hydrology Model (WWHM). [Appendix C](#) includes detailed information concerning how to represent various Low Impact Development (LID) techniques in continuous runoff models so that the models predict lower surface runoff rates and volumes.

Design considerations for conveyance systems are not included in the stormwater manual, as this topic is adequately covered in standard engineering references.

1.3 How to Use this Volume

Volume I should be consulted to determine Minimum Requirements for flow management (e.g. Minimum Requirements #4, #5 and #7 in Chapter 2 of Volume I). After the Minimum Requirements have been determined, this volume should be consulted to design flow management facilities. These facilities can then be included in Stormwater Site Plans (see Volume I, Chapter 3).

Chapter 2 - Hydrologic Analysis

The broad definition of hydrology is “the science which studies the source, properties, distribution, and laws of water as it moves through its closed cycle on the earth (the hydrologic cycle).” As applied in this manual, however, the term “hydrologic analysis” addresses and quantifies only a small portion of this cycle. That portion is the relatively short-term movement of water over the land resulting directly from precipitation and called surface water or stormwater runoff. Localized and long-term ground water movement must also be of concern, but generally only as this relates to the movement of water on or near the surface, such as stream base flow or infiltration systems.

The purpose of this chapter is to define the minimum computational standards required, to outline how these may be applied, and to reference where more complete details may be found, should they be needed. This chapter also provides details on the hydrologic design process; that is, what are the steps required in conducting a hydrologic analysis, including flow routing.

2.1 Minimum Computational Standards

The minimum computational standards depend on the type of information required and the size of the drainage area to be analyzed, as follows:

1. ~~4.~~ For the purpose of designing most types of runoff treatment BMPs, a calibrated continuous simulation hydrologic model based on the EPA’s HSPF (Hydrologic Simulation Program-Fortran) program, or an approved equivalent model, must be used to calculate runoff and determine the water quality design flow rates and volumes.

For the purpose of designing wetpool treatment facilities, there are two acceptable methods: an approved continuous runoff model to estimate the 91st percentile, 24-hour runoff volume, or the NRCS (Natural Resources Conservation Service) curve number method to determine a water quality design storm volume. The water quality design storm volume is the amount of runoff predicted from the 6-month, 24-hour storm.

For the purpose of designing flow control BMPs, a calibrated continuous simulation hydrologic model, based on the EPA’s HSPF, must be used.

The circumstances under which different methodologies apply are summarized below ~~in Table 2.1.1.~~

<p>Table 2.1.1 Summary of the application design methodologies</p>		
Method	BMP designs in western Washington	
	Treatment	Flow Control
SCSUH/SBUH (Soil Conservation Service Unit Hydrograph/Santa Barbara Unit Hydrograph)	Method applies for BMPs that are sized based on the volume of runoff from a 6-month, 24-hour storm. Currently, that includes only wetpool-facilities. Note: These BMPs don't require generating a hydrograph.	Not Applicable
Continuous Runoff Models: (WWHM or approved alternatives. See below)	Method applies to all BMPs.	Method applies throughout Western Washington

2. ~~2.~~ If a basin plan is being prepared, then a hydrologic analysis should be performed using a continuous simulation model such as the EPA's HSPF model, the EPA's Stormwater Management Model (SWMM), or an equivalent model as approved by the local government.

Significant progress has been made in the development and availability of HSPF-based continuous runoff models for Western Washington. The Department of Ecology has coordinated the development of the Western Washington Hydrology Model (WWHM). It uses rainfall/runoff relationships developed for specific basins in the Puget Sound region to all parts of western Washington. Where field monitoring establishes basin-specific rainfall/runoff parameter calibrations, those can be entered into the model, superseding the default input parameters.

Two other HSPF-based continuous runoff models have been approved by the Department of Ecology: MGS Flood and KCRTS (King County Runoff Time Series). Though MGS Flood uses different, extended precipitation files, its features and more importantly, its runoff estimations are very similar to those predicted by WWHM. KCRTS is a pre-packaged set of runoff files developed by King County. It can be used throughout King County. Use of other continuous simulation models should receive prior ~~concurrent~~ approval from ~~the Dept. of~~ Ecology.

Where large master-planned developments are proposed, local governments should consider requiring a basin-specific calibration of HSPF rather than use of the default parameters in the above-referenced

models. ~~The Department of~~ Ecology suggests such basin-specific calibrations should be considered for projects that will occupy more than 320 acres.

2.1.1 Discussion of Hydrologic Analysis Methods Used for Designing BMPs

This section provides a discussion of the methodologies to be used for calculating stormwater runoff from a project site. It includes a discussion of estimating stormwater runoff with single event models, such as the [Santa Barbara Unit Hydrograph \(SBUH-\)](#), versus continuous simulation models.

Single Event and Continuous Simulation Model

A continuous simulation model has considerable advantages over the single event-based methods such as the SCSUH, SBUH, or the Rational Method. HSPF is a continuous simulation model that is capable of simulating a wider range of hydrologic responses than the single event models such as the SBUH method. Single event models cannot take into account storm events that may occur just before or just after the single event (the design storm) that is under consideration. In addition, the runoff files generated by the HSPF models are the result of a considerable effort to introduce local parameters and actual rainfall data into the model and therefore produce better estimations of runoff than the SCSUH, SBUH, or Rational methods.

Ecology has developed a continuous simulation hydrologic model (WWHM) based on the HSPF for use in western Washington (see [Section 2.2](#)). Continuous rainfall records/data files have been obtained and appropriate adjustment factors were developed as input to HSPF. Input algorithms (referred to as IMPLND and PERLND) have been developed for a number of watershed basins in King, Pierce, Snohomish, and Thurston counties. These rainfall files and model algorithms are used in the HSPF in western Washington. Local counties and cities are encouraged to develop basin-specific calibrations of HSPF that can be input into the WWHM. However, until such a calibration is developed for a specific basin, the input data mentioned above must be used throughout western Washington.

Concerns with SBUH

A summary of the concerns with SBUH and other single event models is in order.

While SBUH may give acceptable estimates of total runoff volumes, it tends to overestimate peak flow rates from pervious areas because it cannot adequately model subsurface flow (which is a dominant flow regime for pre-development conditions in western Washington basins). One reason SBUH overestimates the peak flow rate for pervious areas is that the actual time of concentration is typically greater than what is

assumed. Better flow estimates could be made if a longer time of concentration was used. This would change both the peak flow rate (i.e., it would be lower) and the shape of the hydrograph (i.e., peak occurs somewhat later) such that the hydrograph would better reflect actual ~~predeveloped~~pre-developed conditions.

Another reason for overestimation of the runoff is the curve numbers (CN) in the 1992 Manual. These curve numbers were developed by US-Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS) and published as the Western Washington Supplemental Curve Numbers. These CN values are typically higher than the standard CN values published in Technical Release 55, June 1986. In 1995, the NRCS recalled the use of the western Washington CNs for floodplain management and found that the standard CNs better describe the hydrologic conditions for rainfall events in western Washington. However, based on runoff comparisons with the KCRTS better estimates of runoff are obtained when using the western Washington CNs for the developed areas such as parks, lawns, and other landscaped areas. Accordingly, the CNs in this manual (see ~~Table 2.3.2~~Table 2.3) are changed to those in the Technical Release 55 except for the open spaces category for the developed areas which include, lawn, parks, golf courses, cemeteries, and landscaped areas. For these areas, the western Washington CNs are used. These changes are intended to provide better runoff estimates using the SBUH method.

Another major weakness of SBUH is that it is used to model a 24-hour storm event, which is too short to model longer-term storms in western Washington. The use of a longer-term (e.g. 3- or 7-day storm) is perhaps better suited for western Washington.

Related to the last concern is the fact that single event approaches, such as SBUH, assume that flow control ponds are empty at the start of the design event. Continuous runoff models are able to simulate a continuous long-term record of runoff and soil moisture conditions. They simulate situations where ponds are not empty when another rain event begins.

Finally, single event models do not allow for estimation and analyses of flow durations nor water level fluctuations. Flow durations are necessary for discharges to streams. Estimates of water level fluctuations are necessary for discharges to wetlands and for tracking influent water elevations and bypass quantities to properly size treatment facilities.

2.2 Western Washington Hydrology Model

This section summarizes the assumptions made in creating the western Washington Hydrology Model (WWHM) and discusses limitations of the model. Appendix III-B contains more information on the assumptions and on WWHM. However, since the first version of WWHM was developed and released to public in 2001, the WWHM program has gone through

several upgrades incorporating new features and capabilities. Ecology anticipates that the next upgrade to WWHM will add low impact development (LID) modeling capability. WWHM users should periodically check Ecology's WWHM web site for the latest releases of WWHM, user manual, and any supplemental instructions. The web address for WWHM is: www.ecy.wa.gov/programs/wq/stormwater/whmtraining/index.html~~For more information on the WWHM and the assumptions can be found in Appendix III-B.~~

2.2.1 Limitations to the WWHM

~~The WWHM has been~~Ecology created WWHM for the specific purpose of sizing stormwater control facilities for new developments in western Washington. ~~The~~ WWHM can be used for a range of conditions and developments; however, certain limitations are inherent in this software. ~~These limitations are described below.~~

~~The~~WWHM uses the EPA HSPF software program to do all of the rainfall-runoff and routing computations. Therefore, HSPF limitations are included in ~~the~~ WWHM. For example, backwater or tailwater control situations are not explicitly modeled by HSPF. This is also true in ~~the~~ WWHM.

In addition, ~~the~~ WWHM is limited in its routing capabilities. The user is allowed to input multiple stormwater control facilities and runoff is routed through them. If the proposed development site involves routing through a natural lake or wetland in addition to multiple stormwater control facilities then the user should use HSPF to do the routing computations and additional analysis.

Routing effects become more important as the drainage area increases. For this reason ~~it is recommended,~~ Ecology recommends that the WWHM not be used for drainage areas greater than one-half square mile (320 acres). ~~The~~ WWHM can be used for small drainage areas less than an acre in size.

2.2.2 Assumptions made in creating the WWHM

Precipitation data.

- ~~The~~ WWHM uses long-term (43-50 years) precipitation data to simulate the potential impacts of land use development in western Washington. A minimum period of 20 years is required to simulate enough peak flow events to produce accurate flow frequency results.
- ~~A total of WWHM uses a~~ 17 precipitation stations ~~are used,~~ representing the different rainfall regimes found in western Washington. Ecology encourages local governments to use more detailed local precipitation data as when available.

- ~~These~~The precipitation stations represent rainfall at elevations below 1500 feet-. WWHM does not include snowfall and snowmelt~~are not included in.~~
- ~~National Weather Service stations provide~~ the ~~WWHM.~~
- ~~The~~ primary source for precipitation data ~~is National Weather Service stations.~~
- ~~The~~ base computational time step used in ~~the WWHM is one hour.~~ WWHM is one hour. However, future versions of WWHM will incorporate and use 15-minute precipitation data as it becomes available.

The one-hour time step was selected to better represent the temporal variability of actual precipitation than daily data. Based on more frequent (15-minute) rain data collected over 25 years in Seattle, a relationship has been developed and incorporated in WWHM for converting the 60-minute water quality design flows to 15-minute flows. Future versions of WWHM using the 15-minute precipitation time series will not use this relationship. Instead, WWHM will calculate the 15-minute water quality design flows directly.

The 15-minute water quality design flows are more appropriate, and must be used, for the design of water quality treatment facilities that are expected to have a hydraulic residence time of less than one hour.

Precipitation multiplication factors.

- ~~The~~ WWHM uses precipitation multiplication factors to increase or decrease recorded precipitation data to better represent local rainfall conditions.
- The factors are based on the ratio of the 24-hour, 25-year rainfall intensities for the representative precipitation gage and the surrounding area represented by that gage's record.
- The factors have been placed in the WWHM database and linked to each county's map. They will be transparent to the general user, however the advanced user ~~will have~~has the ability to change the coefficient for a specific site. Changes made by the user will be recorded in the WWHM output. By default, WWHM does not allow the precipitation multiplication factor to go below 0.8 or above 2.

Pan evaporation data.

- ~~The~~ WWHM uses pan evaporation coefficients to compute the actual evapotranspiration potential (AET) for a site, based on the potential evapotranspiration (PET) and available moisture supply. AET accounts for the precipitation that returns to the atmosphere without becoming runoff.

- The pan evaporation coefficients have been placed in the WWHM database and linked to each county's map. They will be transparent to the general user. ~~The advanced user will~~ Advanced users have the ability to change the coefficient for a specific site. These changes will be recorded in the WWHM output.

Soil data.

- ~~The~~ WWHM uses three ~~predominate~~predominant soil ~~typetypes~~ to represent the soils of western Washington: till, outwash, and saturated.
- The user determines actual local soil conditions for the specific development planned and inputs that data into ~~the~~ WWHM. The user inputs the number of acres of outwash (A/B), till (C/D), and saturated (wetland) soils for the site conditions.
- Additional soils will be included in ~~the~~ WWHM if appropriate HSPF parameter values are found to represent other major soil groups.

Vegetation data.

- ~~The~~ WWHM ~~will represent~~represents the vegetation of western Washington with three ~~predominate~~predominant vegetation categories: forest, pasture, and lawn (also known as grass).
- The predevelopment land conditions are generally assumed as forest (the default condition), however, the user has the option of specifying pasture if there is documented evidence that pasture vegetation was native to the ~~predevelopment~~pre-development site. In highly urbanized basins (see Minimum Requirement #7 in Volume I, Chapter 2;2) it is possible to use the existing land cover as the pre-developed land condition.

Development land use data.

- Development land use data are used to represent the type of development planned for the site and are used to determine the appropriate size of the required stormwater mitigation facility.
- ~~Among the land uses options,~~Earlier versions of WWHM ~~includes~~included a Standard residential development option which ~~makes~~made specific assumptions about the amount of impervious area per lot and its division between driveways and rooftops. Streets and sidewalk areas ~~are~~were input separately. Ecology ~~has~~had selected a standard impervious area of 4200 square feet per residential lot, with 1000 square feet of that as driveway, walkways, and patio area, and the remainder as rooftop area.

~~The~~ The more recent versions of WWHM (e.g., WWHM3) no longer have the Standard residential development category. Users can use the above land use assumptions for a modeling runoff from Standard residential development or, where better land use information is available, use that

information to model and estimate runoff from the residential development.

- WWHM distinguishes between effective impervious area and non-effective impervious area in calculating total impervious area.
- Credits are given for infiltration and dispersion of roof runoff and for use of porous pavement for driveway areas. ~~The WWHM2 currently includes an option for obtaining credits for the use of porous pavements on Streets/Sidewalk/Parking. The credit given under this option is believed to be too small. Until such time as WWHM2 is upgraded to WWHM3, the LID credit guidance in Appendix C should be followed for porous pavements.~~ Ecology anticipates that future versions of WWHM will include LID modeling features, will calculate credits directly in the model, and will come with a user manual that provides modeling instructions for LIDs.
- Forest and pasture vegetation areas are only appropriate for separate undeveloped parcels dedicated as open space, wetland buffer, or park within the total area of the development. ***Development areas must only be designated as forest or pasture where legal restrictions can be documented that protect these areas from future disturbances.***
- ~~The~~ WWHM can model bypassing a portion of the runoff from the development area around a stormwater detention facility and/or having ~~offsite~~~~off-site~~ inflow enter the development area.

Application of WWHM in ~~Re-developments~~ Redevelopments Projects

Redevelopment requirements may allow, for some portions of the redevelopment project area, the predeveloped condition to be modeled as the existing condition rather than forested or pasture condition. For instance, where the replaced impervious areas do not have to be served by updated flow control facilities because area or cost thresholds in Section 2.4.2 of Volume I are not exceeded.

Pervious and Impervious Land Categories (PERLND and IMPLND parameter values)

- In WWHM (and HSPF) pervious land categories are represented by PERLNDs; impervious land categories by IMPLNDs.
- ~~The~~ WWHM provides ~~46~~over 20 unique PERLND parameters that describe various hydrologic factors that influence runoff and 4 parameters to represent IMPLND.

These values are based on regional parameter values developed by the U.S. Geological Survey for watersheds in western Washington (Dinicola, 1990) plus additional HSPF modeling work conducted by AQUA TERRA Consultants.

Surface runoff and interflow ~~will be~~are computed based on the PERLND and IMPLND parameter values. ~~Groundwater~~Ground water flow can also

be computed and added to the total runoff from a development if there is a reason to believe that ~~groundwater~~ground water would be surfacing (such as where there is a cut in a slope). However, the default condition in WWHM assumes that no ~~groundwater~~ground water flow from small catchments reaches the surface to become runoff. ~~This is consistent with King County procedures (King County, 1998).~~

2.2.3 Guidance for flow-control-related standards.

Flow-control-related standards are used to determine whether or not a proposed stormwater facility will provide a sufficient level of mitigation for the additional runoff from land development. There are three flow-related standards stated in Volume I of this Manual: Minimum Requirement #5 – On-site Stormwater Management; Minimum Requirement #7 – Flow Control; and Minimum Requirement #8 – Wetlands Protection).

~~There are two flow control standards stated in the Ecology Manual: Minimum Requirement #7 – Flow Control and Minimum Requirement #8 – Wetlands Protection (See Volume I). Minimum Requirement #7 specifies specific flow frequency and flow duration ranges for which the postdevelopment runoff cannot exceed predevelopment runoff. Minimum Requirement #8 specifies that discharges to wetlands must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated beneficial uses.~~

Minimum Requirement #5 allows the user to demonstrate compliance with the LID Performance Standard of matching developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 8% and 50% of the 2-year predevelopment peak flow values, then the LID performance standard has not been met.

Minimum Requirement #7 specifies that stormwater discharges to streams shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. –

~~The~~ WWHM computes the predevelopment 2- through 100-year flow frequency values and computes the post-development runoff 2- through 100-year flow frequency values from the outlet of the proposed stormwater facility.

- The model uses pond discharge data to compare the predevelopment and postdevelopment durations and determines if the flow control standards have been met.
- There are three criteria by which flow duration values are compared:

1. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 50% and 100% of the 2-year predevelopment peak flow values (100 Percent Threshold) then the flow duration requirement has not been met.
2. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 100% of the 2-year and 100% of the 50-year predevelopment peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration requirement has not been met.
3. If more than 50 percent of the flow duration levels exceed the 100 percent threshold then the flow duration requirement has not been met.

Minimum Requirement #8 specifies that ~~discharge~~total discharge to ~~wetlands~~a wetland must ~~maintain the hydrologic conditions;~~ ~~hydrophytic vegetation~~not deviate by more than 20% on a single event basis, and ~~substrate characteristics necessary to support existing~~must not deviate by more than 15% on a monthly basis. ~~Flow components feeding the wetland under both pre- and designated beneficial uses.~~ ~~Criteria for determining maximum allowed exceedences in alterations to wetland hydroperiods post-development scenarios are provided in guidelines cited in Guide Sheet 2B~~assumed to be the sum of the Puget Sound Wetland Guidelines (Azoussurface, interflow, and Horner, 1997). ~~Because wetland hydroperiod computations are relatively complex~~ground water flows from the project site. ~~Ecology anticipates revising the WWHM to more easily allow this comparison and are site specific they have not yet been included in the WWHM2.~~ ~~HSPF is required for plans to provide wetland hydroperiod analysis.~~ ~~Ecology intends to include the ability to perform hydroperiod computations in WWHM3.~~modeling guidance based on the WWHM revisions.

2.3 Single Event Hydrograph Method

Hydrograph analysis utilizes the standard plot of runoff flow versus time for a given design storm, thereby allowing the key characteristics of runoff such as peak, volume, and phasing to be considered in the design of drainage facilities. Because the only utility for single event methods in this manual is to size wet pool treatment facilities, only the subjects of design storms, curve numbers and calculating runoff volumes are presented. If single event methods are used to size temporary and permanent conveyances, the reader should reference other texts and software for assistance.

2.3.1 Water Quality Design Storm

The design storm for sizing wetpool treatment facilities is the 6-month, 24-hour storm. Unless amended to reflect local precipitation statistics, the

6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Appendix 1-B of Volume I. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size.

The total depth of rainfall (in tenths of an inch) for storms of 24-hour duration and 2, 5, 10, 25, 50, and 100-year recurrence intervals are published by the National Oceanic and Atmospheric Administration (NOAA). The information is presented in the form of “isopluvial” maps for each state. Isopluvial maps are maps where the contours represent total inches of rainfall for a specific duration. Isopluvial maps for the 2, 5, 10, 25, 50, and 100-year recurrence interval and 24-hour duration storm events can be found in the NOAA Atlas 2, “Precipitation - Frequency Atlas of the Western United States, Volume IX-Washington.” Appendix II-A provides the isopluvials for the 2, 10, and 100-year, 24-hour design storms. Other precipitation frequency data may be obtained through [the Western Regional Climate Center \(WRCC\)](#) at Tel: (775) 674-7010. WRCC can generate 1-30 day precipitation frequency data for the location of interest using data from [1948-1880](#) to present (currently [August 2000](#) [June 2012](#)).

2.3.2 Runoff Parameters

All storm event hydrograph methods require input of parameters that describe physical drainage basin characteristics. These parameters provide the basis from which the runoff hydrograph is developed. This section describes only the key parameter of curve number that is used to estimate the runoff from the water quality design storm.

Curve Number

The NRCS (formerly SCS) has, for many years, conducted studies of the runoff characteristics for various land types. After gathering and analyzing extensive data, NRCS has developed relationships between land use, soil type, vegetation cover, interception, infiltration, surface storage, and runoff. The relationships have been characterized by a single runoff coefficient called a “curve number.” The National Engineering Handbook - Section 4: Hydrology (NEH-4, SCS, August 1972) contains a detailed description of the development and use of the curve number method.

NRCS has developed “curve number” (CN) values based on soil type and land use. They can be found in [Urban Hydrology for Small Watersheds, Technical Release 55 \(TR-55\), June 1986](#) ~~“Urban Hydrology for Small Watersheds”, Technical Release 55 (TR-55), June 1986,~~ published by the NRCS. The combination of these two factors is called the “soil-cover complex.” The soil-cover complexes have been assigned to one of four hydrologic soil groups, according to their runoff characteristics. NRCS has classified over 4,000 soil types into these four soil groups. [Table 2.3.1](#)

Table 2.2 shows the hydrologic soil group of most soils in the state of Washington and provides a brief description of the four groups. For details on other soil types refer to the NRCS publication mentioned above (TR-55, 1986).

Table 2.3.1 Hydrologic Soil Series for Selected Soils in Washington State			
Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Agnew	C	Hoko	C
Ahl	B	Hoodsport	C
Aits	C	Hoogdal	C
Alderwood	C	Hoypus	A
Arents, Alderwood	B	Huel	A
Arents, Everett	B	Indianola	A
Ashoe	B	Jonas	B
Baldhill	B	Jumpe	B
Barneston	C	Kalaloch	C
Baumgard	B	Kapowsin	C/D
Beausite	B	Katula	C
Belfast	C	Kilchis	C
Bellingham	D	Kitsap	C
Bellingham variant	C	Klaus	C
Boistfort	B	Klone	B
Bow	D	Lates	C
Briscot	D	Lebam	B
Buckley	C	Lummi	D
Bunker	B	Lynnwood	A
Cagey	C	Lystair	B
Carlsborg	A	Mal	C
Casey	D	Manley	B
Cassolary	C	Masheh	B
Cathcart	B	Maytown	C
Centralia	B	McKenna	D
Chehalis	B	McMurray	D
Chesaw	A	Melbourne	B
Cinebar	B	Menzel	B
Clallam	C	Mixed Alluvial	variable
Clayton	B	Molson	B
Coastal beaches	variable	Mukilteo	C/D
Colter	C	Naff	B
Custer	D	Nargar	A
Custer, Drained	C	National	B
Dabob	C	Neilton	A
Delphi	D	Newberg	B
Dick	A	Nisqually	B
Dimal	D	Nooksack	C
Dupont	D	Norma	C/D
Earlmont	C	Ogarty	C
Edgewick	C	Olete	C
Eld	B	Olomount	C
Elwell	B	Olympic	B
Esquatzel	B	Orcas	D
Everett	A	Oridia	D
Everson	D	Orting	D
Galvin	D	Oso	C
Getchell	A	Ovall	C
Giles	B	Pastik	C
Godfrey	D	Pheeney	C
Greenwater	A	Phelan	D

Table 2.3.1 Hydrologic Soil Series for Selected Soils in Washington State			
Soil Type	Hydrologic Soil Group	Soil Type	Hydrologic Soil Group
Grove	C	Pilchuck	C
Harstine	C	Potchub	C
Hartnit	C	Poulsbo	C
Hoh	B	Prather	C
Puget	D	Solleks	C
Puyallup	B	Spana	D
Queets	B	Spanaway	A/B
Quilcene	C	Springdale	B
Ragnar	B	Sulsavar	B
Rainier	C	Sultan	C
Raught	B	Sultan variant	B
Reed	D	Sumas	C
Reed, Drained or Protected	C	Swantown	D
Renton	D	Tacoma	D
Republic	B	Tanwax	D
Riverwash	variable	Tanwax, Drained	C
Rober	C	Tealwhit	D
Salal	C	Tenino	C
Salkum	B	Tisch	D
Sammamish	D	Tokul	C
San Juan	A	Townsend	C
Scamman	D	Triton	D
Schneider	B	Tukwila	D
Seattle	D	Tukey	C
Sekiu	D	Urbana	C
Semiahmoo	D	Vailton	B
Shalcar	D	Verlot	C
Shano	B	Wapato	D
Shelton	C	Warden	B
Si	C	Whidbey	C
Sinclair	C	Wilkeson	B
Skipopa	D	Winston	A
Skykomish	B	Woodinville	B
Snahopish	B	Yelm	C
Snohomish	D	Zynbar	B
Solduc	B		

Notes:

Hydrologic Soil Group Classifications, as Defined by the Soil Conservation Service:

A = (Low runoff potential) Soils having low runoff potential and high infiltration rates, even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr.).

B = (Moderately low runoff potential). Soils having moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.3 in/hr.).

C = (Moderately high runoff potential). Soils having low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine textures. These soils have a low rate of water transmission (0.05-0.15 in/hr.).

D = (High runoff potential). Soils having high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr.).

* = From SCS, TR-55, Second Edition, June 1986, Exhibit A-1. Revisions made from SCS, Soil Interpretation Record, Form #5, September 1988 and various county soil surveys.

[Table 2.3.2](#)

[Table 2.3](#) shows the CNs, by land use description, for the four hydrologic soil groups. These numbers are for a 24-hour duration storm and typical antecedent soil moisture condition preceding 24-hour storms.

The following are important criteria/considerations for selection of CN values:

Many factors may affect the CN value for a given land use. For example, the movement of heavy equipment over bare ground may compact the soil so that it has a lesser infiltration rate and greater runoff potential than would be indicated by strict application of the CN value to developed site conditions.

CN values can be area weighted when they apply to pervious areas of similar CNs (within 20 CN points). However, high CN areas should not be combined with low CN areas. In this case, separate estimates of S (potential maximum natural detention) and Q_d (runoff depth) should be generated and summed to obtain the cumulative runoff volume unless the low CN areas are less than 15 percent of the subbasin.

Separate CN values must be selected for the pervious and impervious areas of an urban basin or subbasin. For residential districts the percent impervious area given in [Table 2.3.2](#) [Table 2.3](#) must be used to compute the respective pervious and impervious areas. For proposed commercial areas, planned unit developments, etc., the percent impervious area must be computed from the site plan. For all other land uses the percent impervious area must be estimated from best available aerial topography and/or field reconnaissance. The pervious area CN value must be a weighted average of all the pervious area CNs within the subbasin. The impervious area CN value shall be 98.

Example: The following is an example of how CN values are selected for a sample project.

Select CNs for the following development:

Existing Land Use	-	forest (undisturbed)
Future Land Use	-	residential plat (3.6 DU/GA)
Basin Size	-	60 acres
Soil Type	-	80 percent Alderwood, 20 percent Ragnor

[Table 2.3.1](#) [Table 2.2](#) shows that Alderwood soil belongs to the “C” hydrologic soil group and Ragnor soil belongs to the “B” group. Therefore, for the existing condition, CNs of 70 and 55 are read from [Table 2.3.2](#) [Table 2.3](#) and areal weighted to obtain a CN value of 67. For the developed condition with 3.6 DU/GA the percent impervious of 39 percent is interpolated from [Table 2.3.2](#) [Table 2.3](#) and used to compute pervious and impervious areas of 36.6 acres and 23.4 acres, respectively. The 36.6 acres of pervious area is assumed to be in Fair condition (for a

conservative design) with residential yards and lawns covering the same proportions of Alderwood and Ragnor soil (80 percent and 20 percent respectively). Therefore, CNs of 90 and 85 are read from [Table 2.3.2](#) ~~Table 2.3~~ and areal weighted to obtain a pervious area CN value of 89. The impervious area CN value is 98. The result of this example is summarized below:

<u>On-Site Condition</u>	<u>Existing</u>	<u>Developed</u>
Land use	Forest	Residential
Pervious area	60 ac.	36.6 ac.
CN of pervious area	67	89
Impervious area	0 ac.	23.4 ac.
CN of impervious area	--	98

Table 2.3.2 Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas				
(Sources: TR 55, 1986, and Stormwater Management Manual, 1992. See Section 2.1.1 for explanation)				
	CNs for hydrologic soil group			
Cover type and hydrologic condition.	A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)¹				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs ² , driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Appendix C to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	98	98	98	98
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Single family residential³:	Should only be used for subdivisions > 50 acres		Average Percent impervious area ^{3,4}	
Dwelling Unit/Gross Acre				
1.0 DU/GA	15		Separate curve number	
1.5 DU/GA	20		shall be selected for	
2.0 DU/GA	25		pervious & impervious	
2.5 DU/GA	30		portions of the site or	
3.0 DU/GA	34		basin	
3.5 DU/GA	38			
4.0 DU/GA	42			
4.5 DU/GA	46			
5.0 DU/GA	48			
5.5 DU/GA	50			
6.0 DU/GA	52			
6.5 DU/GA	54			
7.0 DU/GA	56			
7.5 DU/GA	58			
PUD's, condos, apartments, commercial businesses, industrial areas & subdivisions < 50 acres	%impervious must be computed		Separate curve numbers shall be selected for pervious and impervious portions of the site	
For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55, (210-VI-TR-55, Second Ed., June 1986).				

¹ Composite CN's may be computed for other combinations of open space cover type.

²Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Chapter 3, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" (Section 3.1.1), and "Flow Credit for Roof Downspout Dispersion" (Section 3.1.2).

³Assumes roof and driveway runoff is directed into street/storm system.

⁴All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

**NRCS Curve
Number Equations
for determination of
runoff depths and
volumes**

The rainfall-runoff equations of the NRCS curve number method relates a land area's runoff depth (precipitation excess) to the precipitation it receives and to its natural storage capacity, as follows:

$$\begin{aligned} Q_d &= (P - 0.2S)^2 / (P + 0.8S) && \text{for } P \geq 0.2S \\ \text{and } Q_d &= 0 && \text{for } P < 0.2S \end{aligned}$$

Where:

Q_d = runoff depth in inches over the area,

P = precipitation depth in inches over the area, and

S = potential maximum natural detention, in inches over the area, due to infiltration, storage, etc.

The area's potential maximum detention, S , is related to its curve number, CN :

$$S = (1000 / CN) - 10$$

The combination of the above equations allows for estimation of the total runoff volume by computing total runoff depth, Q_d , given the total precipitation depth, P . For example, if the curve number of the area is 70, then the value of S is 4.29. With a total precipitation for the design event of 2.0 inches, the total runoff depth would be:

$$Q_d = [2.0 - 0.2 (4.29)]^2 / [2.0 + 0.8 (4.29)] = 0.24 \text{ inches}$$

This computed runoff represents inches over the tributary area. Therefore, the total volume of runoff is found by multiplying Q_d by the area (with necessary conversions):

Total runoff

$$\begin{array}{lcl} \text{Volume} & = & 3,630 \times Q_d \times A \\ (\text{cu. ft.}) & & (\text{cu. ft./ac. in.}) (\text{in}) (\text{ac}) \end{array}$$

If the area is 10 acres, the total runoff volume is:

$$3,630 \text{ cu. ft./ac. in.} \times 0.24 \text{ in.} \times 10 \text{ ac.} = 8,712 \text{ cu. ft.}$$

This is the design volume for treatment BMPs for which the design criterion is based on the volume of runoff.

**Calculating the
design volume
for wetpool
treatment
facilities**

2.4 Closed Depression Analysis

The analysis of closed depressions requires careful assessment of the existing hydrologic performance in order to evaluate the impacts a proposed project will have. The applicable requirements (see Minimum Requirement #7) and the local government's Sensitive Areas Ordinance and Rules (if applicable) should be thoroughly reviewed prior to proceeding with the analysis.

Closed depressions generally facilitate infiltration of runoff. If a closed depression is classified as a wetland, then the Minimum Requirement #8 for wetlands applies. If there is an outflow from this wetland to a surface water (such as a creek), then the flow from this wetland must also meet the Minimum Requirement #7 for flow control. A calibrated continuous simulation hydrologic model must be used for closed depression analysis and design of mitigation facilities. If a closed depression is not classified as a wetland, model the ponding area at the bottom of the closed depression as an infiltration pond using WWHM or an approved equivalent runoff model²².

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Chapter 3 - Flow Control Design

Note: Figures in Chapter 3 courtesy of King County, except as noted

This chapter presents methods, criteria, and details for hydraulic analysis and design of flow control facilities and roof downspout controls. Flow control facilities are detention or infiltration facilities engineered to meet the flow control standards specified in Volume I. Roof downspout controls ~~are include~~ infiltration ~~or trenches, dry wells, and partial~~ dispersion systems for use in individual lots, proposed plats, and short plats. Roof downspout controls are used in conjunction with, and in addition to, any flow control facilities that may be necessary. They are included in the list of BMPs to consider for compliance with Minimum Requirement #5. Implementation of roof downspout controls may reduce the total effective impervious area and result in less runoff from these surfaces. Ecology's Western Washington Hydrology Model (WWHM) incorporates flow credits for implementing two types of roof downspout controls. These are:

- If roof runoff is *infiltrated* according to the requirements of this section, the roof area may be discounted from the total project area used for sizing stormwater facilities. ~~This is done by clicking on the "Credit" button in the WWHM and entering the percent of roof area that is being infiltrated.~~
- If roof runoff is *dispersed* according to the requirements of this section on single-family lots greater than 22,000 square feet, and the *vegetative flow** path is 50 feet or larger through *undisturbed* native landscape or lawn/landscape area that meets BMP T5.13, the roof area may be modeled as grassed surface. ~~This is done by clicking on the "Credits" button in the WWHM and entering the percent of roof area that is being dispersed.~~

This chapter also provides ~~a description of the use of design procedures, criteria, and field tests methods concerning~~ infiltration facilities used for flow control or treatment. Section 3.4 covers design of bioretention and permeable pavement facilities. Additional design considerations ~~and general limitations for bioretention facilities, a type of the infiltration facilities and small site BMPs design,~~ are covered in Chapter 7 of Volume V.

~~Roof downspout controls and small site BMPs should be applied to individual commercial lot developments when the percent impervious area and pollutant characteristics are comparable to those from residential lots.~~

* *Vegetative flow* path is measured from the downspout or dispersion system discharge point to the downstream property line, stream, wetland, or other impervious surface.

Selection of Roof Downspout Controls

3.1 Roof Downspout Controls

This section presents the criteria for design and implementation of roof downspout controls. Roof downspout controls are simple pre-engineered designs for infiltrating and/or dispersing runoff from roof areas for the purposes of increasing opportunities for ~~groundwater~~ground water recharge and reduction of runoff volumes from new developments.

Large lots in rural areas (5 acres or greater) typically have enough area to disperse or infiltrate roof runoff. Lots created in urban areas will typically be smaller (about 8,000 square feet) and have a limited amount of area in which to site infiltration or dispersion trenches. Downspout infiltration should be used in those soils that readily infiltrate. Dispersion BMPs should be used for urban lots located in less permeable soils, where infiltration is not feasible. Where dispersion is not feasible because of very small lot size, or where there is a potential for creating drainage problems on adjacent lots, connect downspouts with perforated stub-out connections to the street storm drain system, which directs the runoff to a stormwater management facility.

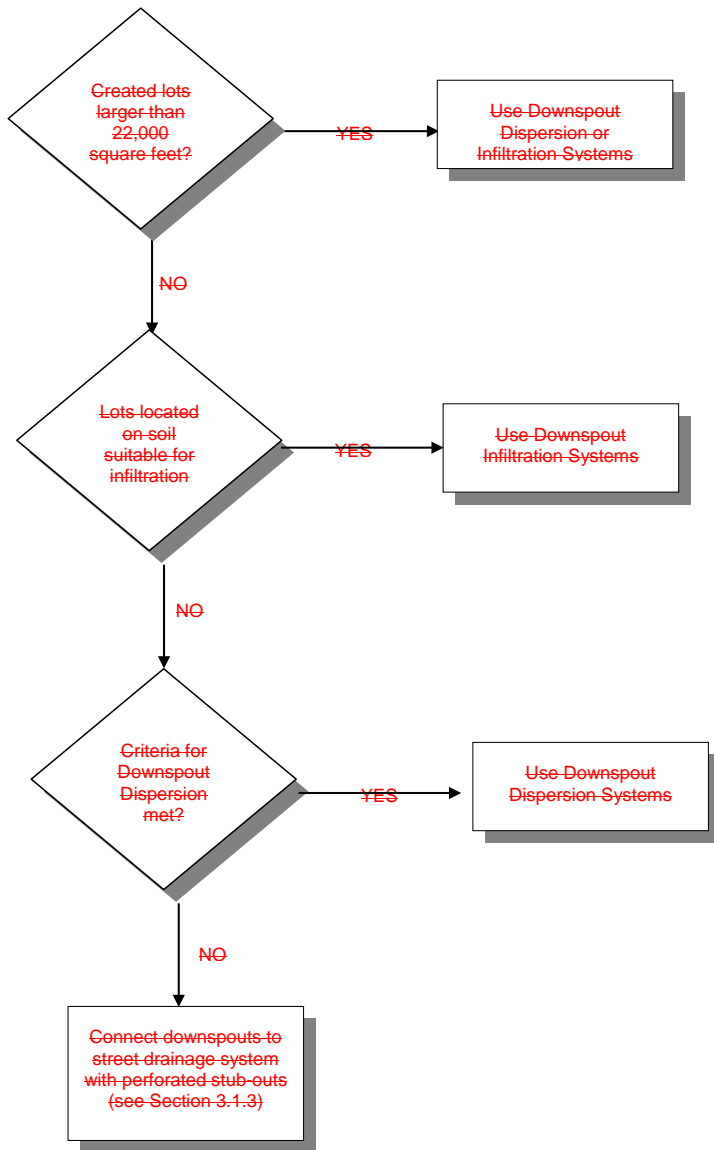
Where roof downspout controls are planned, the following ~~three~~ types must be considered in descending order of preference:

1. ~~Full Dispersion in accordance with BMP T5.30 in Chapter 5, or Downspout Full Infiltration Systems in accordance with BMP T5.10A in Section 3.1.1~~Downspout infiltration systems (Section 3.1.1)
2. ~~Rain Gardens in accordance with the "Rain Garden Handbook for Western Washington;" or if the project area is subject to Minimum Requirements #6 and/or #7, Bioretention BMPs in Chapter 7 of Volume V.~~
3. ~~Downspout Dispersion Systems in accordance with BMP T5.10B in Section 3.1.2~~(Section 3.1.2).
4. ~~Downspout-perforated stub~~Perforated Stub-out Connections in accordance with BMP T5.10C in Section 3.1.3.(Section 3.1.3).

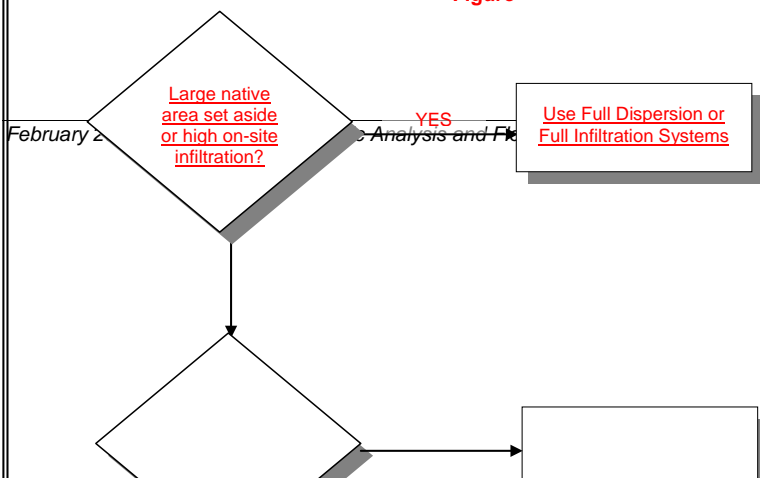
~~Figure 3.1.1~~Figure 3.1 illustrates, in general, how roof downspout controls are selected and applied in single-family subdivision projects. ~~However, local jurisdictions may adopt approaches that are more specific to their locality.~~ Where supported by appropriate soil infiltration tests, downspout ~~full~~ infiltration in finer soils may be practical using a larger infiltration system.

Roof downspout controls can be applied to individual commercial lot developments when the percent impervious area and pollutant characteristics are comparable to those from residential lots.

Note: Other innovative downspout control BMPs such as rain barrels, ornamental ponds, downspout cisterns, or other downspout water storage devices may ~~also~~ be used to supplement any of the above BMPs if approved by the reviewing authority.



Figure



February 2

Analysis and Plan

3-4

3.1—Flow Diagram Showing Selection of Roof, 1 Downspout Controls

3.1.1—Downspout Full Infiltration Systems (BMP T5.10A)

Downspout full infiltration systems are trench or drywell designs intended only for use in infiltrating runoff from roof downspout drains. They are not designed to directly infiltrate runoff from pollutant-generating impervious surfaces.

Application

~~The following apply to parcels as described in Volume I:~~

~~1. Single family subdivision~~ Projects subject to Minimum Requirement #7 ~~for flow control~~ (5 (Section 2.5.5, Volume I) must provide for individual downspout full infiltration systems ~~on all lots smaller than 22,000 square feet or full dispersion~~ if feasible. ~~Local governments may specify a different lot size that is more appropriate based on local soil and slope conditions and rainfall. Concentrated flows may not be directed to adjoining lots. They must be dispersed and retained on Evaluate the building lot to the maximum extent possible.~~

~~2. The feasibility, or applicability, of downspout full infiltration must be evaluated for all subdivision single family lots smaller than 22,000 square feet unless full dispersion is proposed. Use the evaluation procedure detailed below must be used to determine if the feasibility of downspout full infiltration is feasible or whether downspout dispersion can be used in lieu of infiltration.~~

Flow Credit for Roof Downspout Full Infiltration

If roof runoff is infiltrated according to the requirements of this section, the roof area may be discounted from the project area used for sizing stormwater facilities.

Procedure for Evaluating Feasibility

1. Have one of the following prepare a soils report to determine if soils suitable for infiltration are present on the site:
 - A professional soil scientist certified by the Soil Science Society of America (or an equivalent national program)
 - A locally licensed on-site sewage designer
 - A suitably trained person working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

The report shall reference a sufficient number of soils logs to establish the type and limits of soils on the project site. The report should at a minimum identify the limits of any outwash type soils (i.e., those meeting USDA soil texture classes ranging from coarse sand and cobbles to medium sand) versus other soil types and include an inventory of topsoil depth.

~~3. For subdivision single family lots greater than or equal to 22,000 square feet, downspout infiltration is optional, and the evaluation procedure detailed below may be used if downspout infiltration is being proposed voluntarily.~~

~~4. If site specific tests indicate less than 3 feet of permeable soil from the proposed final grade to the seasonal high groundwater table, then a downspout dispersion system per Section 3.1.2 may be used in lieu of infiltration.~~

~~5. On lots or sites with more than 3 feet of permeable soil from the proposed final grade to the seasonal high groundwater table, downspout infiltration is considered feasible if the soils are outwash type soils and the infiltration trench can be designed to meet the minimum design criteria specified below.~~

~~*Note: If downspout infiltration is not provided on these lots, then a downspout dispersion system must be provided per Section 3.1.2.*~~

~~2. On lots or sites with no outwash type soils, a downspout dispersion system per Section 3.1.2 may be used in lieu of infiltration.~~

~~2. 3. If the lots or site does not have outwash or loam soils, and full dispersion is not feasible, then consider a rain garden or bioretention BMPs (the next lower priority on-site stormwater management system).~~

~~3. Complete additional site-specific testing on lots or sites containing outwash type soils (coarse sand and cobbles to medium sand), additional site specific testing must be done.) and loam type soils.~~

~~Individual lot or site tests must consist of at least one soils log at the location of the infiltration system, a minimum of 4 feet in depth (from the proposed grade), identifying the SCS and at least 1 foot below the expected bottom elevation of the infiltration trench or dry well.~~

~~Identify the NRCS series of the soil and the USDA textural class of the soil horizon through the depth of the log, and notingnote any evidence of high groundwaterground water level, such as mottling.~~

~~2-4. Note: This testing must also be carried out on lots or sites where Downspout infiltration is being proposed in soils other than outwash, considered feasible on lots or sites that meet all of the following:~~

- ~~• 4. If site specific tests indicate less than 3 feet or more of permeable soil from the proposed final grade to the seasonal high groundwaterground water table, then a downspout dispersion system per Section 3.~~

~~At least 1.2 may be used in lieu of infiltration.~~

- ~~5. On lots or sites with more than 3 feet-foot of permeable soil clearance from the proposed final grade to the seasonal high groundwater table, downspout infiltration is considered feasible if the soils are outwash type soils and expected bottom elevation of the infiltration trench or dry well.~~
- The downspout full infiltration system can be designed to meet the minimum design criteria specified below.

Design Criteria for Infiltration Trenches

[Figure 3.1.2](#) shows a typical downspout infiltration trench system, and [Figure 3.1.3](#) presents an alternative infiltration trench system for sites with coarse sand and cobble soils. These systems are designed as specified below.

General

1. ~~4.~~ The following minimum lengths (linear feet) per 1,000 square feet of roof area based on soil type may be used for sizing downspout infiltration trenches.

Coarse sands and cobbles	20 LF
Medium sand	30 LF
Fine sand, loamy sand	75 LF
Sandy loam	125 LF
Loam	190 LF
2. ~~2.~~ Maximum length of trench ~~must shall~~ not exceed 100 feet from the inlet sump.
3. ~~3.~~ Minimum spacing between trench centerlines ~~must shall~~ be 6 feet.
4. ~~4.~~ Filter fabric ~~must shall~~ be placed over the drain rock as shown on [Figure 3.1.2](#) ~~Figure 3.2~~ prior to backfilling.
5. ~~5.~~ Infiltration trenches may be placed in fill material if the fill is placed and compacted under the direct supervision of a geotechnical engineer or professional civil engineer with geotechnical expertise, and if the measured infiltration rate is at least 8 inches per hour. Trench length in fill must be 60 linear feet per 1,000 square feet of roof area. Infiltration rates can be tested using the methods described in [Section 3.3](#) ~~Section 3.3.~~
6. ~~6.~~ Infiltration trenches should not be built on slopes steeper than 25 ~~percent%~~ (4:1). A geotechnical analysis and report may be required on slopes over 15 percent or if located within 200 feet of the top of ~~steep~~ slope ~~steeper than 40%~~, or ~~in a~~ landslide hazard area.
7. ~~7.~~ Trenches may be located under pavement if a small yard drain or catch basin with grate cover is placed at the end of the trench pipe such that overflow would occur out of the catch basin at an elevation at least one foot below that of the pavement, and in a location which can accommodate the overflow without creating a significant adverse

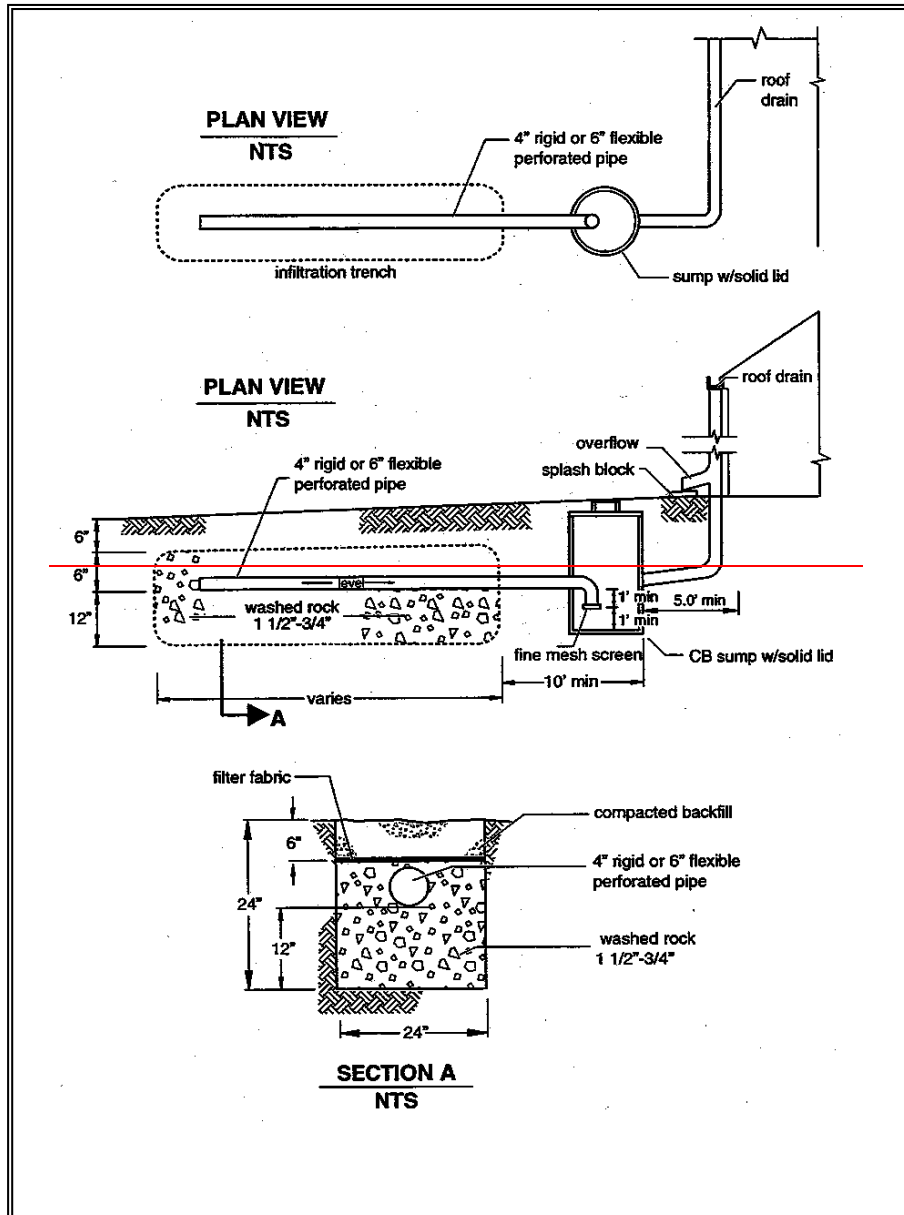
**Design Criteria
for Infiltration
Drywells**

impact to downhill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure.

Figure 3.1.4 shows a typical downspout infiltration drywell system. These systems are designed as specified below.

General

1. Drywell bottoms must be a minimum of 1 foot above seasonal high ~~groundwater~~ ground water level or impermeable soil layers.
- ~~2. If using~~ When located in coarse sands and cobbles, drywells, each drywell may serve up must contain a volume of gravel equal to or greater than 60 cubic feet per 1000 square feet of impervious surface for either served. When located in medium sands or coarse sands.
- ~~2. Typically, drywells are~~ must contain at least 90 cubic feet of gravel per 1,000 square feet of impervious surface served.
3. Drywells must be at least 48 inches in diameter (minimum) and have a depth of 5 feet (4 feet of gravel and 1 foot of suitable cover material) deep enough to contain the gravel amounts specified above for the soil type and impervious surface served.
4. Filter fabric (geotextile) must be placed on top of the drain rock and on trench or drywell sides prior to backfilling.
5. Spacing between drywells must be a minimum of ~~4~~ 10 feet.
6. Downspout infiltration drywells must not be built on slopes greater than 25% (4:1). Drywells may not be placed on or above a landslide hazard area or on slopes greater than 15% without evaluation by a professional engineer with geotechnical expertise or a licensed geologist, hydrogeologist, or engineering geologist, and with jurisdiction approval.



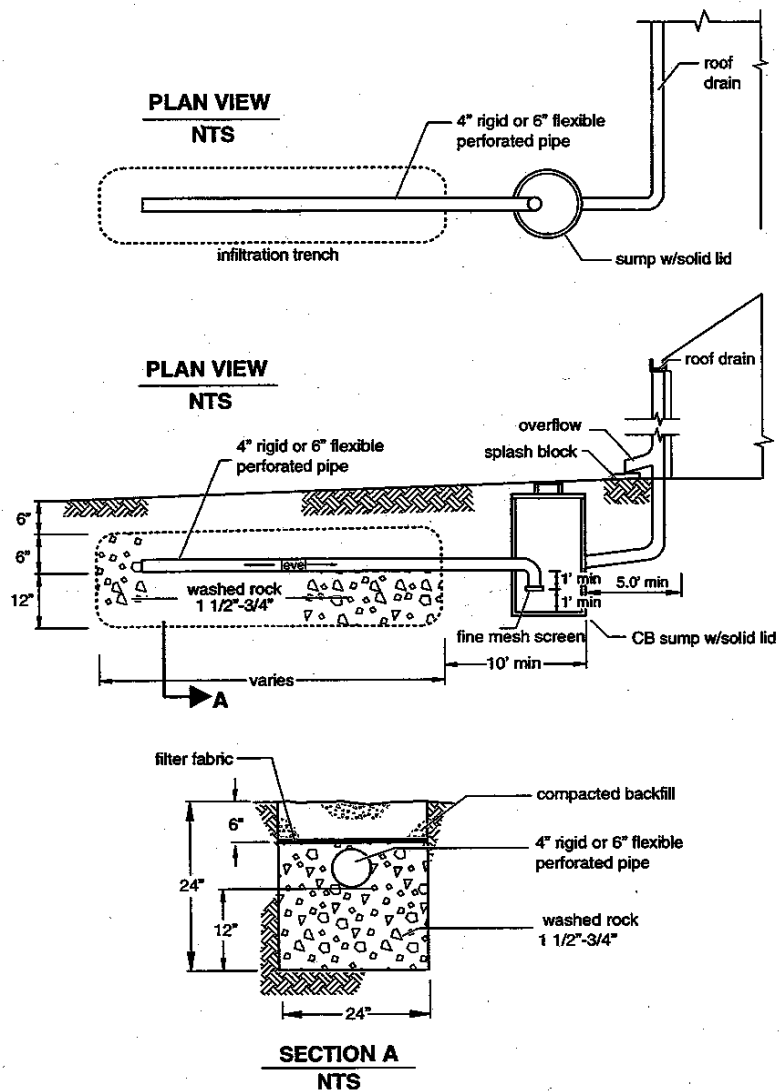


Figure 3.1.2 - Typical Downspout Infiltration Trench

Source: King County

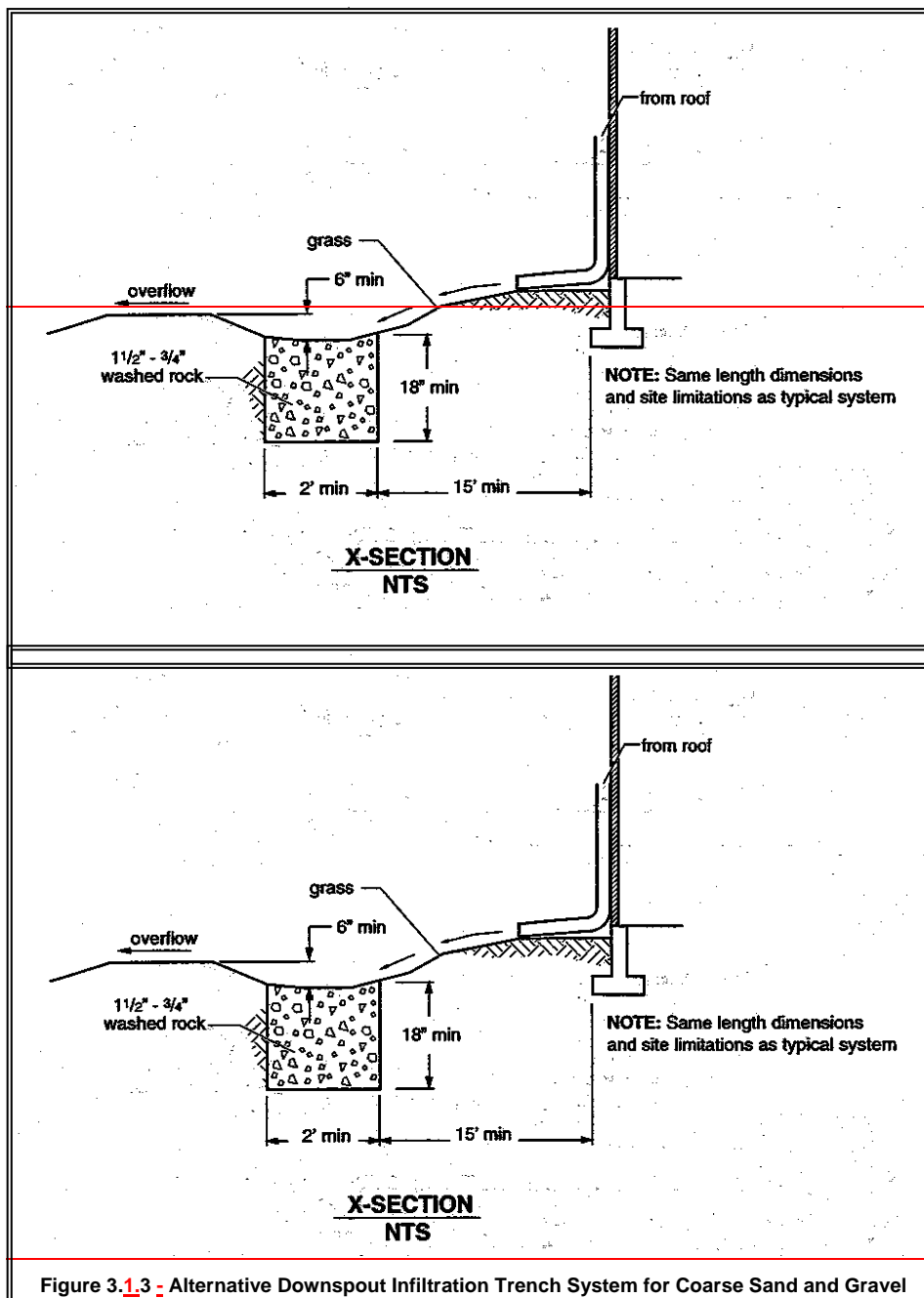


Figure 3.1.3 - Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel

Source: King County

|

Figure 3.4—Typical Downspout Infiltration Drywell

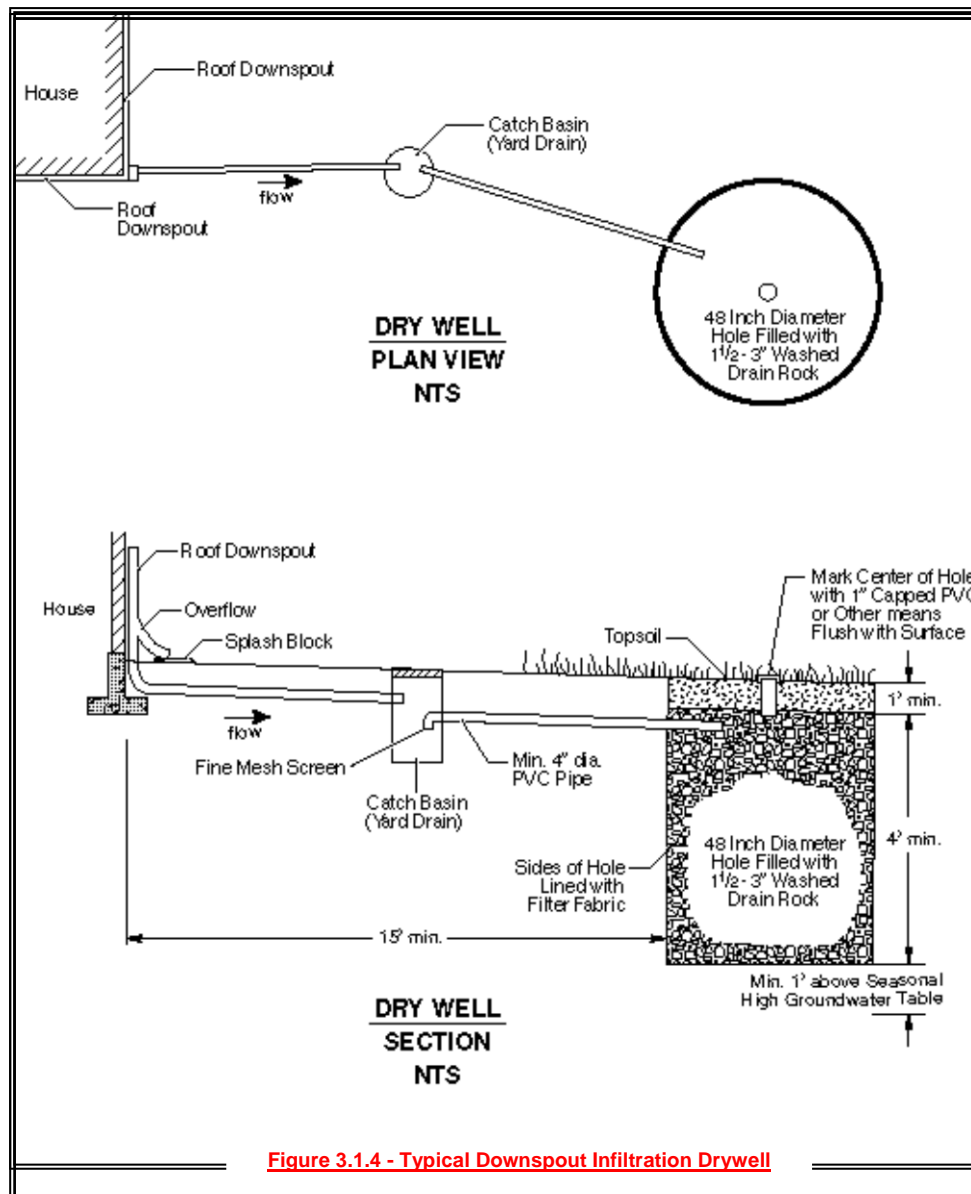


Figure 3.1.4 - Typical Downspout Infiltration Drywell

Source: King County

Setbacks

Local governments may require specific setbacks in sites with ~~steep slopes~~, over 40%, land slide areas, open water features, springs, wells, and septic tank drain fields. Adequate room for maintenance access and equipment should also be considered. Examples of setbacks commonly used include the following:

1. ~~1.~~ All infiltration systems should be at least 10 feet from any structure, property line, or sensitive area (except ~~steep slopes~~, over 40%).
2. ~~2.~~ All infiltration systems must be at least 50 feet from the top of any ~~sensitive area steep slope~~, over 40%. This setback may be reduced to 15 feet based on a geotechnical evaluation, but in no instances may it be less than the buffer width.
3. ~~3.~~ For sites with septic systems, infiltration systems must be downgradient of the drainfield unless the site topography clearly prohibits subsurface flows from intersecting the drainfield.

3.1.2 Downspout Dispersion Systems (BMP T5.10B)

Downspout dispersion systems are splash blocks or gravel-filled trenches, which serve to spread roof runoff over vegetated pervious areas.

Dispersion attenuates peak flows by slowing ~~entry of~~ the runoff entering into the conveyance system, ~~allows for~~allowing some infiltration, and ~~provides~~providing some water quality benefits.

Applications & Limitations

Downspout dispersion may be used in all subdivision lots where downspout full infiltration, full dispersion, and bioretention/rain gardens are not feasible.

Flow Credit for Roof Downspout Dispersion

In WWHM3, roof areas may be modeled as grassed surfaces if roof runoff is dispersed according to the requirements of this section on lots greater than 22,000 square feet, and the *vegetative flow** path is 50 feet or larger through undisturbed native landscape or lawn/landscape area that meets BMP T5.13. This is done in WWHM on the Mitigated Scenario screen by entering the roof area into one of the entry options for dispersal of impervious area runoff. For WWHM 2012, see Appendix III-C in this Volume.

Design Criteria

1. Use downspout trenches designed as shown in [Figures 3.1.5](#) and [3.1.6](#) for all downspout dispersion applications except where splash blocks are allowed below.

~~**Application** — Downspout dispersion must be used in all subdivision single family lots, which meet one of the following criteria:~~

- ~~1. Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Section 3.1.1.~~
- ~~2. Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration (as determined in Section 3.1.1) and where the design criteria below can be met.~~
2. ~~2.~~ Splash blocks shown in [Figure 3.1.7](#)~~Figure 3.7~~ may be used for downspouts discharging to a vegetated flowpath at least 50 feet in length as measured from the downspout to the downstream property line, structure, ~~steep~~ slope, over 15%, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- ~~3. 3.—Cover the vegetated flowpath with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.~~

* *Vegetative flow* path is measured from the downspout or dispersion system discharge point to the downstream property line, stream, wetland, or other impervious surface.

~~3.4.~~ If the vegetated flowpath (measured as defined above) is less than 25 feet ~~on a subdivision single family lot~~, a perforated stub-out connection per ~~Section 3.1.3~~ ~~Section 3.1.3~~ may be used in lieu of downspout dispersion. A perforated stub-out may also be used where implementation of downspout dispersion might cause erosion or flooding problems, either on site or on adjacent lots. ~~For example~~, this provision might be appropriate ~~, for example~~, for lots constructed on steep hills where downspout discharge could ~~be cumulative~~ culminate and might pose a potential hazard for lower lying lots, or where dispersed flows could create problems for adjacent ~~off-site lots~~ ~~off-site lots~~. This provision does not apply to situations where lots are flat and on-site downspout dispersal would result in saturated yards. Perforated stub-outs are not appropriate when seasonal water table is <1 foot below trench bottom.

Note: For all other types of projects, the use of a perforated stub-out in lieu of downspout dispersion shall be as determined by the Local Plan Approval Authority.

~~4.5.~~ For sites with septic systems, the discharge point of all dispersion systems must be downgradient of the drainfield. This requirement may be waived if site topography clearly prohibits flows from intersecting the drainfield.

Design Criteria for Dispersion Trenches

1. ~~4.~~ A vegetated flowpath of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any ~~steep~~ slope: steeper than 15%. Sensitive area buffers may count towards flowpath lengths.
2. ~~2.~~ Trenches serving up to 700 square feet of roof area may be simple 10-foot-long by 2-foot wide gravel filled trenches as shown in ~~Figure 3.1.5~~ ~~Figure 3.5.~~ For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in ~~Figure 3.1.6~~ ~~Figure 3.6~~ may be used as or alternative material approved by the Local ~~jurisdiction.~~ Plan Approval Authority may be used. The total length of this design must not exceed 50 feet and must provide at least 10 feet of trench per 700 square feet of roof area.
3. ~~3.~~ Maintain a setback of at least 5 feet ~~should be maintained~~ between any edge of the trench and any structure or property line.
4. ~~4.~~ No erosion or flooding of downstream properties may result.
5. ~~5.~~ Runoff discharged towards landslide hazard areas must be evaluated by ~~Have~~ a geotechnical engineer or a licensed geologist, hydrogeologist, or engineering geologist ~~evaluate runoff discharged towards landslide hazard areas. Don not place~~ the discharge point ~~may not be placed~~ on or

above slopes greater than ~~20~~15% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and jurisdiction approval.

6. For purposes of maintaining adequate separation of flows discharged from adjacent dispersion devices, the outer edge of the vegetated flowpath segment for the dispersion trench must not overlap with other flowpath segments, except those associated with sheet flow from a non-native pervious surface.

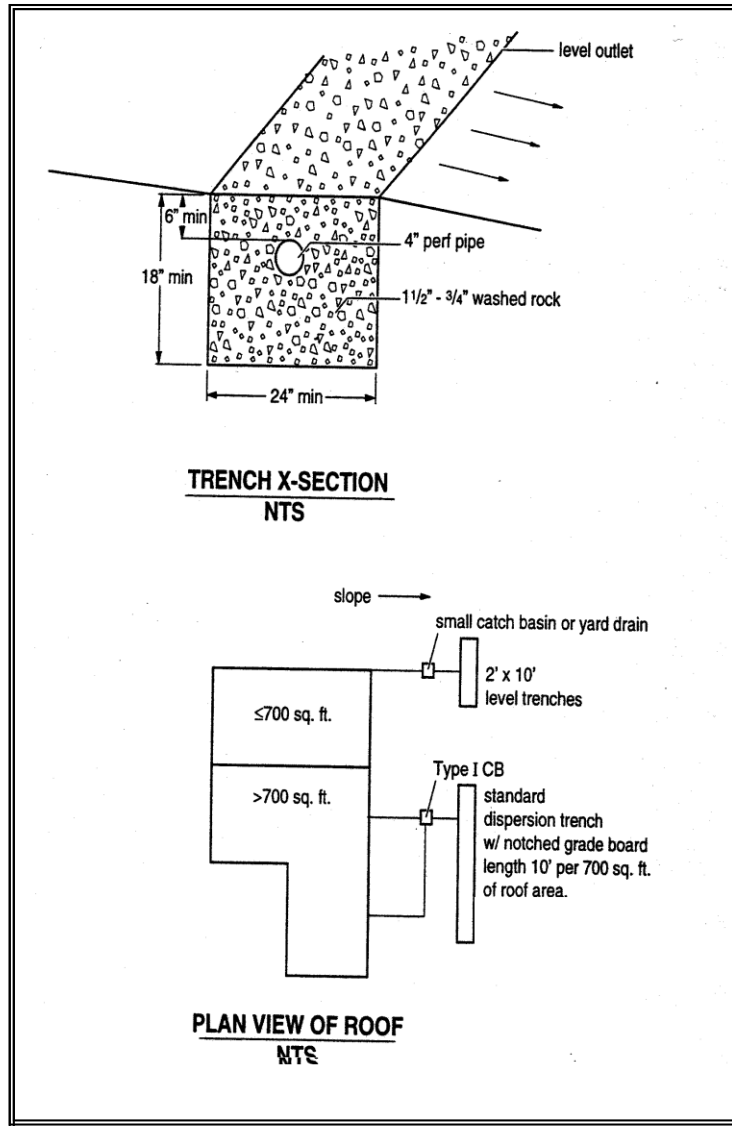


Figure 3.1.5 - Typical Downspout Dispersion Trench

Source: King County

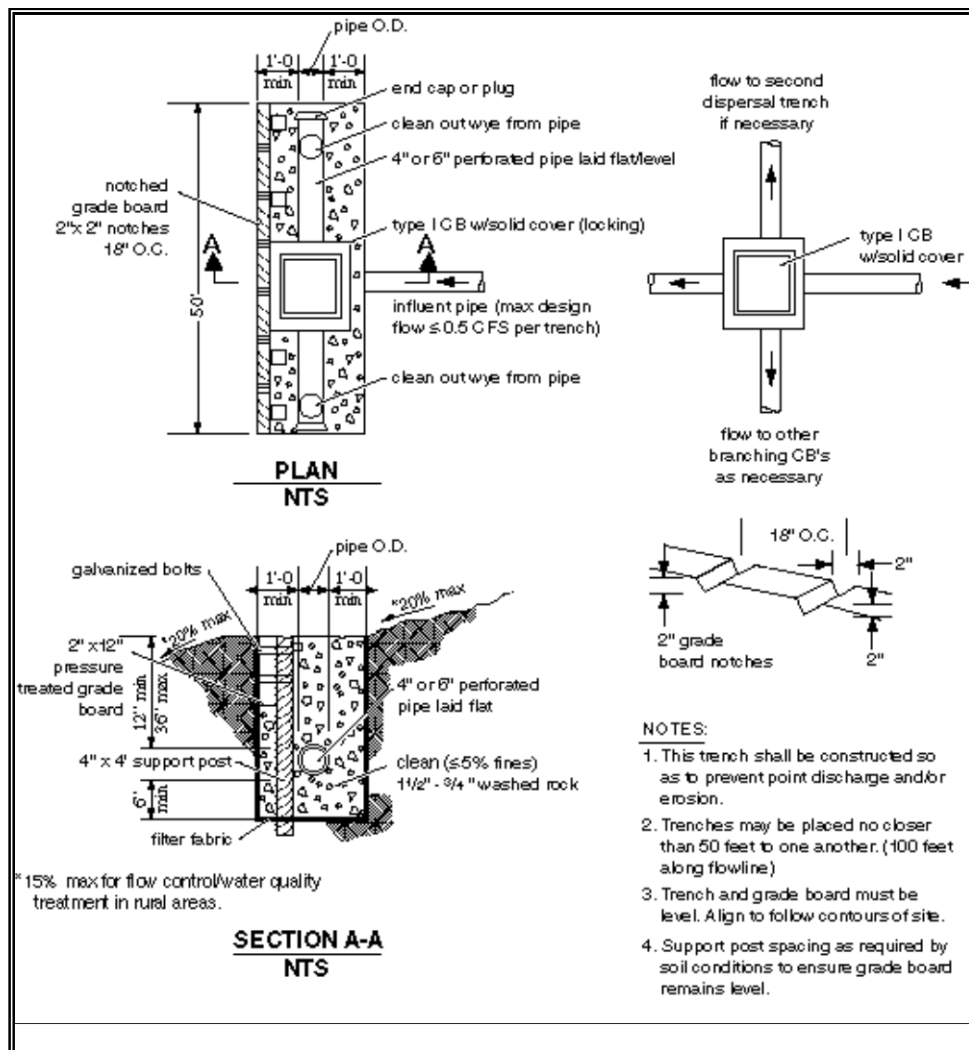


Figure 3.1.6 : Standard Dispersion Trench with Notched Grade Board

Design Criteria for Splashblocks

A typical downspout splashblock is shown in [Figure 3.1.7](#)~~Figure 3.7.~~. In general, if the ground is sloped away from the foundation and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

The following apply to the use of splashblocks:

1. Maintain a vegetated flowpath of at least 50 feet ~~should be maintained~~ between the discharge point and any property line, structure, ~~steep~~ slope, ~~steeper than 15%~~, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
2. A maximum of 700 square feet of roof area may drain to each splashblock.
3. For purposes of maintaining adequate separation of flows discharged from adjacent dispersion devices, the vegetated flowpath segment for the splashblock must not overlap with other flowpath segments, except those associated with sheet flow from a non-native pervious surface.
- 3-4. Place a splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) ~~should be placed~~ at each downspout discharge point.
- 4-5. No erosion or flooding of downstream properties may result.
- 5-6. Have a geotechnical engineer or a licensed geologist, hydrogeologist, or engineering geologist evaluate runoff discharged towards landslide hazard areas ~~must be evaluated by a professional engineer with geotechnical expertise or a qualified geologist.~~ Do not place Splashblocks ~~may not be placed~~ on or above slopes greater than ~~20~~15% or above erosion hazard areas without evaluation by a professional engineer with geotechnical expertise or a licensed geologist, hydrogeologist, or engineering geologist, and ~~jurisdiction~~ approval by the Local Plan Approval Authority.
- 6-7. For sites with septic systems, the discharge point must be downslope of the primary and reserve drainfield areas. This requirement may be waived if site topography clearly prohibits flows from intersecting the drainfield or where site conditions (soil permeability, distance between systems, etc) indicate that this is unnecessary.

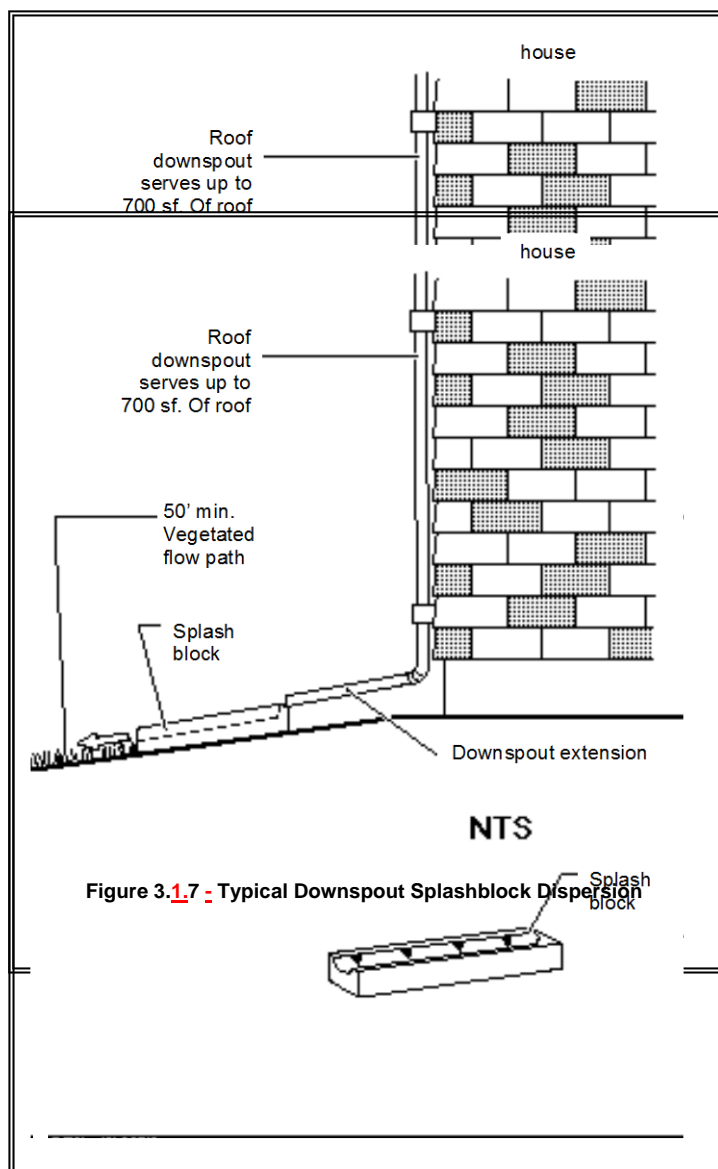


Figure 3.1.7 : Typical Downspout Splashblock Dispersion

Applications & Limitations

3.1.3 Perforated Stub-Out Connections

A perforated stub-out connection is a length of perforated pipe within a gravel-filled trench that is placed between roof downspouts and a stub-out to the local drainage system. ~~Figure 3.1.8~~ ~~Figure 3.8~~ illustrates a perforated stub-out connection. These systems are intended to provide some infiltration during drier months. During the wet winter months, they may provide little or no flow control. ~~Perforated stub-outs are not appropriate when seasonal water table is < 1 foot below trench bottom.~~

Perforated stub-outs are not appropriate when seasonal water table is less than one foot below trench bottom.

~~In single-family subdivision~~ ~~In~~ projects subject to Minimum Requirement ~~#7 for flow control~~ ~~5~~ (see Volume I), perforated stub-out connections may be used only when ~~downspout infiltration or dispersion is all other higher priority on-site stormwater management BMPs are not feasible, per the criteria in Sections 3.1.1 and 3.1.2 for each of those BMPs.~~

~~Select the~~ location of the connection ~~should be selected~~ to allow a maximum amount of runoff to infiltrate into the ground (ideally a dry ~~location on the site that is,~~ relatively well drained) ~~location~~. To facilitate maintenance, ~~do not locate~~ the perforated pipe portion of the system ~~should not be located~~ under impervious or heavily compacted (e.g., driveways and parking areas) surfaces.

~~Perforated stub-out connections should consist of at least 10 feet of perforated pipe per 5,000 square feet of roof area laid in a level, 2-foot wide trench backfilled with washed drain rock. The drain rock should extend to a depth of at least 8 inches below the bottom of the pipe and should cover the pipe. The pipe should be laid level and the rock trench covered with filter fabric and 6 inches of fill (see Figure 3.8).~~

~~Setbacks are~~ ~~Use~~ the same ~~setbacks~~ as for infiltration trenches ~~in Section 3.1.1.~~

~~Potential runoff discharge towards a landslide hazard area must be evaluated by a professional engineer with geotechnical expertise or~~ ~~Have~~ a licensed geologist, hydrogeologist, or engineering geologist ~~evaluate potential runoff discharges towards landslide hazard areas. Do not place the perforated portion of the pipe may not be placed~~ on or above slopes greater than 20% or above erosion hazard areas without evaluation by a professional engineer with geotechnical expertise or qualified geologist and jurisdiction approval.

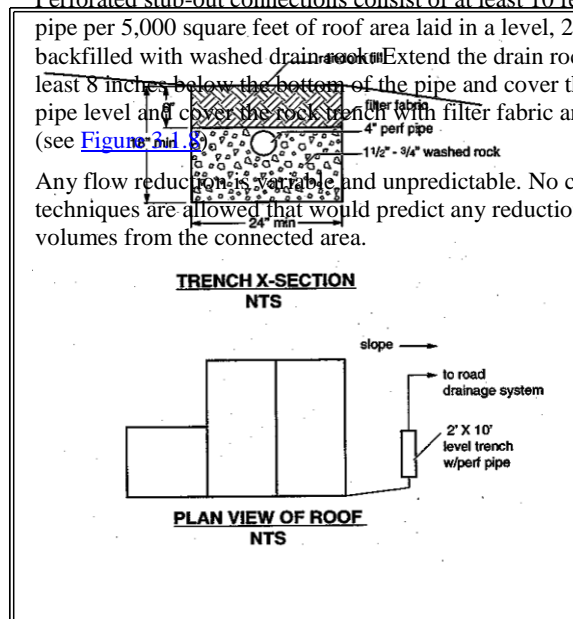
For sites with septic systems, the perforated portion of the pipe must be downgradient of the drainfield primary and reserve areas. This requirement can be waived if site topography will clearly prohibit flows from intersecting the drainfield or where site conditions (soil permeability, distance between systems, etc) indicate that this is unnecessary.

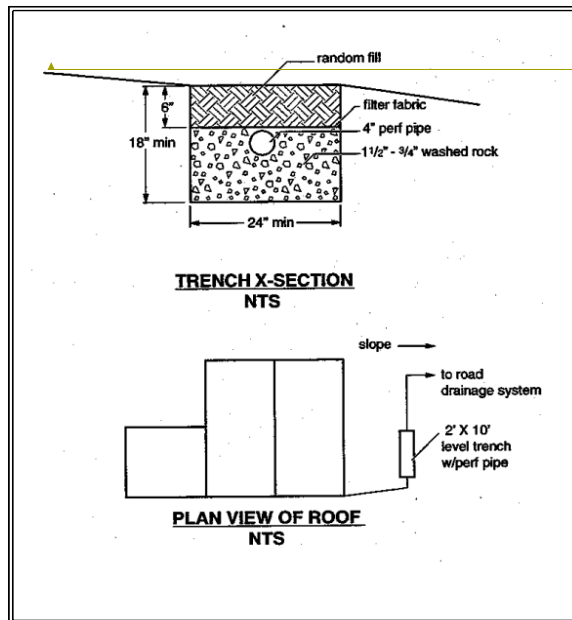
Design Criteria

Perforated stub-out connections consist of at least 10 feet of perforated pipe per 5,000 square feet of roof area laid in a level, 2-foot wide trench backfilled with washed drain rock. Extend the drain rock to a depth of at least 8 inches below the bottom of the pipe and cover the pipe. Lay the pipe level and cover the rock trench with filter fabric and 6 inches of fill (see [Figure 2.1.8](#)).

Runoff Model Representation

Any flow reduction is variable and unpredictable. No computer modeling techniques are allowed that would predict any reduction in flow rates and volumes from the connected area.





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Figure 3.1.8 - Perforated Stub-Out Connection

3.2 Detention Facilities

This section presents the methods, criteria, and details for design and analysis of detention facilities. These facilities provide for the temporary storage of increased surface water runoff resulting from development pursuant to the performance standards set forth in Minimum Requirement #7 for flow control (Volume I).

There are three primary types of detention facilities described in this section: detention ponds, tanks, and vaults.

3.2.1 Detention Ponds

The design criteria in this section are for detention ponds. However, many of the criteria also apply to infiltration ponds (~~Section 3.3~~[Section 3.3](#) and Volume V), and water quality wetponds and combined detention/wetponds (Volume V).

Stormwater detention facilities that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level measured at the embankment crest are subject to the state's dam safety requirements, even if water storage is intermittent and infrequent ([WAC 173-175-020\(1\)](#)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled release of the pond contents. Peak flows from dam failures are typically much larger than the 100-year flows which these ponds are typically designed to accommodate.

The Dam Safety Office of the Department of Ecology uses consequence dependent design levels for critical project elements. There are eight design levels with storm recurrence intervals ranging from 1 in 500 for design step, 1 to 1 in 1,000,000 for design step 8. The specific design step for a particular project depends on the downstream population and other resources that would be at risk from a failure of the dam. Precipitation events more extreme than the 100-year event may be rare at any one location, but have historically occurred somewhere within Washington State every few years on average.

With regard to the engineering design of stormwater detention facilities, the primary effect of the state's dam safety requirements is in sizing the emergency spillway to accommodate the runoff from the dam safety design storm without overtopping the dam. The hydrologic computation procedures are the same as for the original pond design, except that the computations must use more extreme precipitation values and the appropriate dam safety design storm hyetographs. This information is described in detail within guidance documents developed by and available from the Dam Safety Office. In addition to the other design requirements for stormwater detention BMPs described elsewhere in this manual, dam safety requirements should be an integral part of planning and design for

stormwater detention ponds. It is most cost-effective to consider these requirements right from the beginning of the project.

In addition to the hydrologic and hydraulic issues related to precipitation and runoff, other dam safety requirements include geotechnical issues, construction inspection and documentation, dam breach analysis, inundation mapping, emergency action planning, and periodic inspections by project owners and by Dam Safety engineers. All of these requirements, plus procedural requirements for plan review and approval and payment of construction permit fees are described in detail in guidance documents developed by and available from the Dam Safety Office.

In addition to the written guidance documents, Dam Safety engineers are available to provide technical assistance to project owners and design engineers in understanding and addressing the dam safety requirements for their specific project. In the interest of providing a smooth integration of dam safety requirements into the stormwater detention project and streamlining Dam Safety's engineering review and issuance of the construction permit, it is recommended and requested that Dam Safety be contacted early in the facilities planning process. The Dam Safety Office is located in the Ecology headquarters building in Lacey. Electronic versions of the guidance documents in PDF format are available on the Department of Ecology Web site at <http://www.ecy.wa.gov/programs/wr/dams/dss.html>.

Design Criteria

Standard details for detention ponds are shown in [Figure 3.2.1](#) through [Figure 3.2.3](#). Control structure details are provided in [Section 3.2.4](#).

General

1. ~~1.~~ Ponds must be designed as flow-through systems (however, parking lot storage may be utilized through a back-up system; see [Section 3.2.5](#)). Developed flows must enter through a conveyance system separate from the control structure and outflow conveyance system. Maximizing distance between the inlet and outlet is encouraged to promote sedimentation.
2. ~~2.~~ Pond bottoms should be level and be located a minimum of 0.5 foot (preferably 1 foot) below the inlet and outlet to provide sediment storage.
3. ~~3.~~ Design guidelines for outflow control structures are specified in [Section 3.2.4](#).
4. ~~4.~~ A geotechnical analysis and report must be prepared for ~~steep slopes (i.e., slopes over 15%)~~, or if located within 200 feet of the top of a ~~steep~~ slope ~~steeper than 40%~~, or landslide hazard area. The scope of the geotechnical report should include the assessment of impoundment

seepage on the stability of the natural slope where the facility will be located within the setback limits set forth in this section.

Side Slopes

1. ~~1.~~ Interior side slopes up to the emergency overflow water surface should not be steeper than 3H:1V unless a fence is provided (see "Fencing").
2. ~~2.~~ Exterior side slopes must not be steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.
3. ~~3.~~ Pond walls may be vertical retaining walls, provided:
 - ~~(a)~~ They are constructed of reinforced concrete per [Section 3.2.3](#) ~~Section 3.2.3~~, Material: ~~(b)~~.
 - A fence is provided along the top of the wall; ~~(c)~~.
 - The entire pond perimeter may be retaining walls, however, it is recommended that at least 25 percent of the pond perimeter be a vegetated soil slope not steeper than 3H:1V; ~~and (d).~~ If the entire pond perimeter is to be retaining walls, provide ladders on the walls for safety reasons.
 - The design is stamped by a licensed civil engineer with structural expertise.

Other retaining walls such as rockeries, concrete, masonry unit walls, and keystone type wall may be used if designed by a geotechnical engineer or a civil engineer with structural expertise. ~~If the entire pond perimeter is to be retaining walls, ladders should be provided on the walls for safety reasons.~~

Embankments

1. ~~1. Pond berm embankments higher than 6 feet must be designed by~~ Have a professional engineer with geotechnical expertise design pond berm embankments higher than 6 feet.
2. ~~2.~~ For berm embankments 6 feet or less, the minimum top width should be 6 feet or as recommended by a geotechnical engineer.
3. ~~3. Construct~~ pond berm embankments ~~must be constructed~~ on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots, and other organic debris.
4. ~~4. Construct~~ pond berm embankments greater than 4 feet in height ~~must be constructed~~ by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width, unless specified otherwise by a geotechnical engineer.
5. Embankment compaction should be accomplished in such a manner as to produce a dense, low permeability engineered fill that can tolerate

post-construction settlements with a minimum of cracking. Place the embankment fill ~~should be placed~~ on a stable subgrade and ~~compacted~~compact to a minimum of 95% of the Standard Proctor Maximum Density, ASTM Procedure D698. Placement moisture content should lie within 1% dry to 3% wet of the optimum moisture content. The referenced compaction standard may have to be increased to comply with local regulations.

Construct the berm embankment ~~should be constructed~~ of soils with the following characteristics ~~per the United States Department of Agriculture's Textural Triangle~~: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content. Soils outside this specified range can be used, provided the design satisfactorily addresses the engineering concerns posed by these soils. The paramount concerns with these soils are their susceptibility to internal erosion or piping and to surface erosion from wave action and runoff on the upstream and downstream slopes, respectively. *Note: In general, excavated glacial till is well suited for berm embankment material.*

6. ~~6.—~~Place anti-seepage filter-drain diaphragms ~~must be placed~~ on outflow pipes in berm embankments impounding water with depths greater than 8 feet at the design water surface. See Dam Safety Guidelines, Part IV, Section 3.3.B on pages 3-27 to 3-30. An electronic version of the Dam Safety Guidelines is available in PDF format at <https://fortress.wa.gov/ecy/publications/summarypages/9255d.html> ~~www.wa.gov/ecy/publications/summarypages/9255d.html~~.

Overflow

1. ~~1.— In all ponds, tanks, and vaults,~~Provide a primary overflow (usually a riser pipe within the control structure; see [Section 3.2.4](#) ~~Section 3.2.4~~) ~~must be provided~~ in all ponds, tanks, and vaults to bypass the 100-year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows; the primary overflow is intended to protect against breaching of a pond embankment (or overflows of the upstream conveyance system in the case of a detention tank or vault). The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.
2. ~~2.—~~Provide a secondary inlet to the control structure ~~must be provided~~ in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening ("jailhouse window") in the control structure manhole functions as a weir (see [Figure 3.2.2](#) ~~Figure 3.10~~) when used as a secondary inlet. *Note: The maximum circumferential length of this opening must not exceed one-half the control structure circumference. The "birdcage"*

overflow structure as shown in [Figure 3.2.3](#) ~~Figure 3.11~~ may also be used as a secondary inlet.

Emergency Overflow Spillway

1. ~~1.~~—In addition to the above overflow provisions, ponds must have an emergency overflow spillway. For impoundments of 10 acre-feet or greater, the emergency overflow spillway must meet the state's dam safety requirements (see above). For impoundments under 10 acre-feet, ponds must have an emergency overflow spillway that is sized to pass the 100-year developed peak flow in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow spillways are intended to control the location of pond overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.
2. ~~2.~~—Provide emergency overflow spillways ~~must be provided~~ for ponds with constructed berms over 2 feet in height, or for ponds located on grades in excess of 5 percent. As an option for ponds with berms less than 2 feet in height and located at grades less than 5 percent, emergency overflow may be provided by an emergency overflow structure, such as a Type II manhole fitted with a birdcage as shown in [Figure 3.2.3](#) ~~Figure 3.11~~. The emergency overflow structure must be designed to pass the 100-year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a ~~steep slope, steeper than 15%~~, consideration should be given to providing an emergency overflow structure in addition to the spillway.
3. ~~3.~~—Armour the emergency overflow spillway ~~must be armored~~ with riprap in conformance with ~~the "BMP C209: Outlet Protection" BMP~~ in Volume II. The spillway must be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows re-enter the conveyance system (see [Figure 3.2.2](#) ~~Figure 3.10~~).
4. ~~4.~~—Emergency overflow spillway designs must be analyzed as broad-crested trapezoidal weirs as described in Methods of Analysis at the end of this section ~~(Section 3.2.1)~~. Either one of the weir sections shown in [Figure 3.2.2](#) ~~Figure 3.10~~ may be used.

Access

The following guidelines for access may be used.

3. ~~1.~~—Provide maintenance access road(s) ~~should be provided~~ to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures). It is recommended that manhole and catch basin lids be in or at the edge of the access road and at least three feet from a property line.

4. ~~2.~~—An access ramp is needed for removal of sediment with a trackhoe and truck. Extend the ramp ~~must extend~~ to the pond bottom if the pond bottom is greater than 1,500 square feet (measured without the ramp) ~~and it may end at an elevation 4 feet above the pond bottom.~~ If the pond bottom is less than 1,500 square feet (measured without the ramp) ~~), the ramp may end at an elevation 4 feet above the pond bottom.~~

On large, deep ponds, provide truck access to the pond bottom via an access ramp ~~is necessary~~ so loading can be done in the pond bottom. On small deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wetpond or combined pond (trackhoes can negotiate interior pond side slopes).

5. ~~3.~~—The internal berm of a wetpond, or combined detention and wetpond, may be used for access if ~~if~~ all of the following apply:
- The internal berm is no more than 4 feet above the first wetpool cell, ~~if~~.
 - The first wetpool cell is less than 1,500 square feet (measured without the ramp) ~~, and if it~~.
 - The internal berm is designed to support a loaded truck, considering the berm is normally submerged and saturated.
- ~~5-6.~~ ~~4.~~—Access ramps must meet the requirements for design and construction of access roads specified below.
- ~~6-7.~~ ~~5.~~—If a fence is required, access should be limited by a double-posted gate or by bollards ~~—that is~~, two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

Design of Access Roads

The design guidelines for access ~~road are given below~~ roads:

1. ~~1.~~—A maximum grade ~~should be of~~ 15 percent %.
2. ~~2.~~—A minimum of 40 feet outside turning radius ~~should be a minimum of 40 feet~~.
3. ~~3.~~—Locate fence gates ~~should be located~~ only on straight sections of road.
4. ~~4.~~—Access roads ~~should be~~ 15 feet in width on curves and 12 feet on straight sections.
5. Provide a paved apron ~~must be provided~~ where access roads connect to paved public roadways.

Construction of Access Roads

Construct access roads ~~may be constructed with an asphalt or permeable pavement~~, gravel surface, or modular grid pavement. All surfaces must conform to the jurisdictional standards and manufacturer's specifications.

Fencing

1. ~~4.—~~A fence is needed at the emergency overflow water surface elevation, or higher, where a pond interior side slope is steeper than 3H:1V, or where the impoundment is a wall greater than 24 inches in height. The fence need only be constructed for those slopes steeper than 3H:1V. ~~Note, however, that~~ Other regulations such as the International Building Code or Uniform Building Code may require fencing of vertical walls. If more than 10 percent of slopes are steeper 3H:1V, it is recommended that the entire pond be fenced.

~~Also note that~~ Detention ponds on school sites will need to comply with safety standards developed by the Department of Health (DOH) and the Superintendent for Public Instruction (SPI). These standards include what is called a 'non-climbable fence.' One example of a non-climbable fence is a chain-link fence with a tighter mesh, so children cannot get a foot-hold for climbing. For school sites, and possibly for parks and playgrounds, the designer should consult the DOH's Office of Environmental Programs.

~~A fence is needed to~~Fences discourage access to portions of a pond where steep side slopes (steeper than 3:1) increase the potential for slipping into the pond. Fences also serve to guide those who have fallen into a pond to side slopes that are flat enough (flatter than 3:1 and unfenced) to allow for easy escape.

2. ~~2.—~~It is recommended that fences be 6 feet in height. For example designs, see WSDOT Standard Plan L-2, Type 1 or Type 3 chain link fence. The fence may be a minimum of 4 feet in height if the depth of the impoundment (measured from the lowest elevation in the bottom of the impoundment, directly adjacent to the bottom of the fenced slope, up to the emergency overflow water surface) is 5 feet or less. For example designs, see WSDOT Standard Plan L-2, Type 4 or Type 6 chain link fence.
3. ~~3.—~~Access road gates may be 16 feet in width consisting of two swinging sections 8 feet in width. Provide additional vehicular access gates ~~may be as~~ needed to facilitate maintenance access.
4. ~~4.—~~Pedestrian access gates (if needed) should be 4 feet in width.
5. ~~5.—~~Vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating can be used as fence material. For steel fabric fences, consider the following aesthetic features ~~may be considered~~:
 - a) ~~a) —~~ Vinyl coating that is compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in

wooded areas). All posts, cross bars, and gates may be painted or coated the same color as the vinyl clad fence fabric.

- b) ~~b)~~ Fence posts and rails that conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.
- 6. ~~6.~~ For metal baluster fences, Uniform Building Code standards apply.
- 7. ~~7.~~ Wood fences may be used in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners.
- 8. ~~8.~~ Wood fences should have pressure treated posts (ground contact rated) either set in 24-inch deep concrete footings or attached to footings by galvanized brackets. Rails and fence boards may be cedar, pressure-treated fir, or hemlock.
- 9. ~~9.~~ Where only short stretches of the pond perimeter (< 10 percent) have side slopes steeper than 3:1, use split rail fences (3-foot minimum height) or densely planted thorned hedges (e.g., barberry, holly, etc.) ~~may be used~~ in place of a standard fence.

Signage

Detention ponds, infiltration ponds, wetponds, and combined ponds should have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. An example of sign specifications for a permanent surface water control pond is illustrated in [Figure 3.2.4](#) ~~Figure 3.12.~~

Right-of-Way

Right-of-way may be needed for detention pond maintenance. It is recommended that any tract not abutting public right-of-way have 15-20 foot wide extension of the tract to an acceptable access location.

Setbacks

It is recommended that facilities be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government. The detention pond water surface at the pond outlet invert elevation must be set back 100 feet from proposed or existing septic system drainfields. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All facilities must be a minimum of 50 feet from the top of any steep (greater than 15 ~~percent~~%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on a ~~steep slope~~ steeper than 15%.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow ~~groundwater~~ ground water source (interflow) flowing along a relatively impermeable soil stratum. These flows are storm driven and should

discontinue after a few weeks of dry weather. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper ~~groundwater~~ground water source. When continuous flows are intercepted and directed through flow control facilities, adjustments to the facility design may have to be made to account for the additional base flow ~~(unless already considered in design).~~

Planting Requirements

Sod or seed exposed earth on the pond bottom and interior side slopes ~~should be sodded or seeded~~ with an appropriate seed mixture. Plant all remaining areas of the tract ~~should be planted~~ with grass or ~~be landscaped~~landscape and ~~mulched~~mulch with a 43-inch cover of hog fuel or shredded wood mulch. Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch should be free of garbage and weeds and should not contain excessive resin, tannin, or other material detrimental to plant growth. Do not use construction materials wood debris or wood treated with preservatives for producing shredded wood mulch.

Landscaping

Landscaping is encouraged for most stormwater tract areas (see below for areas not to be landscaped). However, if provided, landscaping should adhere to the criteria that follow so as not to hinder maintenance operations. Landscaped stormwater tracts may, in some instances, provide a recreational space. In other instances, “naturalistic” stormwater facilities may be placed in open space tracts.

~~The following~~Follow these guidelines ~~should be followed~~ if landscaping is proposed for facilities:-

1. ~~4.—No~~Do not plant trees or shrubs ~~may be planted on berms meeting the criteria of dams regulated for safety.~~
- ~~1-2.~~2. Do not plant trees or shrubs within 10 feet of inlet or outlet pipes or manmade drainage structures such as spillways or flow spreaders. Avoid using species with roots that seek water, such as willow or poplar, ~~should be avoided~~ within 50 feet of pipes or manmade structures.
- ~~2-3.~~2. ~~Planting should be restricted~~Restrict planting on berms that impound water ~~either~~ permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.
 - a) ~~a) —~~Do not plant trees or shrubs ~~may not be planted~~ on portions of water- impounding berms taller than four feet high. Plant only grasses ~~may be planted~~ on berms taller than four feet.Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

- b) ~~b)~~—Trees planted on portions of water-impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system. ~~Table 3.2.1~~ ~~Table 3.4~~ gives some examples of trees with these characteristics developed for the central Puget Sound.

These trees reduce the likelihood of blow-down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.

Note: The internal berm in a wetpond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.

- ~~3-4.~~ 3.—Plant all landscape material, including grass, ~~should be planted~~ in good topsoil. Make native underlying soils ~~may be made~~ suitable for planting ~~if amended by amending~~ with 4 inches of well-aged compost tilled into the subgrade. Compost used should meet specifications for Grade A compost quality as described in Ecology publication 94-38.
- ~~4-5.~~ 4.—Soil in which trees or shrubs are planted may need additional enrichment or additional compost top-dressing. Consult a ~~nurseryman~~ nursery, landscape professional, or arborist for site-specific recommendations.
- ~~5-6.~~ 5.—For a naturalistic effect as well as ease of maintenance, plant trees or ~~shrubs should be planted~~ in clumps to form “landscape islands” rather than ~~spacing~~ evenly spaced.
- ~~6-7.~~ 6.—The landscaped islands should be a minimum of six feet apart, and if set back from fences or other barriers, the setback distance should also be a minimum of 6 feet. Where tree foliage extends low to the ground, the six feet setback should be counted from the outer drip line of the trees (estimated at maturity).
- This setback allows a 6-foot wide mower to pass around and between clumps.
- ~~7.~~ 7.—~~Evergreen trees and trees which produce relatively little leaf fall (such as Oregon ash, mimosa, or locust) are preferred in areas draining to the pond.~~
- ~~8.~~ 8.—~~Trees should be set back~~ Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating. Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar, etc.) typically have fewer leaves than other deciduous trees.
- In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Setback trees

so ~~that the~~ branches ~~do will~~ not extend over the pond ~~(to prevent leaf drop into the water).~~

7.9. Drought tolerant species are recommended.

Table 3.2.1 Small Trees and Shrubs with Fibrous Roots	
Small Trees / High Shrubs	Low Shrubs
* Red twig dogwood (<i>Cornus stolonifera</i>)	* Snowberry (<i>Symphoricarpos albus</i>)
* Serviceberry (<i>Amelanchier alnifolia</i>)	* Salmonberry (<i>Rubus spectabilis</i>)
* Filbert (<i>Corylus cornuta</i> , others)	Rosa rugosa (avoid spreading varieties)
Highbush cranberry (<i>Vaccinium opulus</i>)	Rock rose (<i>Cistus spp.</i>)
Blueberry (<i>Vaccinium spp.</i>)	Ceanothus spp. choose hardier varieties)
Fruit trees on dwarf rootstock	New Zealand flax (<i>Phormium penax</i>)
Rhododendron (native and ornamental varieties)	Ornamental grasses (e.g., <i>Miscanthis</i> , <i>Pennisetum</i>)
* Native species	

Guidelines for Naturalistic Planting. Stormwater facilities may sometimes be located within open space tracts if “natural appearing.” Two generic kinds of naturalistic planting are outlined below, but other options are also possible. Native vegetation is preferred in naturalistic plantings.

Open Woodland. In addition to the general landscaping guidelines above, the following are recommended.

1. ~~4.—~~Landscaped islands (when mature) should cover a minimum of 30 percent or more of the tract, exclusive of the pond area.
2. ~~2.—~~Underplant tree clumps ~~should be underplanted~~ with shade-tolerant shrubs and groundcover plants. The goal is to provide a dense understory that need not be weeded or mowed.
3. ~~3.—~~Place landscaped islands ~~should be placed~~ at several elevations rather than “ring” the pond, and vary the size of clumps ~~should vary~~ from small to large to create variety.
4. ~~4.—~~Not all islands need to have trees. Shrub or groundcover clumps are acceptable, but lack of shade should be considered in selecting vegetation.

Note: Landscaped islands are best combined with the use of wood-based mulch (hog fuel) or chipped ~~on-site~~ on-site vegetation for erosion control

(only for slopes above the flow control water surface). *It is often difficult to sustain a low-maintenance understory if the site was previously hydroseeded. Compost or composted mulch (typically used for constructed wetland soil) can be used below the flow control water surface (materials that are resistant to and preclude flotation). The method of construction of soil landscape systems can also cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations.*

Northwest Savannah or Meadow. In addition to the general landscape guidelines above, the following are recommended.

1. ~~4.—~~Landscape islands (when mature) should cover 10 percent or more of the site, exclusive of the pond area.
2. ~~2.—~~Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.
3. ~~3.—~~**Place** landscape islands ~~should be placed~~ at several elevations rather than “ring” the pond.

Plant the remaining site area ~~should be planted~~ with an appropriate grass seed mix, which may include meadow or wildflower species. Native or dwarf grass mixes are preferred. [Table 3.2.2](#) ~~Table 3.2~~ below gives an example of dwarf grass mix developed for central Puget Sound. **Apply** grass seed ~~should be applied~~ at 2.5 to 3 pounds per 1,000 square feet.

Note: Amended soil or good topsoil is required for all plantings.

Creation of areas of emergent vegetation in shallow areas of the pond is recommended. Native wetland plants, such as sedges (*Carex* sp.), bulrush (*Scirpus* sp.), water plantain (*Alisma* sp.), and burreed (*Sparganium* sp.) are recommended. If the pond does not hold standing water, a clump of wet-tolerant, non-invasive shrubs, such as salmonberry or snowberry, is recommended below the detention design water surface.

Note: This landscape style is best combined with the use of grass or sod for site stabilization and erosion control.

Seed Mixes. The seed mixes listed below were developed for central Puget Sound.

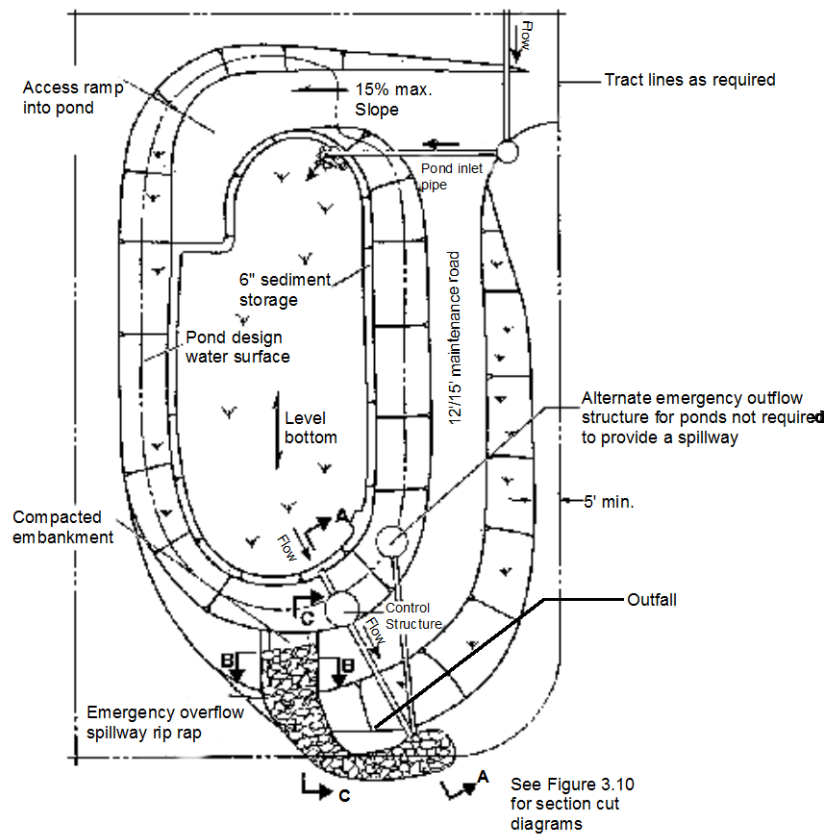
Table 3.2.2 Stormwater Tract “Low Grow” Seed Mix	
Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye “Bardlay”*	30%
Red fescue	25%
Colonial bentgrass	5%

Table 3.2.2
Stormwater Tract "Low Grow" Seed Mix

Seed Name	Percentage of Mix
-----------	-------------------

* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perennial rye can be reduced proportionately to the amount of wildflower seed used.

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Note:
This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

Figure 3.9-2.1 - Typical Detention Pond

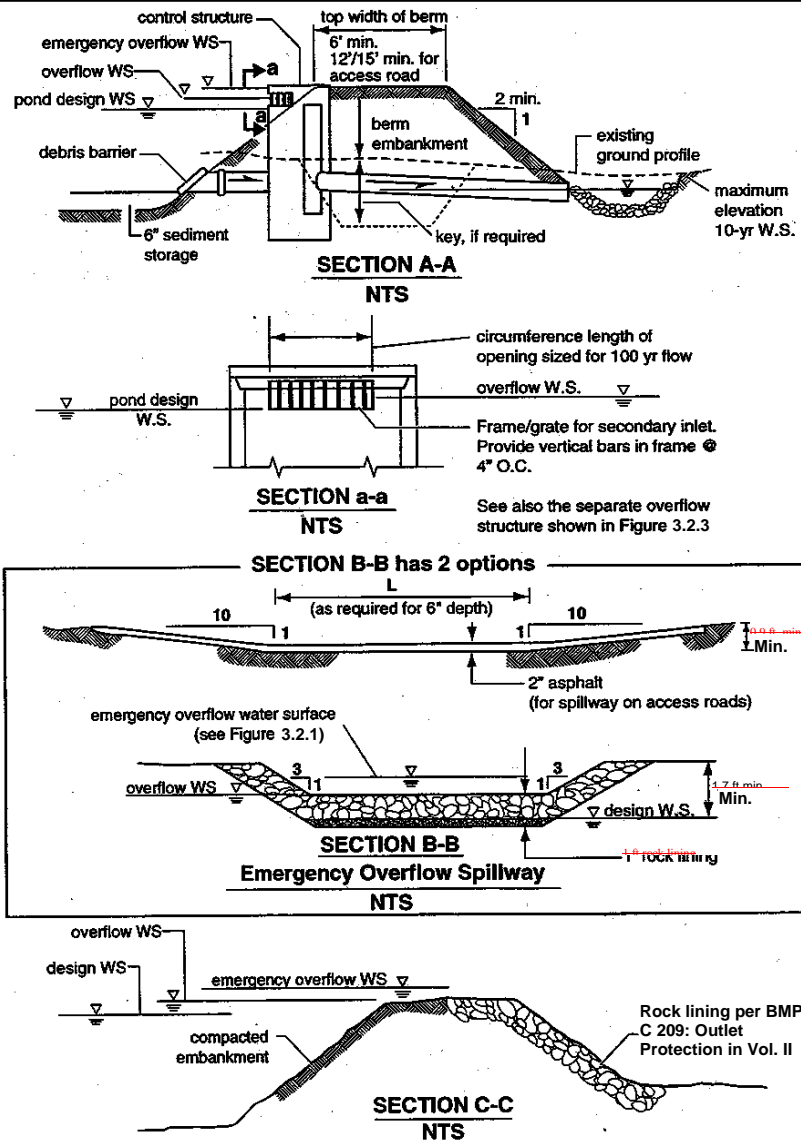


Figure 3.10-2.2 - Typical Detention Pond Sections

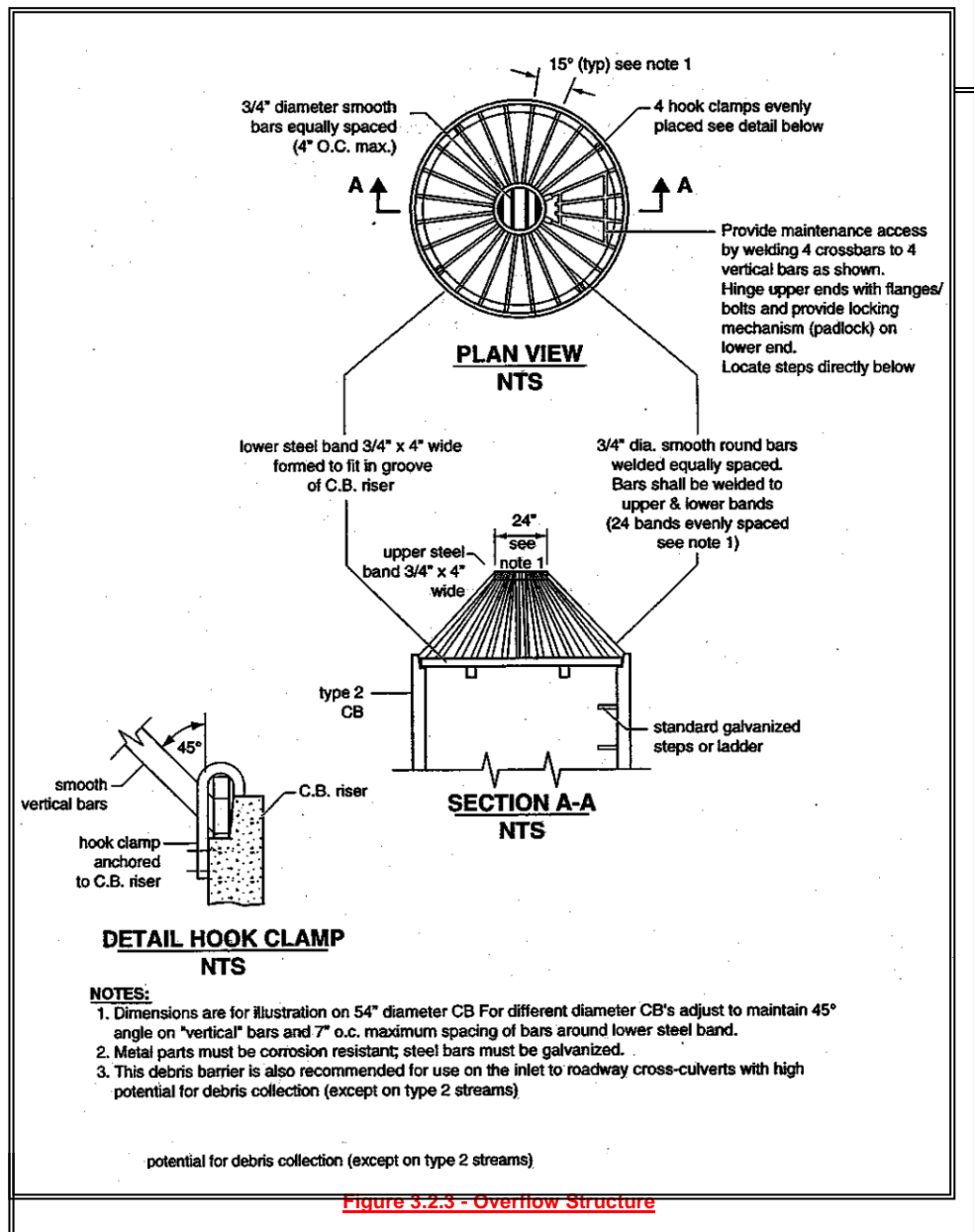
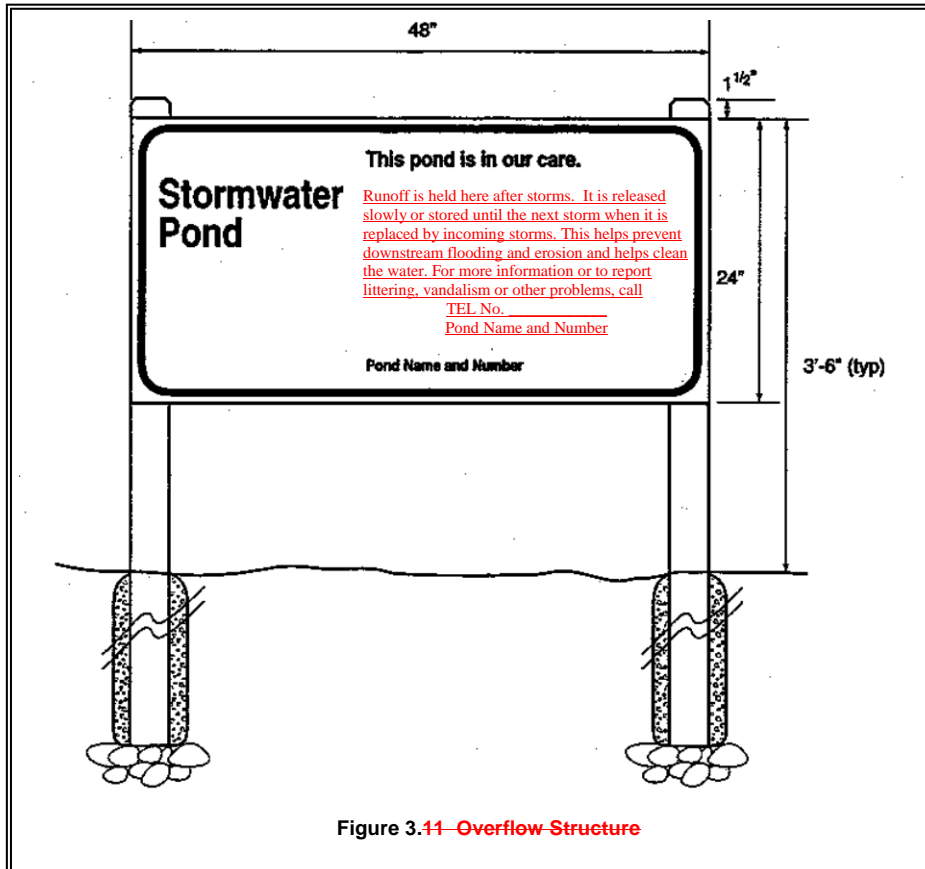
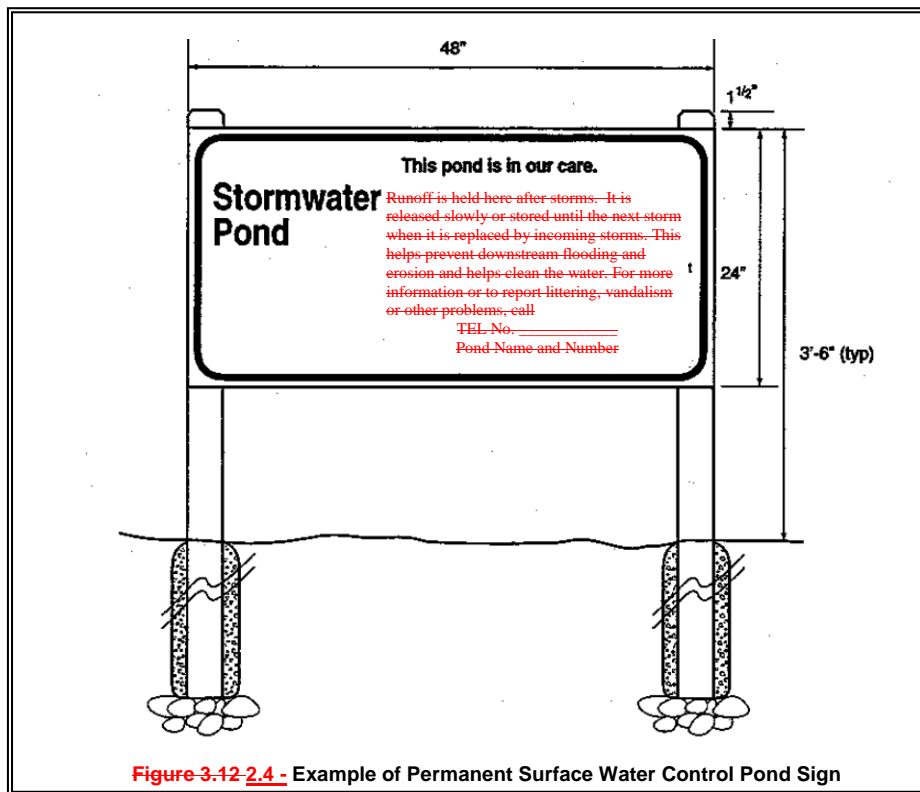


Figure 3.2.3 - Overflow Structure





Sample Specifications:

- Size: 48 inches by 24 inches
- Material: 0.125-gauge aluminum
- Face: Non-reflective vinyl or 3 coats outdoor enamel (sprayed).
- Lettering: Silk screen enamel where possible, or vinyl letters.
- Colors: Beige background, teal letters.
- Type face: Helvetica condensed. Title: 3 inch; Sub-Title: 1 1/2 inch; Text: 1 inch; Outer border: 1/8 inch border distance from edge: 1/4 inch; all text 1 3/4 inch from border.
- Posts: Pressure treated, beveled tops, 1 1/2 inch higher than sign.
- Installation: Secure to chain link fence if available. Otherwise install on two 4"x4" posts, pressure treated, mounted atop gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter). Top of sign no higher than 42 inches from ground surface.
- Placement: Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g. manholes, spillways, pipe inlets).
- Special Notes: This facility is lined to protect ~~groundwater~~ ground water (if a liner that restricts infiltration of stormwater exists).

Maintenance

General. Maintenance is of primary importance if detention ponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or some individual must accept the responsibility for maintaining the structures and the impoundment area. Formulate a specific maintenance plan ~~must be formulated~~ outlining the schedule and scope of maintenance operations. Achieve debris removal in detention basins ~~can be achieved through the use of~~ by using trash racks or other screening devices.

Design with maintenance in mind. Good maintenance will be crucial to successful use of the impoundment. Hence, build in provisions to facilitate maintenance operations ~~must be built~~ into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Table 3.2.3 ~~Table 3.3~~ for specific maintenance requirements.

Handle any standing water and sediments removed during the maintenance operation ~~must be disposed of to~~ in a sanitary sewer at an approved discharge location ~~Pretreatment may be necessary. Residuals must be disposed in accordance~~ manner consistent with ~~state and local solid waste regulations (See Minimum Functional Standards For Solid Waste Handling, Chapter 173-304 WAC). Appendix IV-G in Volume IV.~~

Vegetation. If a shallow marsh is established, then periodic removal of dead vegetation may be necessary. Since decomposing vegetation can release pollutants captured in the wet pond, especially nutrients, it may be necessary to harvest dead vegetation annually prior to the winter wet season. Otherwise the decaying vegetation can export pollutants out of the pond and also can cause nuisance conditions to occur. If harvesting is to be done in the wetland, have a wetland scientist prepare a written harvesting procedure ~~should be prepared by a wetland scientist~~ and submitted it with the drainage design to the local government.

Sediment. Maintenance of sediment forebays and attention to sediment accumulation within the pond is extremely important. Continually monitor sediment deposition ~~should be continually monitored~~ in the basin. Owners, operators, and maintenance authorities should be aware that significant concentrations of metals (e.g., lead, zinc, and cadmium) as well as some organics such as pesticides, may be expected to accumulate at the bottom of these treatment facilities. ~~Testing of~~ Regularly conduct testing sediment, especially near points of inflow, ~~should be conducted regularly~~ to determine the leaching potential and level of accumulation of potentially hazardous material before disposal.

**Table 3.2.3
Specific Maintenance Requirements for Detention Ponds**

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted Integrated Pest Management (IPM) policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department). Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required.
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants. (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department and Ecology Dam Safety Office if pond exceeds 10 acre feet).

Table 3.2.3
Specific Maintenance Requirements for Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies).
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies.
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove. If dead, diseased, or dying trees are identified. (Use a certified Arborist to determine health of tree or removal requirements).	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard trees.
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.

Table 3.2.3 Specific Maintenance Requirements for Detention Ponds			
Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Have a Goethechnical engineer inspect and evaluate discernable water flow conditions and recommend repairs).	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways create blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Have a Goethechnical engineer inspect and evaluate discernable water flow conditions and recommend repairs).	Piping eliminated. Erosion potential resolved.
Emergency Overflow/S pillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side slopes of Pond"	

Methods of Analysis

Detention Volume and Outflow. Design volumes and outflows for detention ponds in accordance with Minimum Requirements #7 in Volume I and the hydrologic analysis and design methods in [Chapter 2](#) of this Volume. Design guidelines for restrictor orifice structures are given in [Section 3.2.4](#).

Note: The design water surface elevation is the highest elevation which occurs in order to meet the required outflow performance for the pond.

Detention Ponds in Infiltrative Soils. Detention ponds may occasionally be sited on till soils that are sufficiently permeable for a properly functioning infiltration system (see [Section 3.3](#)~~Section 3.3~~). These detention ponds have a surface discharge and may also utilize infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements of [Section 3.3](#)~~Section 3.3~~ for infiltration ponds, including a soils report, testing, ~~groundwater~~[groundwater](#) protection, pre-settling, and construction techniques.

Emergency Overflow Spillway Capacity. For impoundments under 10-acre-feet, the emergency overflow spillway weir section must be designed to pass the 100-year runoff event for developed conditions assuming a broad-crested weir. The **broad-crested weir equation** for the spillway section in [Figure 3.2.5](#)~~Figure 3.13.1~~ for example, would be:

$$Q_{100} = C (2g)^{1/2} \left[\frac{2}{3} LH^{3/2} + \frac{8}{15} (\tan \theta) H^{5/2} \right] \quad (\text{equation 1})$$

Where Q_{100} = peak flow for the 100-year runoff event (cfs)
 C = discharge coefficient (0.6)
 g = gravity (32.2 ft/sec²)
 L = length of weir (ft)
 H = height of water over weir (ft)
 θ = angle of side slopes

Q_{100} is either the peak 10-minute flow computed from the 100-year, 24-hour storm and a Type 1A distribution, or the 100-year, 1-hour flow, indicated by an approved continuous runoff model, multiplied by a factor of 1.6.

Assuming $C = 0.6$ and $\tan \theta = 3$ (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21 [LH^{3/2} + 2.4 H^{5/2}] \quad (\text{equation 2})$$

To find width L for the weir section, the equation is rearranged to use the computed Q_{100} and trial values of H (0.2 feet minimum):

$$L = [Q_{100} / (3.21H^{3/2})] - 2.4 H \quad \text{or} \quad 6 \text{ feet minimum} \quad (\text{equation 3})$$

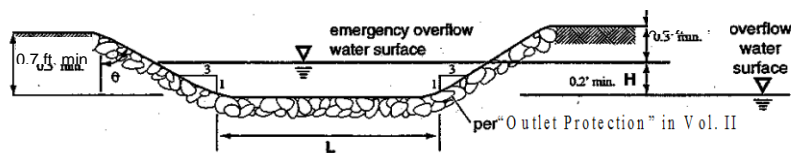


Figure 3.2.5: Weir Section for Emergency Overflow Spillway

3.2.2 Detention Tanks

Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in [Figure 3.2.6](#) [Figure 3.14](#) and [Figure 3.2.7](#) [Figure 3.15](#). Control structure details are shown in [Section 3.2.4](#) [Section 3.2.4](#).

Design Criteria

General. Typical design guidelines are as follows:

1. Tanks may be designed as flow-through systems with manholes in line (see [Figure 3.2.6](#) [Figure 3.14](#)) to promote sediment removal and facilitate maintenance. Tanks may be designed as back-up systems if preceded by water quality facilities, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank.
2. Locate the detention tank bottom ~~should be located~~ 0.5 feet below the inlet and outlet to provide dead storage for sediment.
3. The Use a 36-inch minimum pipe diameter ~~for a detention tank is 36 inches.~~
4. Tanks larger than 36 inches may be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe.
5. Refer to the details of outflow control structures ~~are given in~~ [Section 3.2.4](#) [Section 3.2.4](#).

Note: Control and access manholes should have additional ladder rungs to allow ready access to all tank access pipes when the catch basin sump is filled with water (see [Figure 3.2.9](#) [Figure 3.17](#), plan view).

Materials. Galvanized metals leach zinc into the environment, especially in standing water situations. This can result in zinc concentrations that can be toxic to aquatic life. Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other

metals, such as aluminum or stainless steel, or plastics are available, they should be used.

Pipe material, joints, and protective treatment for tanks should be in accordance with Section 9.05 of the *WSDOT/APWA Standard Specification*.

Structural Stability. Tanks must meet structural requirements for overburden support and traffic loading if appropriate. Accommodate H-20 live loads ~~must be accommodated~~ for tanks lying under parking areas and access roads. Design metal tank end plates ~~must be designed~~ for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gage material than the pipe and/or require reinforcing ribs. ~~Tanks must be placed~~ Place tanks on stable, well consolidated native material with a suitable bedding. ~~Tanks must~~ Do not be placed place tanks in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Buoyancy. In moderately pervious soils where seasonal ~~groundwater~~ ground water may induce flotation, balance buoyancy tendencies ~~must be balanced by~~ either ~~by~~ ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the ~~groundwater~~ ground water table. Calculations that demonstrate stability must be documented.

Access. The following guidelines for access may be used.

1. ~~4.—~~ The maximum depth from finished grade to tank invert should be 20 feet.
2. ~~2.—~~ Position access openings ~~should be positioned~~ a maximum of 50 feet from any location within the tank.
3. ~~3.—~~ All tank access openings may have round, solid locking lids (usually 1/2 to 5/8-inch diameter Allen-head cap screws).
4. ~~4.—~~ Thirty-six-inch minimum diameter CMP riser-type manholes (Figure 3.2.7 (Figure 3.15)) of the same gage as the tank material may be used for access along the length of the tank and at the upstream terminus of the tank in a backup system. The top slab is separated (1-inch minimum gap) from the top of the riser to allow for deflections from vehicle loadings without damaging the riser tank.
5. ~~5.—~~ Make all tank access openings ~~must be~~ readily accessible by maintenance vehicles.
6. ~~6.—~~ Tanks must comply with the OSHA confined space requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Access Roads. Access roads are needed to all detention tank control structures and risers. ~~The~~Design and construct access roads ~~must be designed and constructed~~ as specified for detention ponds in [Section 3.2.1](#)~~Section 3.2.1.~~

Right-of-Way. Right-of-way may be needed for detention tank maintenance. It is recommended that any tract not abutting public right-of-way have a 15 to 20-foot wide extension of the tract to accommodate an access road to the facility.

Setbacks. It is recommended that facilities be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

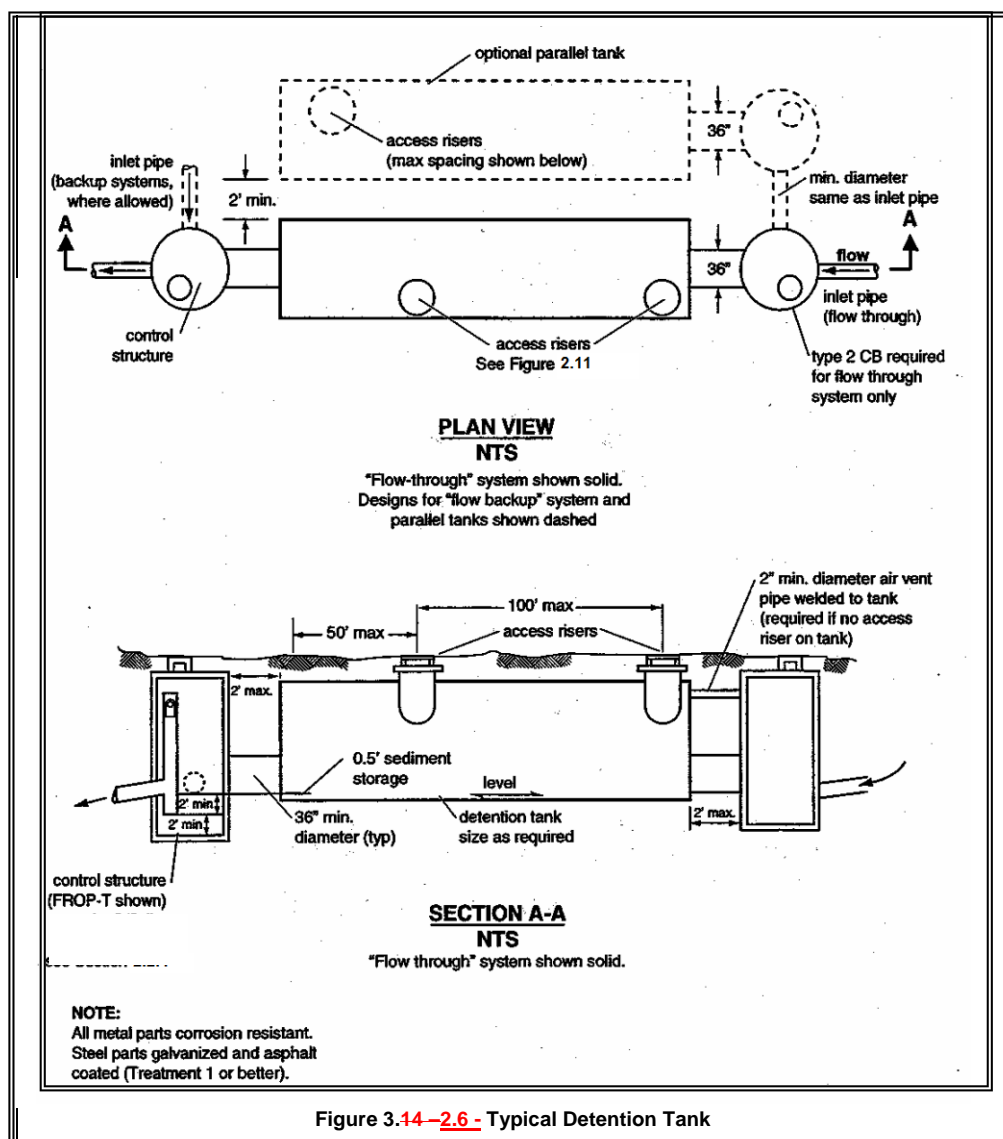
All facilities must be a minimum of 50 feet from the top of any steep (greater than 15 ~~percent~~%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on a ~~steep slope~~ steeper than 15%.

Maintenance. Build in provisions to facilitate maintenance operations ~~must be built~~ into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See [Table 3.2.4](#)~~Table 3.4~~ for specific maintenance requirements.

Table 3.2.4 Specific Maintenance Requirements for Detention Vaults/Tanks			
Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.

Methods of Analysis Detention Volume and Outflow

The volume and outflow design for detention tanks must be in accordance with Minimum Requirement #7 in Volume I and the hydrologic analysis and design methods in [Chapter 2](#). Restrictor and orifice design are given in [Section 3.2.4](#).



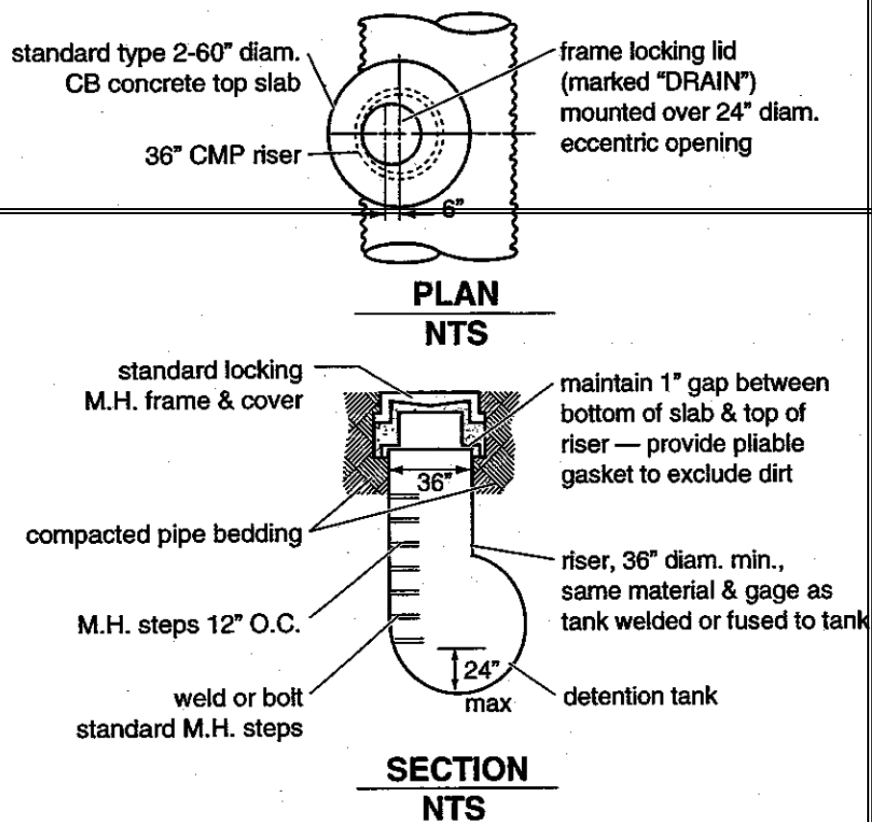


Figure 3.15 — Detention Tank Access Detail

Notes:

1. Use adjusting blocks as required to bring frame to grade.
2. All materials to be aluminum or galvanized and asphalt coated (Treatment 1 or better).
3. Must be located for access by maintenance vehicles.
4. May substitute WSDOT special Type IV manhole (RCP only).

Figure 3.2.7 - Detention Tank Access Detail

3.2.3 Detention Vaults

Detention vaults are box-shaped underground storage facilities typically constructed with reinforced concrete. A standard detention vault detail is shown in [Figure 3.2.8](#)~~Figure 3.16.~~. Control structure details are shown in [Section 3.2.4](#)~~Section 3.2.4.~~

Design Criteria

General. Typical design guidelines are as follows:

1. ~~4.~~—Detention vaults may be designed as flow-through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Maximize the distance between the inlet and outlet ~~should be maximized~~ (as feasible).
2. ~~2.~~—The detention vault bottom may slope at least 5 percent from each side towards the center, forming a broad “v” to facilitate sediment removal. More than one “v” may be used to minimize vault depth. However, the vault bottom may be flat with 0.5-1 foot of sediment storage if removable panels are provided over the entire vault. It is recommended that the removable panels be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
3. ~~3.~~—Elevate the invert elevation of the outlet ~~should be elevated~~ above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. Also, elevate the outlet ~~should also be elevated~~ a minimum of 2 feet above the orifice to retain oil within the vault.
4. ~~4.~~—Details of outflow control structures are given in [Section 3.2.4](#)~~Section 3.2.4.~~

Materials. Minimum 3,000 psi structural reinforced concrete may be used for detention vaults. Provide all construction joints ~~must be provided~~ with water stops.

Structural Stability. All vaults must meet structural requirements for overburden support and H-20 traffic loading (See Standard Specifications for Highway Bridges, 1998 Interim Revisions, American Association of State Highway and Transportation Officials). Vaults located under roadways must meet any live load requirements of the local government. Design cast-in-place wall sections ~~must be designed~~ as retaining walls. Structural designs for cast-in-place vaults must be stamped by a licensed civil engineer with structural expertise. ~~Vaults must be placed~~Place vaults on stable, well-consolidated native material with suitable bedding. ~~Vaults must~~Do not be placedplace vaults in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Access. ~~Access must be provided~~ Provide access over the inlet pipe and outlet structure. Use the following guidelines for access ~~may be used~~.

1. ~~4.~~—Position access openings ~~should be positioned~~ a maximum of 50 feet from any location within the tank. Additional access points may be

- needed on large vaults. Provide access to each “v” if more than one “v” is provided in the vault floor, ~~access to each “v” must be provided.~~
2. ~~2.—~~For vaults with greater than 1,250 square feet of floor area, provide a 5' by 10' removable panel ~~should be provided~~ over the inlet pipe (instead of a standard frame, grate and solid cover). ~~Alternatively, Or,~~ provide a separate access vault ~~may be provided~~ as shown in [Figure 3.2.8](#) ~~Figure 3.16.~~
 3. ~~3.—~~For vaults under roadways, locate the removable panel ~~must be located~~ outside the travel lanes. ~~Alternatively, Or, provide~~ multiple standard locking manhole covers ~~may be provided.~~ Ladders and hand-holds need only be provided at the outlet pipe and inlet pipe, and as needed to meet OSHA confined space requirements. Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes as specified in Item 10 below.
 4. ~~4.—~~All access openings, except those covered by removable panels, may have round, solid locking lids, or 3-foot square, locking diamond plate covers.
 5. ~~5.—~~Vaults with widths 10 feet or less must have removable lids.
 6. ~~6.—~~The maximum depth from finished grade to the vault invert should be 20 feet.
 7. ~~7.—~~Provide internal structural walls of large vaults ~~should be provided~~ with openings sufficient for maintenance access between cells. Size and situate the openings ~~should be sized and situated~~ to allow access to the maintenance “v” in the vault floor.
 8. ~~8.—~~The minimum internal height should be 7 feet from the highest point of the vault floor (not sump), and the minimum width should be 4 feet. However, concrete vaults may be a minimum 3 feet in height and width if used as tanks with access manholes at each end, and if the width is no larger than the height. Also, the minimum internal height requirement may not be needed for any areas covered by removable panels.
 9. ~~9.—~~Vaults must comply with the OSHA confined space requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.
 10. ~~10.—~~Provide ventilation pipes (minimum 12-inch diameter or equivalent) ~~should be provided~~ in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. ~~Alternatively, Or, provide~~ removable panels over the entire vault ~~may be provided.~~

Access Roads. Access roads are needed to the access panel (if applicable), the control structure, and at least one access point per cell, and

they may be designed and constructed as specified for detention ponds in [Section 3.2.1](#)~~Section 3.2.1.~~

Right-of-Way. Right-of-way is needed for detention vaults maintenance. It is recommended that any tract not abutting public right-of-way should have a 15 to 20-foot wide extension of the tract to accommodate an access road to the facility.

Setbacks. It is recommended that facilities be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government and from any septic drainfield. However, the setback requirements are generally specified by the local government, uniform building code, or other statewide regulation and may be different from those mentioned above.

All facilities must be a minimum of 50 feet from the top of any steep (greater than 15~~percent~~%) slope. A geotechnical analysis and report must be prepared addressing the potential impact of the facility on a ~~steep~~-slope-
~~steeper than 15%.~~

Maintenance. ~~Build in~~ provisions to facilitate maintenance operations ~~must be built~~ into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See [Table 3.2.4](#)~~Table 3.4~~ for specific maintenance requirements.

Detention Volume and Outflow

Design the volume and outflow for detention vaults in accordance with Minimum Requirement #7 in Volume I and the hydrologic analysis and design methods in [Section 2.2.3](#). Restrictor and orifice design are given in [Section 3.2.4](#).

Methods of Analysis

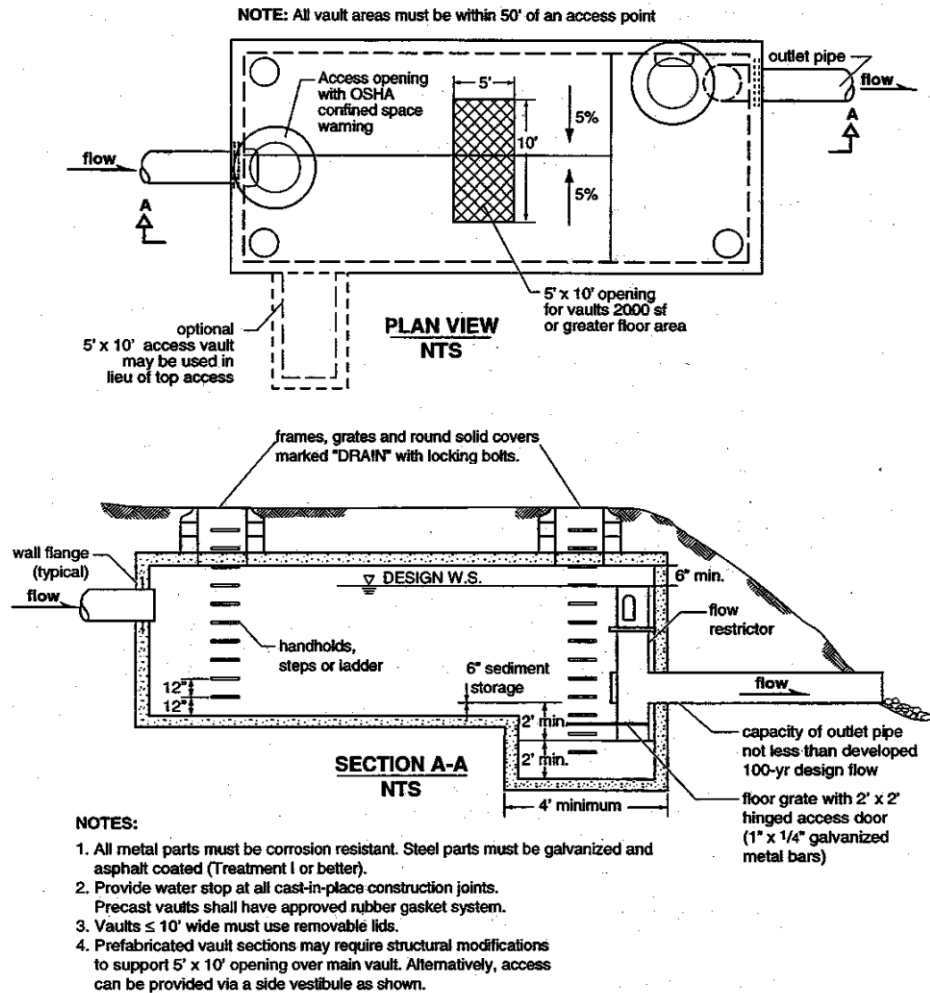


Figure 3.46-2.8 - Typical Detention Vault

3.2.4 Control Structures

Control structures are catch basins or manholes with a restrictor device for controlling outflow from a facility to meet the desired performance. Riser type restrictor devices (“tees” or “FROP-Ts”) also provide some incidental oil/water separation to temporarily detain oil or other floatable pollutants in runoff due to accidental spill or illegal dumping.

The restrictor device usually consists of two or more orifices and/or a weir section sized to meet performance requirements.

Standard control structure details are shown in [Figure 3.2.9](#) through [Figure 3.2.11](#).

Design Criteria

Multiple Orifice Restrictor

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

1. ~~1.~~—Minimum orifice diameter is 0.5 inches. *Note:* In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth need not be reduced to less than 3 feet in an attempt to meet the performance standards. Also, under such circumstances, flow-throttling devices may be a feasible option. These devices will throttle flows while maintaining a plug-resistant opening.
2. ~~2.~~—Orifices may be constructed on a tee section as shown in [Figure 3.2.9](#) or on a baffle as shown in [Figure 3.2.10](#).
3. ~~3.~~—In some cases, performance requirements may require the top orifice/elbow to be located too high on the riser to be physically constructed (e.g., a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see [Figure 3.2.13](#)).
4. ~~4.—Consideration must be given to~~ Consider the backwater effect of water surface elevations in the downstream conveyance system. High tailwater elevations may affect performance of the restrictor system and reduce live storage volumes.

Riser and Weir Restrictor

1. ~~4.—~~Properly designed weirs may be used as flow restrictors (see [Figure 3.2.11](#)~~Figure 3.19~~ and [Figure 3.2.13](#)~~Figure 3.21~~ through [Figure 3.2.15](#)~~Figure 3.23~~). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention facility.
2. ~~2.—~~The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 100-year peak flow assuming all orifices are plugged. [Figure 3.2.16](#)~~Figure 3.24~~ can be used to calculate the head in feet above a riser of given diameter and flow.

Access. The following guidelines for access may be used.

1. ~~4.—~~Provide an access road to the control structure ~~is needed~~ for inspection and maintenance. ~~Design~~ and ~~must be designed and constructed~~construct the access road as specified for detention ponds in [Section 3.3.1](#)~~Section 3.3.1.~~
2. ~~2.—~~Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.
3. ~~3.—~~Manholes and catch-basins must meet the OSRA confined space requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser, just under the access lid.

Information Plate. It is recommended that a brass or stainless steel plate be permanently attached inside each control structure with the following information engraved on the plate:

Name and file number of project

Name and company of (1) developer, (2) engineer, and (3) contractor

Date constructed

Date of manual used for design

Outflow performance criteria

Release mechanism size, type, and invert elevation

List of stage, discharge, and volume at one-foot increments

Elevation of overflow

Recommended frequency of maintenance.

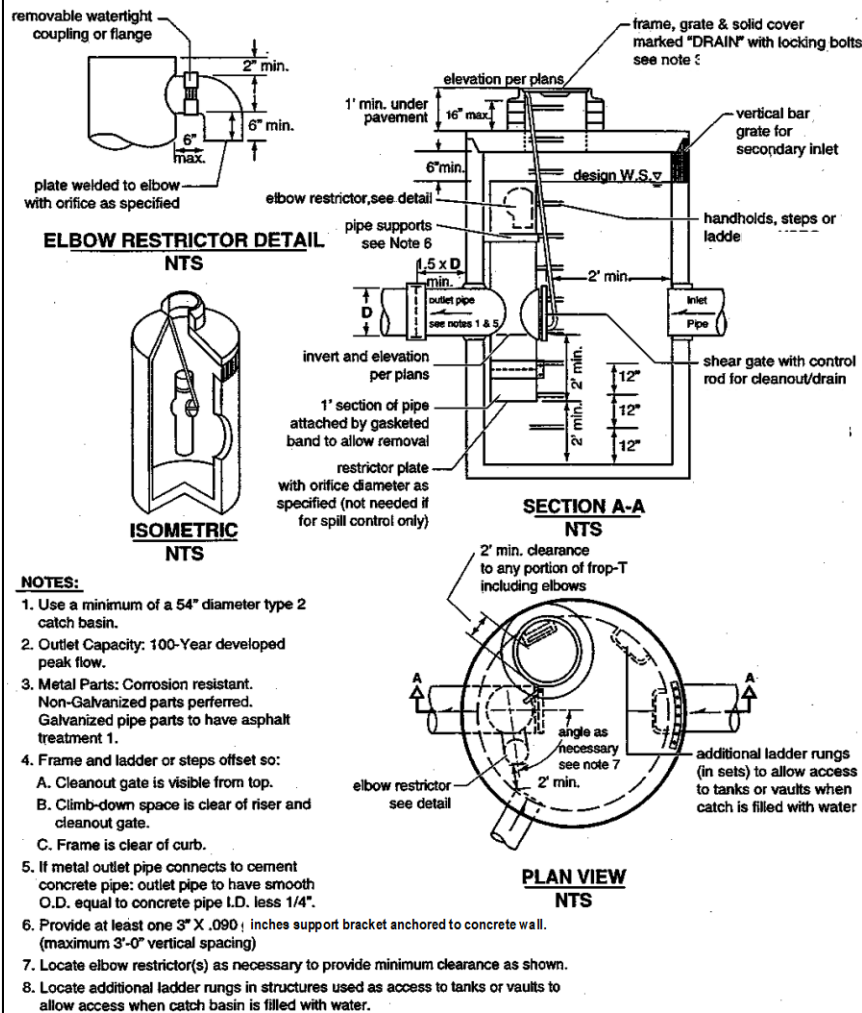
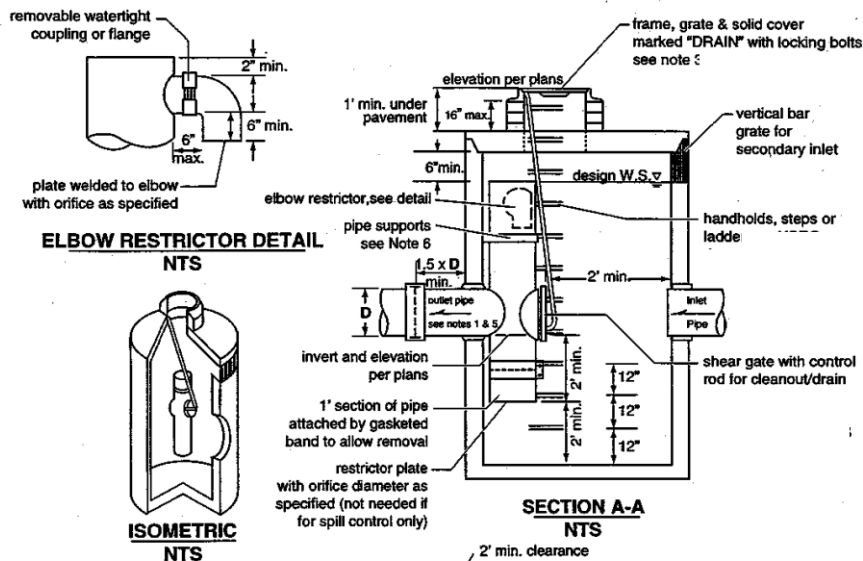
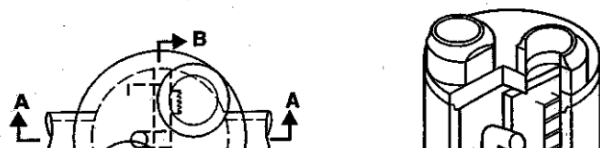
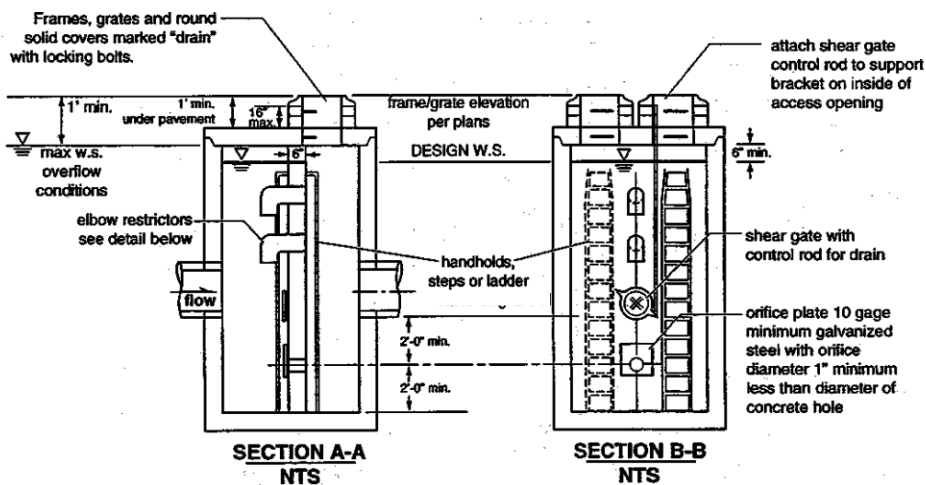
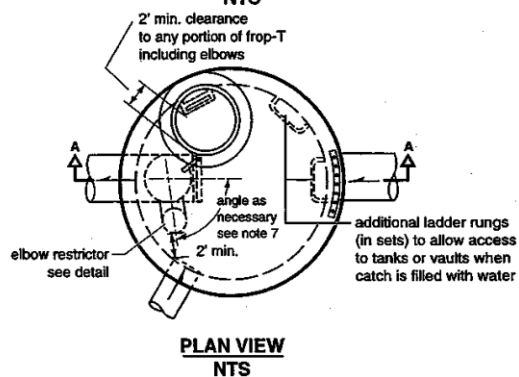


Figure 3.17-2.9- Flow Restrictor (TEE)



NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts preferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
 - A. Cleanout gate is visible from top.
 - B. Climb-down space is clear of riser and cleanout gate.
 - C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less 1/4".
6. Provide at least one 3" X .090 inches support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.



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Figure 3.18-2.10 - Flow Restrictor (Baffle)

Shear gate
with control
rod for drain

Figure 3.19 - Flow Restrictor (Weir)

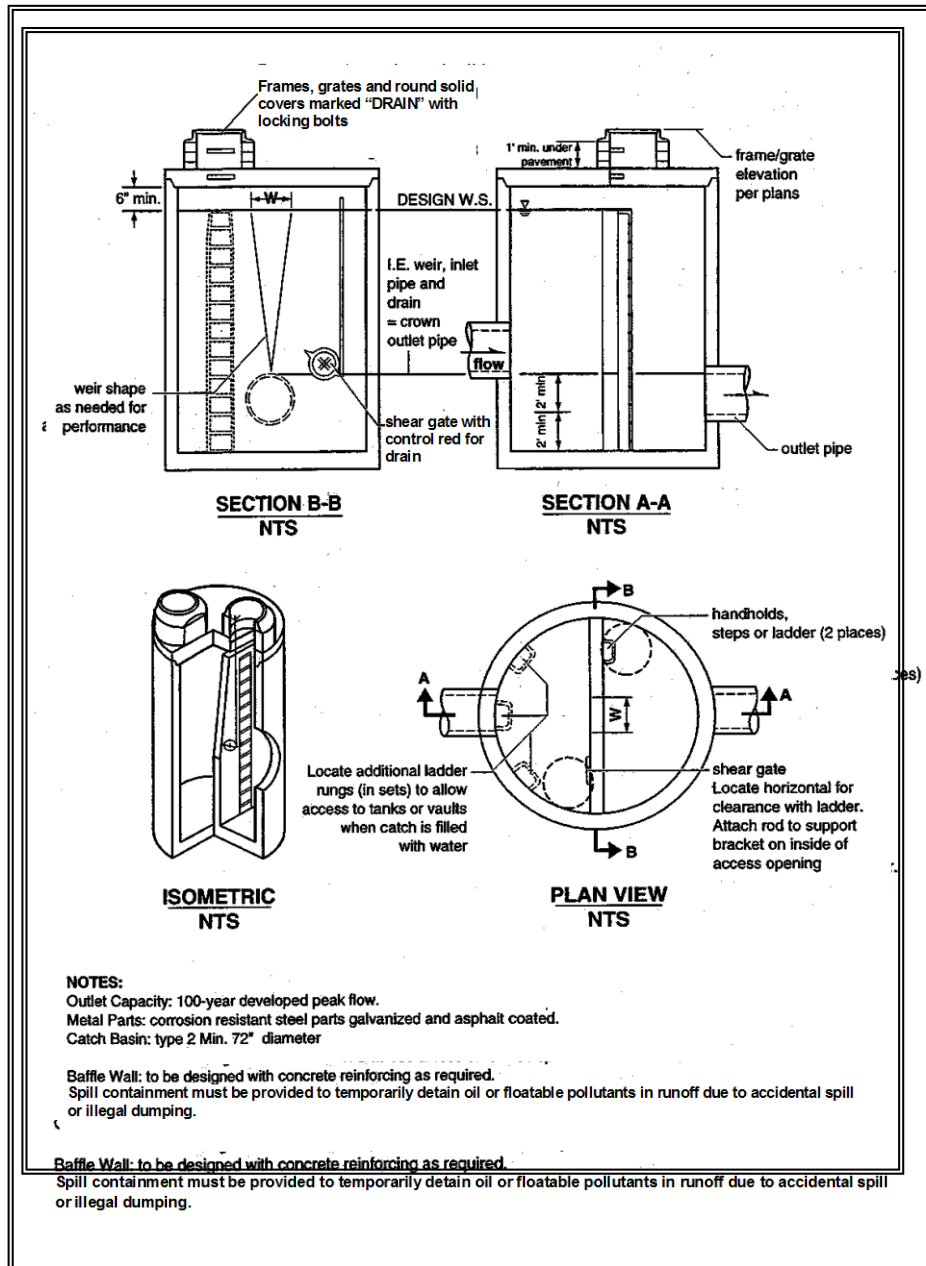


Figure 3.49-2.11 - Flow Restrictor (Weir)

Maintenance. Control structures and catch basins have a history of maintenance-related problems and it is imperative ~~that to establish~~ a good maintenance program ~~be established for their proper functioning. A typical problem is that~~ them to function properly. Typical sediment builds up inside the structure, which blocks or restricts flow to the inlet. To prevent this problem ~~routinely clean out~~ these structures ~~should be routinely cleaned out~~ at least twice per year. ~~Conduct~~ regular inspections of control structures ~~should be conducted~~ to detect the need for non-routine cleanout, especially if construction or land-disturbing activities ~~are occurring~~ occur in the contributing drainage area.

Instal a 15-foot wide access road to the control structure ~~should be installed~~ for inspection and maintenance.

~~Table 3.2.5~~ Table 3.5 provides maintenance recommendations for control structures and catch basins.

**Table 3.2.5
Maintenance of Control Structures and Catchbasins**

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.

**Table 3.2.5
Maintenance of Control Structures and Catchbasins**

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Manhole	See Table 3.4	See Table 3..4	See Table 3.4
CATCH BASINS			
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe. Measured from the bottom of basin to invert of the lowest pipe into or out of the basin.	No sediment in the catch basin.
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.

<p align="center">Table 3.2.5 Maintenance of Control Structures and Catchbasins</p>			
Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Contamination and Pollution	See "Detention Ponds".	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance).	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Gate opening Unsafe	Gate with opening wider than 7/8 inch.	Gate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Gate free of trash and debris.
	Damaged or Missing.	Gate missing or broken member(s) of the grate.	Gate is in place and meets design standards.

Methods of Analysis

This section presents the methods and equations for design of **control structure restrictor devices**. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, suture weirs, and overflow risers.

Orifices. Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = C A \sqrt{2gh} \quad (\text{equation 4})$$

where Q = flow (cfs)
 C = coefficient of discharge (0.62 for plate orifice)
 A = area of orifice (ft²)
 h = hydraulic head (ft)
 g = gravity (32.2 ft/sec²)

[Figure 3.2.12](#) ~~Figure 3.20~~ illustrates this simplified application of the orifice equation.

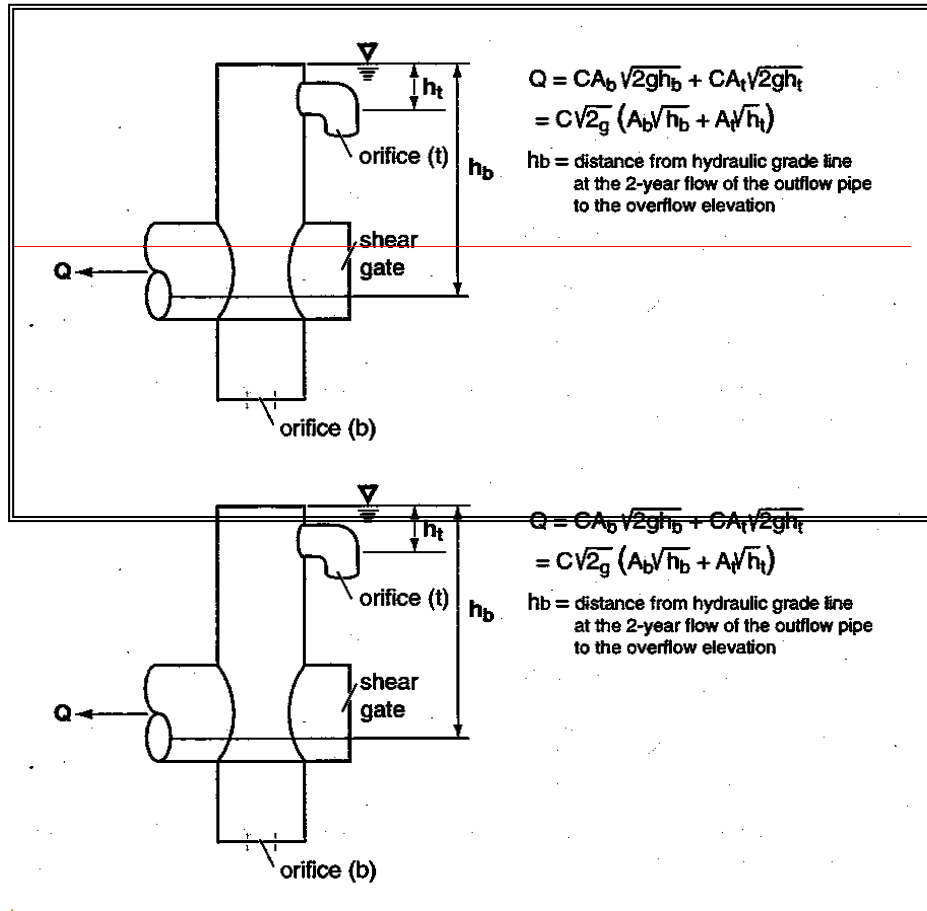


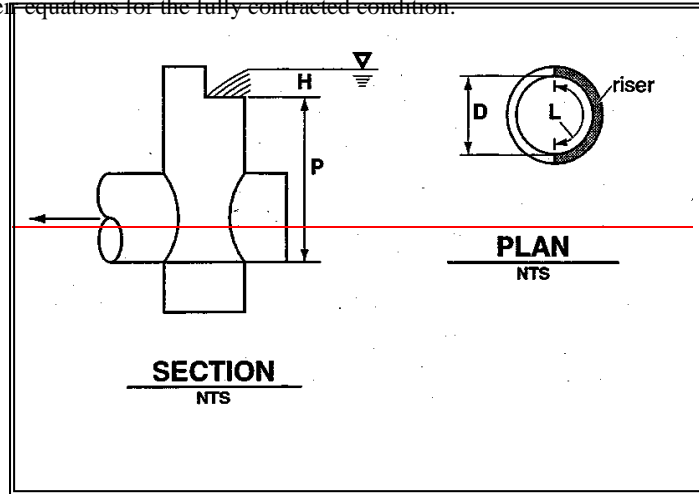
Figure 3.20-2.12 - Simple Orifice

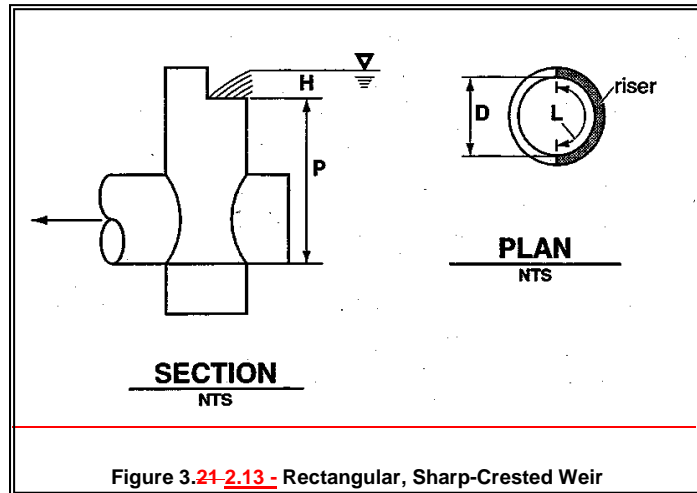
The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \quad (\text{equation 5})$$

where d = orifice diameter (inches)
 Q = flow (cfs)
 h = hydraulic head (ft)

Rectangular Sharp-Crested Weir. The rectangular sharp-crested weir design shown in [Figure 3.2.13](#) ~~Figure 3.21~~ may be analyzed using standard weir equations for the fully contracted condition.





$$Q = C (L - 0.2H) H^{3/2} \quad (\text{equation 6})$$

where Q = flow (cfs)

$$C = 3.27 + 0.40 H/P \text{ (ft)}$$

H, P are as shown above

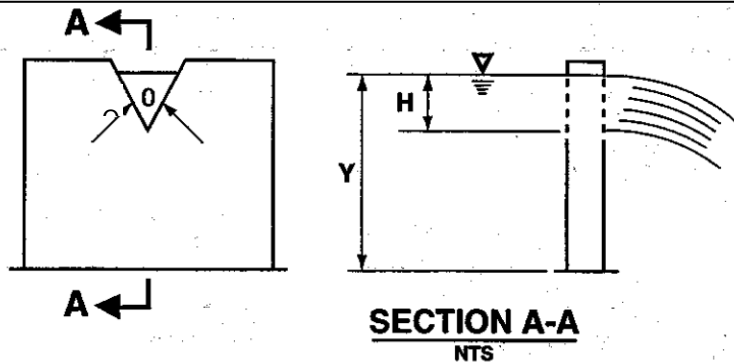
L = length (ft) of the portion of the riser circumference
as necessary not to exceed 50 percent of the
circumference

D = inside riser diameter (ft)

Note that this equation accounts for side contractions by subtracting $0.1H$ from L for each side of the notch weir.

V-Notch Sharp - Crested Weir

V-notch weirs as shown in [Figure 3.2.14](#) [Figure 3.22](#) may be analyzed using standard equations for the fully contracted condition.



$$Q = C_d (\tan \theta / 2) H^{5/2} \text{ in cfs}$$

Where values of C_d may be taken from the following chart:

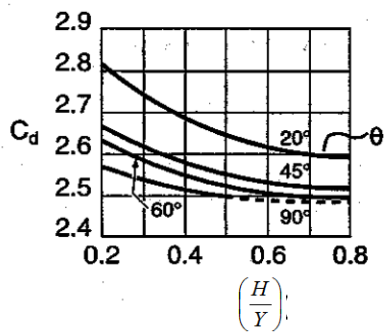


Figure 3.22-2.14 - V-Notch, Sharp-Crested Weir

Proportional or Sutro Weir. Sutro weirs are designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet performance requirements.

The sutro weir consists of a rectangular section joined to a curved portion that provides proportionality for all heads above the line A-B (see [Figure 3.2.15](#) ~~Figure 3.23-~~). The weir may be symmetrical or non-symmetrical.

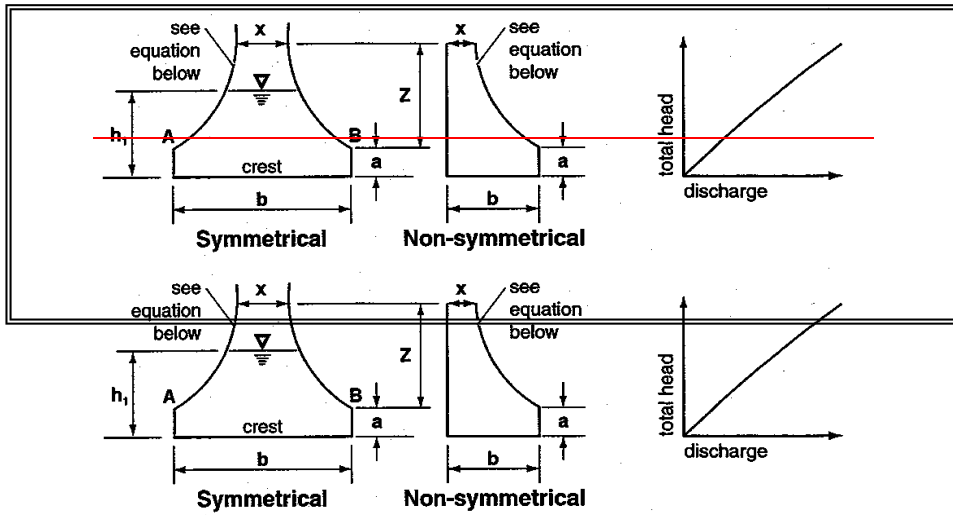


Figure 3.23-2.15 - Suto Weir

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi} \tan^{-1} \sqrt{\frac{Z}{a}} \quad (\text{equation 7})$$

where a, b, x and Z are as shown in [Figure 3.2.15](#) ~~Figure 3.23-~~. The head-discharge relationship is:

$$Q = (C_d) (b) (\sqrt{2ga}) (h_1 - \frac{a}{3}) \quad (\text{equation 8})$$

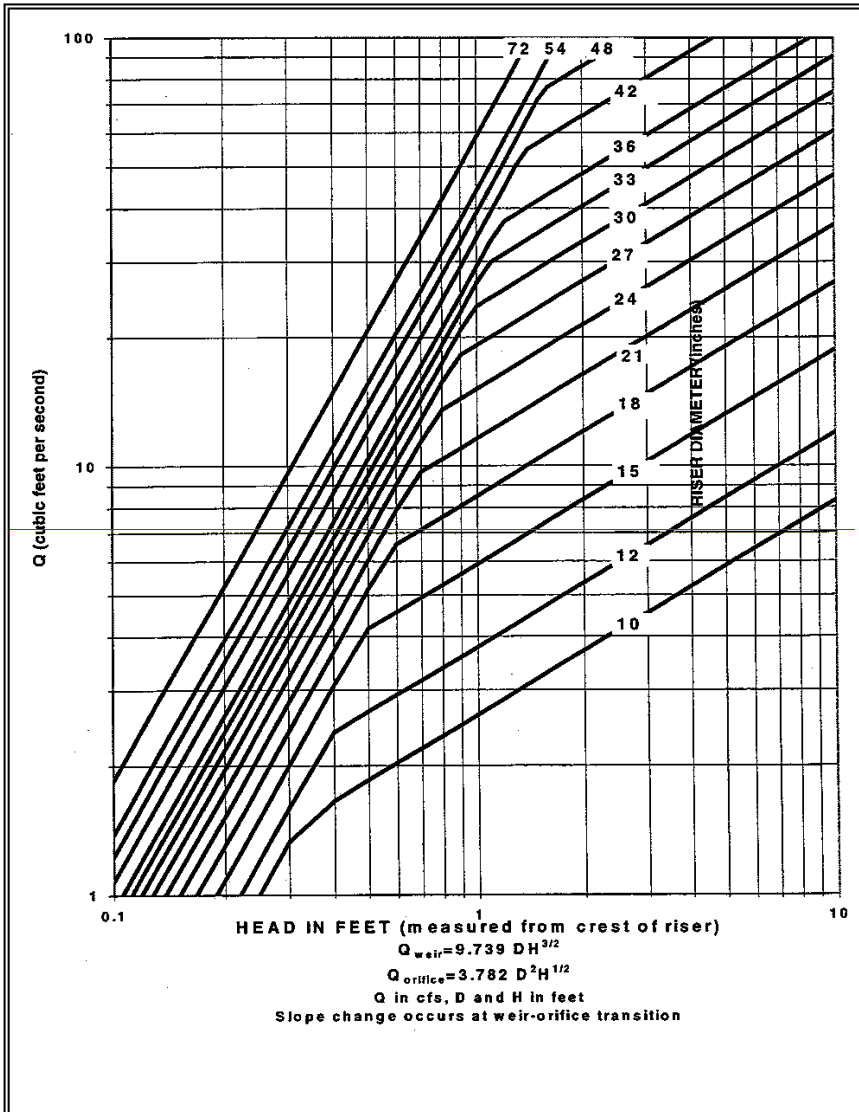
Values of C_d for both symmetrical and non-symmetrical sutro weirs are summarized in [Table 3.2.6](#) ~~Table 3.6-~~.

Note: When $b > 1.50$ or $a > 0.30$, use $C_d = 0.6$.

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Table 3.2.6 Values of C_d for Sutro Weirs					
<i>Cd Values, Symmetrical</i>					
<i>b (ft)</i>					
a (ft)	0.50	0.75	1.0	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608
<i>Cd Values, Non-Symmetrical</i>					
<i>b (ft)</i>					
a (ft)	0.50	0.75	1.0	1.25	1.50
0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

Riser Overflow. The nomograph in [Figure 3.2.16](#) ~~Figure 3.24~~ can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions).



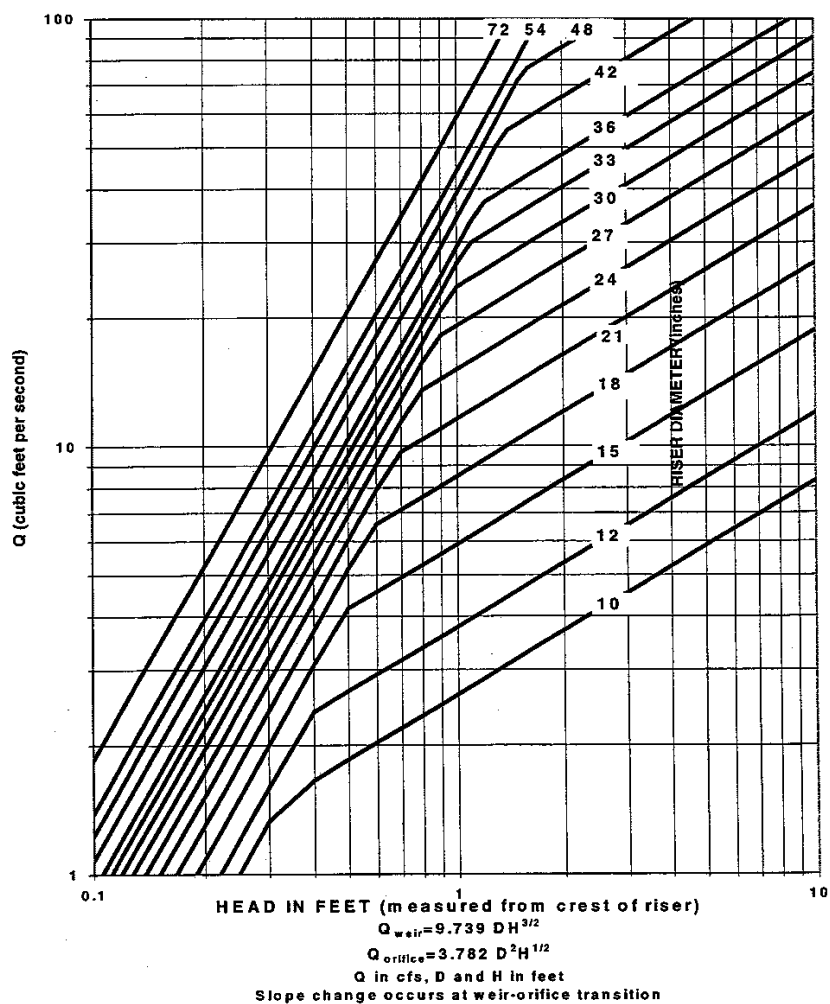


Figure 3.24-2.16 - Riser Inflow Curves

3.2.5 Other Detention Options

This section presents other design options for detaining flows to meet flow control facility requirements.

Use of Parking Lots for Additional Detention. Private parking lots may be used to provide additional detention volume for runoff events greater than the 2-year runoff event provided all of the following are met:

1. ~~4.~~—The depth of water detained does not exceed 1 foot at any location in the parking lot for runoff events up to and including the 100-year event.
2. ~~2.~~—The gradient of the parking lot area subject to ponding is 1 percent or greater.
3. ~~3.~~—The emergency overflow path is identified and noted on the engineering plan. The overflow must not create a significant adverse impact to downhill properties or drainage system.
4. ~~4.~~—Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.

Use of Roofs for Detention

Detention ponding on roofs of structures may be used to meet flow control requirements provided all of the following are met:

1. ~~4.~~—The roof support structure is analyzed by a structural engineer to address the weight of ponded water.
2. ~~2.~~—The roof area subject to ponding is sufficiently waterproofed to achieve a minimum service life of 30 years.
3. ~~3.~~—The minimum pitch of the roof area subject to ponding is 1/4-inch per foot.
4. ~~4.~~—An overflow system is included in the design to safely convey the 100-year peak flow from the roof
5. ~~5.~~—A mechanism is included in the design to allow the ponding area to be drained for maintenance purposes or in the event the restrictor device is plugged.

3.3 Infiltration Facilities for Flow Control and for Treatment

3.3.1 Purpose

~~To provide-~~ The purpose of this section is to describe the steps required to: evaluate the suitability of a site for infiltration capacity for stormwater runoff quantity facilities; establish a design infiltration rate; and flow control, design facilities for infiltration.

This section applies to infiltration ponds/basins, trenches, vaults and tanks. It does not apply to downspout infiltration trenches. This section only applies to the design of Bioretention facilities, permeable pavements, and filter media devices where specific references are made in:

- Section 3.4 for water quality.
- BMP T7.30 – Bioretention (see Volume V).
- BMP T5.15 – Permeable Pavement (see Volume V).

This section also highlights design criteria that are applicable to infiltration facilities serving a treatment- function.

3.3.2 Description

An infiltration ~~BMP~~facility is typically an open basin (pond), trench, or buried perforated pipe used for distributing the stormwater runoff into the underlying soil (See ~~Figure 3.3.1~~Figure 3.25). Stormwater dry-wells receiving uncontaminated or properly treated stormwater can also be considered as infiltration facilities. (See Underground Injection Control Program, ~~Chapter 173-218 WAC~~Chapter 173-218 WAC).

Coarser more permeable soils can be used for ~~quantity control~~complying with the LID performance standard (an option in Minimum Requirement #5), and the flow control requirement (Minimum Requirement #7) provided that the infiltrated stormwater discharge does not cause a violation of ~~ground-water~~groundwater quality ~~criteria. Typically, standards. At a minimum, pre-treatment for removal of TSS, oil, and/or soluble pollutants~~ criteria. Typically, standards. At a minimum, pre-treatment for removal of TSS, oil, and/or soluble pollutants is necessary prior to ~~conveyance~~discharge to anthe infiltration ~~BMP~~facility if any runoff comes from a pollution-generating surface. An oil control facility is also necessary for “high use” sites. Pre-treatment facilities that have the capability for removal of soluble pollutants, particularly, petroleum-related pollutants and bacteria, are advisable if Site Suitability Criterion SSC-6 is not met at the infiltration facility.

Use of the soil for treatment purposes is ~~also~~ an option as long as it is preceded by a pre-settling basin or a basic treatment BMP. ~~This section highlights design criteria that are applicable to infiltration facilities serving~~

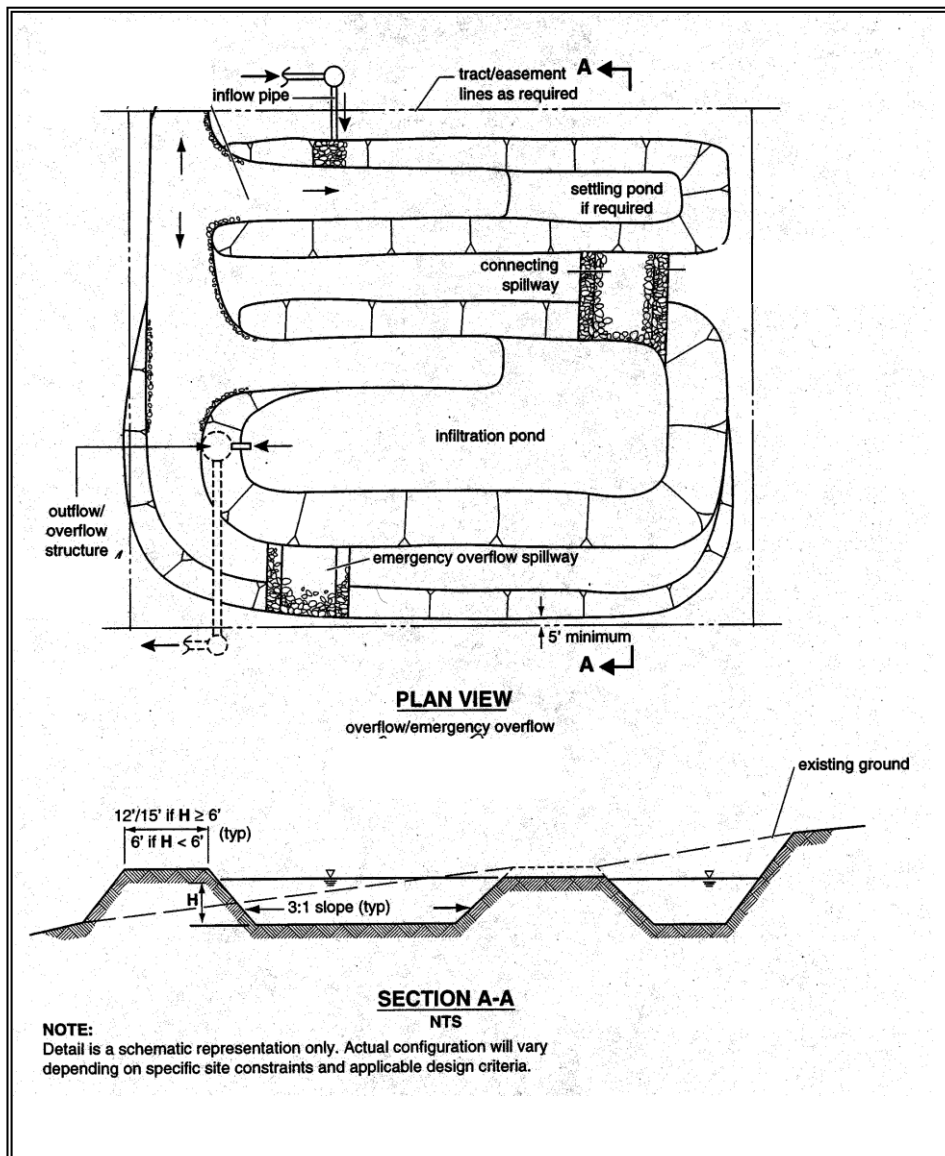
~~a treatment function. This pre-treatment should reduce the incidence of plugging and extend operational times between major maintenance.~~

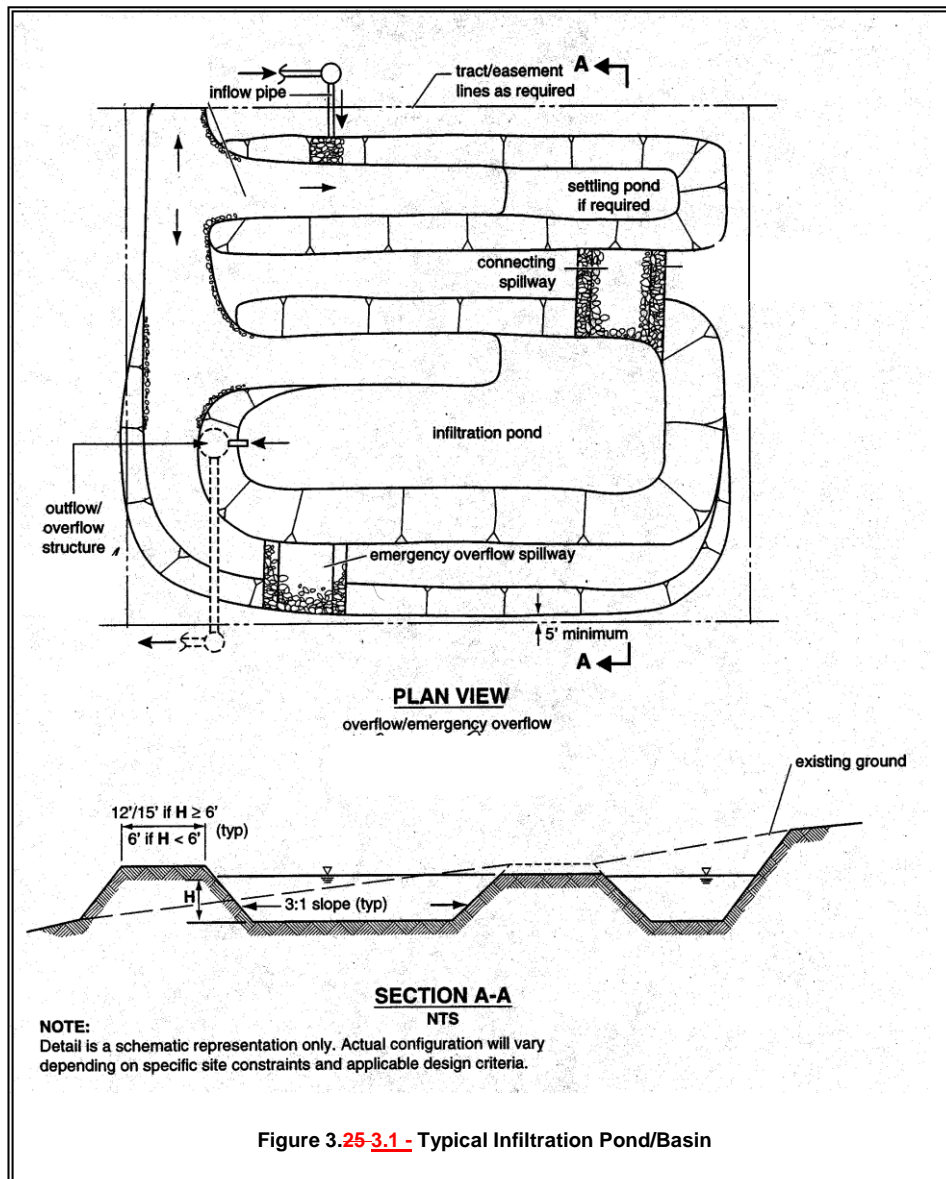
3.3.3 Applications

Infiltration facilities for ~~complying with the LID performance standard and the~~ flow control ~~requirement~~ are used to convey stormwater runoff from new development or redevelopment to the ground and ~~ground water/groundwater~~ after appropriate treatment. Infiltration facilities for treatment purposes rely on the soil profile to provide treatment. In either case, ~~manage~~ runoff in excess of the infiltration capacity of the facilities ~~must be managed~~ to comply with the flow control requirement in Volume I, if flow control applies to the project.

Infiltration facilities can help accomplish the following:

- Ground water recharge.
- Discharge of uncontaminated or properly treated stormwater to dry-wells in compliance with Ecology's UIC regulations ([Chapter 173-218 WAC](#) ~~(Chapter 173-218 WAC)~~).
- Retrofits in limited land areas: Infiltration trenches can be considered for residential lots, commercial areas, parking lots, and open space areas.
- Flood control.
- Streambank erosion control.





3.3.4 Steps for the Design of Infiltration Facilities - Simplified Approach (Figure 3.26)

The simplified approach for the design of infiltration facilities was derived from high ~~ground-water~~groundwater and shallow pond sites in western Washington, and in general will produce [>]conservative designs. ~~The simplified~~This approach can be used when determining the trial geometry of the infiltration facility, for small ~~or low impact facilities, or for facilities where~~reserving short plots or commercial developments less than 1 acre of contributing area. Designs of infiltration facilities for larger projects should use the detailed approach and may have to incorporate the results of a ground water mounding analysis as described in Section 3.3.8~~more conservative design.~~ Note: A ground water mounding analysis is acceptable. ~~advisable for facilities with drainage areas smaller than 1 acre if the depth to a low permeability layer (e.g., less than 0.1 inches per hour) is less than 10 feet.~~

The simplified approach is applicable to ponds and trenches and includes the process in Figure 3.3.2 and the following steps:

1. **Select a location:**

This will be based on the ability to convey flow to the location and the expected soil conditions of the location. Conduct a preliminary surface and sub-surface characterization study (Section 3.3.5~~(Section 3.3.5)-~~). Do a preliminary check of Site Suitability Criteria (Section 3.3.7~~(Section 3.3.7)~~) to ~~initially~~estimate feasibility~~-- of locating an infiltration facility on the site.~~

2. **Estimate volume of stormwater, V_{design}:**

~~For western Washington,~~Estimate the volume of stormwater by using a continuous hydrograph ~~should be used, requiring use of~~and an approved continuous runoff model such as WWHM, MGSFlood, or KCRTS for the calculations. The runoff file developed for the project site serves as input to the infiltration basin.

For infiltration basins sized simply to meet treatment requirements, the basin must successfully infiltrate 91% of the influent runoff file. The remaining 9% of the influent file can bypass the infiltration facility. ~~However, if the bypass discharges to a surface water that is not exempt from flow control, the bypass must meet the flow control standard.~~

For infiltration basins sized to meet the flow control standard, the basin must infiltrate either all of the influent file, or a sufficient amount of the influent file such that any overflow/bypass meets the flow duration standard. In addition, the overflow/bypass must meet the LID performance standard if it is the option chosen to meet Minimum Requirement #5, or if it is required of the project.

3. **Develop trial infiltration facility geometry:**

To ~~accomplish this, develop the trial facility geometry assume~~ an infiltration rate ~~will need to be assumed~~ based on previously available data, or a default infiltration rate of 0.5 inches/hour ~~can be used.~~ Use this trial facility geometry ~~should be used~~ to help locate the facility and for planning purposes in developing the geotechnical subsurface investigation plan.

4. Complete More Detailed Site Characterization Study and Consider Site Suitability Criteria:

Information gathered during initial geotechnical and surface investigations ~~are~~ necessary to know whether infiltration is feasible. The geotechnical investigation evaluates the suitability of the site for infiltration, establishes the infiltration rate for design, and evaluates slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the facility.

See sections ~~3.3.5~~ ~~3.3.5~~ and ~~3.3.7~~ ~~3.3.7~~.

5. Determine the design infiltration rate as follows:

~~Three possible methods for estimating~~ Estimate the design (long-term) infiltration rate ~~are provided as follows:~~

- Use the Large Scale or Small Scale Pilot Infiltration Test (PIT) method (or other local-approved method) as described in Section 3.3.6 to estimate a measured (initial) saturated hydraulic conductivity (K_{sat}). Alternatively, for sites underlain with soils not consolidated by glacial advance (e.g., recessional outwash soils), the measured saturated hydraulic conductivity rate (K_{sat}) may be estimated using the grain size analysis method in Section 3.3.6.
- Assume that the K_{sat} is the measured (initial) infiltration rate for the facility.
- Adjust this rate using the appropriate correction factors, as explained in Section 3.3.6 for the PIT results and the Gradation Analysis results, to obtain the design infiltration rate.

6. Size the facility:

~~Ensure that~~ The maximum ~~pond~~ ponded water depth ~~stays below the minimum required~~ should be between 2 and 6 feet with at least one foot of freeboard.

If sizing a treatment facility, use the output files from an approved continuous runoff model to document: 1) that the facility can infiltrate 91 percent of the influent runoff file; and 2) that the 91st-percentile, 24-hour runoff volume Water Quality Design Storm Volume (indicated by WWHM or MGS Flood) can infiltrate through the infiltration basin surface within 48 hours. ~~This~~ The latter can be calculated by multiplying a horizontal projection of the infiltration basin mid-depth dimensions by the

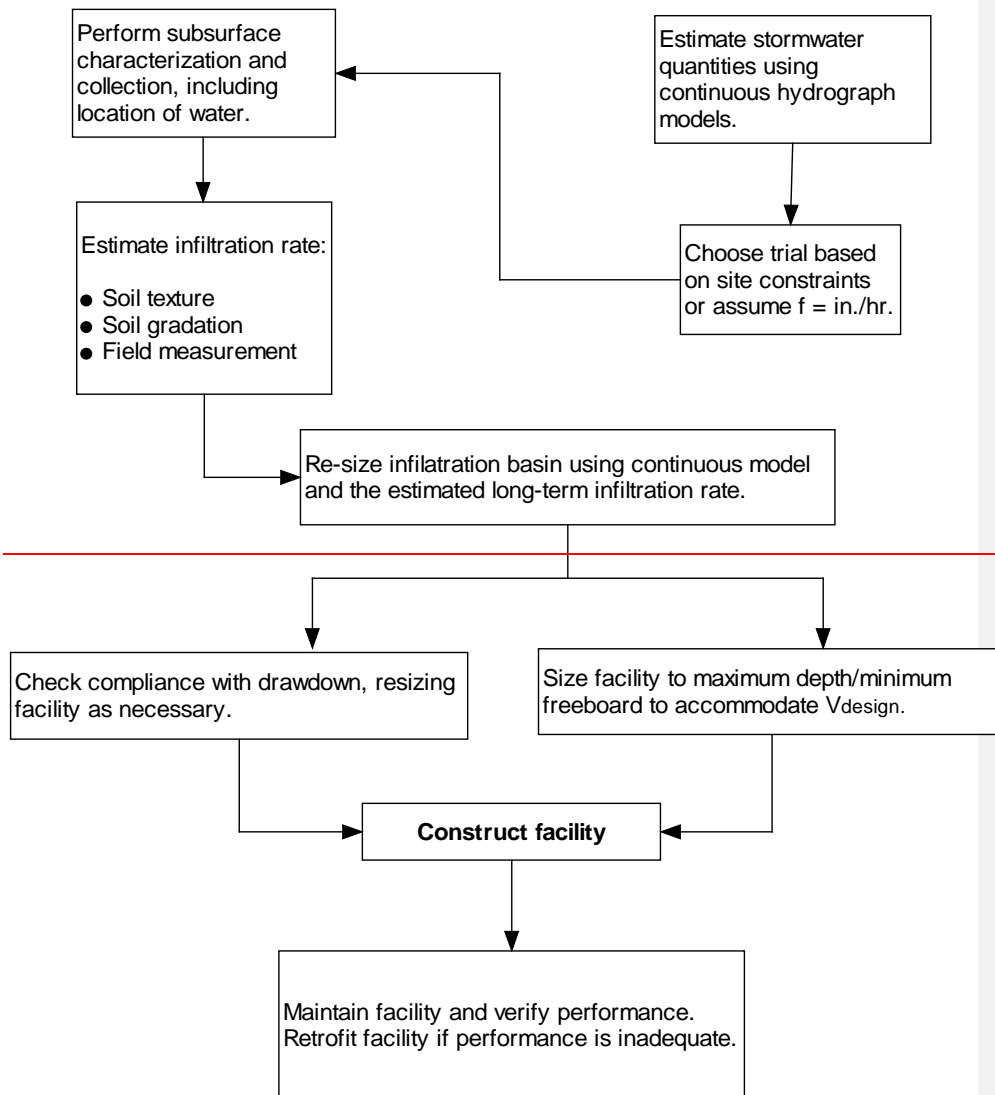
estimated long-term infiltration rate; and multiplying the result by 48 hours.

If sizing a facility to meet the flow control requirement, use the output files of an approved continuous runoff model to document that the total of any bypass and overflow meets the applicable flow control standard.

If choosing, or required, to comply with the LID performance standard use the output files to document that the facility's total of bypass and overflow meets the LID performance standard. *Note:* Use of distributed LID facilities dispersed throughout the project site will help achieve the LID performance standard.

7. Construct the facility & Conduct Performance Testing:

~~Maintain and monitor the facility for performance~~



Test and monitor the constructed facility to demonstrate that the facility performs as designed. Use the same test method for saturated hydraulic conductivity as used in the planning stages so that results are comparable. Perform the testing after stabilizing the construction site. Submit the results and comparisons to the pre-project measured (initial) and design

rates to the local stormwater authority that approved the project design. If the rates are lower than the design saturated hydraulic conductivity, the applicant shall implement measures to improve infiltration capability within the footprint of the constructed facility and re-test. If less intensive measures prove unsuccessful, replacement of the top foot of soil – or more if visual observation indicates deeper fouling of the bed with fine sediment – with a soil meeting the design needs (i.e., treatment, flow control, or both) shall be provided. Longer-term monitoring of drawdown times and periodic testing of the facility should provide an indication of when the facility needs maintenance to restore infiltration rates.

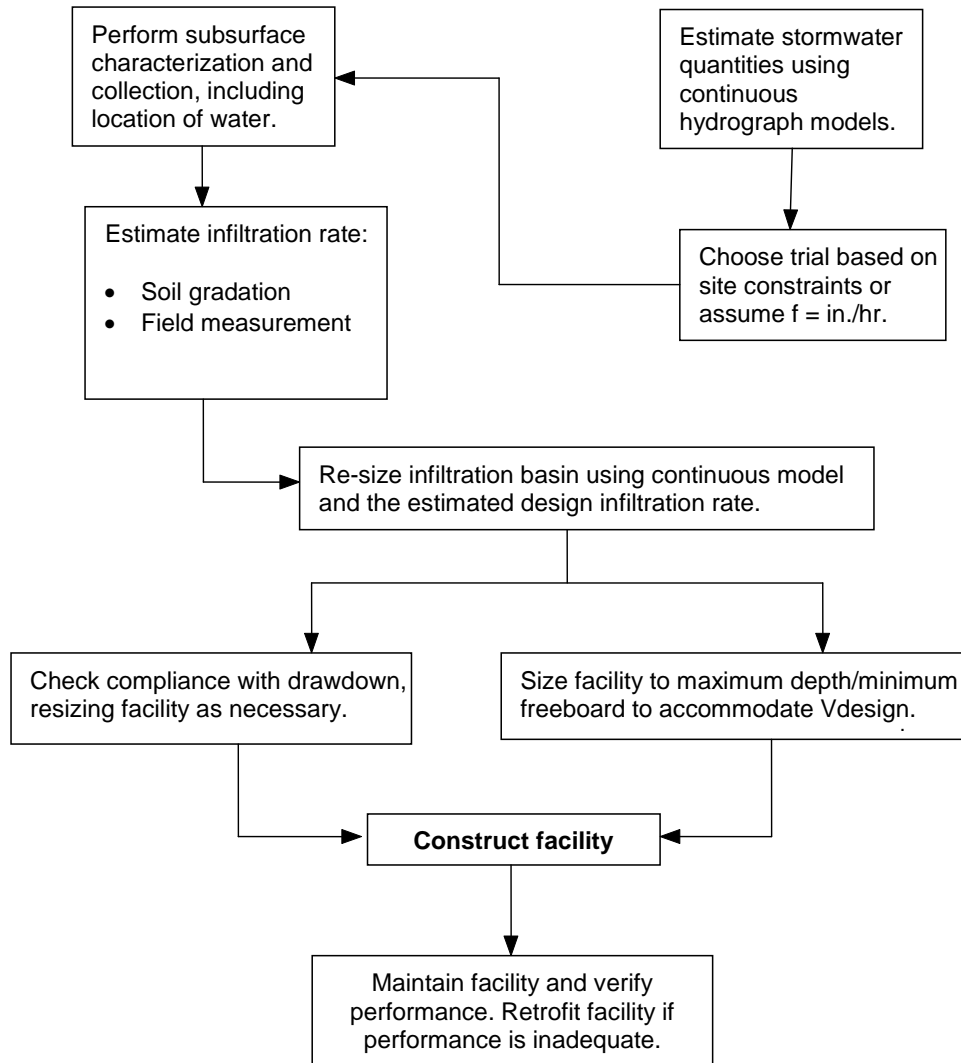


Figure 3.26-3.2 - Steps for Design of Infiltration Facilities – Simplified Approach

3.3.5 Site Characterization Criteria

One of the first steps in siting and designing infiltration facilities is to conduct a characterization study that includes the following:

Note: Information gathered during initial geotechnical investigations can be used for the site characterization.

Surface Features Characterization:

1. Topography within 500 feet of the proposed facility.
2. Anticipated site use (street/highway, residential, commercial, high-use site).
3. Location of water supply wells within 500 feet of proposed facility.
4. Location of ~~ground water~~groundwater protection areas and/or 1, 5 and 10 year time of travel zones for municipal well protection areas: (if available).
5. A description of local site geology, including soil or rock units likely to be encountered, the ~~ground water~~ground water regime, and geologic history of the site.

Subsurface Characterization:

1. Subsurface explorations (test holes or test pits) to a depth below the base of the infiltration facility of at least 5 times the maximum design depth of ponded water proposed for the infiltration facility, but not less than 10 feet below the base of the facility. However, at sites with shallow ground water (less than 15 feet from the estimated base of facility), if a ground water mounding analysis is necessary, determine the thickness of the saturated zone.

Continuous sampling (representative samples from each soil type and/or unit within the infiltration receptor) to a depth below the base of the infiltration facility of 2.5 times the maximum design ponded water depth, but not less than ~~6 feet~~10 feet. For large infiltration facilities serving drainage areas of 10 acres or more, perform soil grain size analyses on layers up to 50 feet deep (or no more than 10 feet below the water table).

2. If proposing to estimate the infiltration rate using the soil grain size analysis method, obtain samples adequate for the purposes of that gradation/classification testing.
 - For basins, at least one test pit or test hole per 5,000 ft² of basin infiltrating surface (in no case less than two per basin).
 - For trenches, at least one test pit or test hole per ~~50~~200 feet of trench length (in no case less than two per trench).

Note: The depth and number of test holes or test pits, and samples should be increased, if in the judgment of a licensed engineer with geotechnical expertise (P.E.), a licensed geologist, engineering geologist, hydrogeologist, or other licensed professional acceptable to the local jurisdiction, the conditions are highly variable and such increases are necessary to accurately estimate the performance of the infiltration system. The exploration program may also be decreased if, in the opinion of the licensed engineer or other professional, the conditions are relatively uniform and the borings/test pits omitted will not influence the design or successful operation of the facility. In high water table sites, the subsurface exploration sampling need not be conducted lower than two (2) feet below the ground water table.

2-3. Prepare detailed logs for each test pit or test hole and a map showing the location of the test pits or test holes. Logs must include at a minimum, depth of pit or hole, soil descriptions, depth to water, presence of stratification. *(Note: Logs must substantiate whether stratification does or does not exist. The licensed professional may consider additional methods of analysis to substantiate the presence of stratification that will significantly impact the design of the infiltration facility).*

Infiltration Rate Determination:

4. Determine Ground water monitoring wells (or driven well points if expected shallow depth to ground water) installed to locate the representative ground water table and establish its gradient, direction of flow, and seasonal variations, considering both confined and unconfined aquifers. For facilities serving a drainage area less than an acre, establish that the depth to ground water or other hydraulic restriction layer will be at least 10 feet below the base of the facility. Use subsurface explorations or information from nearby wells.

In general, a minimum of three wells per infiltration rate of the unsaturated vadose zone based on infiltration tests and/or grain size distribution/texture (see next section). Determine facility, or three hydraulically connected surface or ground water features, are needed to determine the direction of flow and gradient. If in the assessment of the site professional, the surrounding site conditions indicate that gradient and flow direction are not critical (e.g., there is low risk of down-gradient impacts) one monitoring well may be sufficient. Alternative means of establishing the ground water levels may also be considered. If the ground water in the area is known to be greater than 50 feet below the proposed facility, detailed investigation of the ground water regime is not necessary.

Monitoring through at least one wet season is required, unless substantially equivalent site historical data regarding ground water levels is available.

~~3-5. If using the soil Grain Size Analysis Method for estimating infiltration rates using the Pilot Infiltration Test (PIT) described in Appendix III-D, if practicable. Such site- laboratory testing should be considered to verify infiltration rate estimates based on soil size distribution and textural analysis. Infiltration rates may also be estimated based on as necessary to establish the soil grain size distributions from test pits or test hole samples (particularly where a sufficient source of water does not exist to conduct a pilot infiltration test). As gradation characteristics and other properties as necessary, to complete the infiltration facility design. At a minimum, conduct one soil-grain size analysis per soil stratum in each test hole shall be performed within 2.5 times the maximum design water depth, but not less than 6 feet-10 feet. When assessing the hydraulic conductivity characteristics of the site, soil layers at greater depths must be considered if the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, requiring soil gradation/classification testing for layers deeper than indicated above.~~

Soil Testing:

Soil characterization for each soil unit (soils of the same texture, color, density, compaction, consolidation and permeability) encountered should include:

- Grain-size distribution (ASTM D422 or equivalent AASHTO specification) *(If using the grain size analysis method to estimate infiltration rates)*
- ~~• Textural class (USDA) (See Figure 3.27)~~
- Visual grain size classification
- Percent clay content (include type of clay, if known)
- Color/mottling
- Variations and nature of stratification

If the infiltration facility will ~~be used to~~ provide treatment as well as flow control, the soil characterization should also include:

- Cation exchange capacity (CEC) and organic matter content for each soil type and strata- where distinct changes in soil properties occur, to a depth below the base of the facility of at least 2.5 times the maximum design water depth, but not less than 6 feet. ~~Consider if soils are already contaminated, thus diminishing pollutant sorptive capacity.~~
- For soils with low CEC and organic content, deeper characterization of soils may be warranted (refer to [Section 3.3.7](#) ~~Section 3.3.7~~ Site Suitability Criteria)

Infiltration Receptor:

Infiltration receptor (unsaturated and saturated soil receiving the stormwater) characterization should include:

- ~~1. Installation of ground water monitoring wells (at least three per infiltration facility, or three hydraulically connected surface and ground water features that will establish a three dimensional relationship for the ground water table, unless the highest ground water level is known to be at least 50 feet below the proposed infiltration facility) to:~~
 - ~~• monitor the seasonal ground water levels at the site during at least one wet season, and;~~
 - ~~• consider the potential for both unconfined and confined aquifers, or confining units, at the site that may influence the proposed infiltration facility as well as the groundwater gradient. Other approaches to determine ground water levels at the proposed site could be considered if pre-approved by the local government jurisdiction, and;~~
- ~~1. determine~~The information obtained from ground water monitoring in #4 of the Subsurface Characterization above.
2. An assessment of the ambient ground water quality, if that is a concern.
3. An estimate of the volumetric water holding capacity of the infiltration receptor soil. This is the soil layer below the infiltration facility and above the seasonal high-water mark, bedrock, hardpan, or other low permeability layer. Conduct this analysis ~~should be conducted~~ at a conservatively high infiltration rate based on vadose zone porosity, and the water quality runoff volume to be infiltrated. This, along with an analysis of ground water movement, will be useful in determining if there are volumetric limitations that would adversely affect drawdown, and if a ground water mounding analysis should be conducted.
4. Determination of:
 - Depth to ground water table and to bedrock/impermeable layers.
 - Seasonal variation of ground water table based on well water levels and observed mottling.
 - Existing ground water flow direction and gradient.
 - Lateral extent of infiltration receptor.
 - Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
 - Impact of the infiltration rate and volume at the project site on ground water mounding, flow direction, and water table; and the discharge point or area of the infiltrating water. Conduct a ground water mounding analysis ~~should be conducted~~ at all sites where the

depth to seasonal ground water table or low permeability stratum is less than 15 feet ~~and from the estimated bottom elevation of the infiltration facility, and the~~ runoff to the infiltration facility is from more than one acre. ~~—(The site professional can consider conducting an aquifer test, or slug test and the type of ground water mounding analysis necessary at the site)~~

Note: ~~—— A detailed soils and hydrogeologic investigation should be conducted if potential pollutant impacts to ground water are a concern, or if the applicant is proposing to infiltrate in areas underlain by till or other impermeable layers. (Suggested references: "Implementation Guidance for the Ground Water Quality Standards", Department of Ecology, publication 96-2, 1996, and, "Washington State Water Quality Guide," Natural Resources Conservation Service, W-316 Boone Ave, Spokane WA 99201-2348).~~

Textural Triangle U.S.D.A.

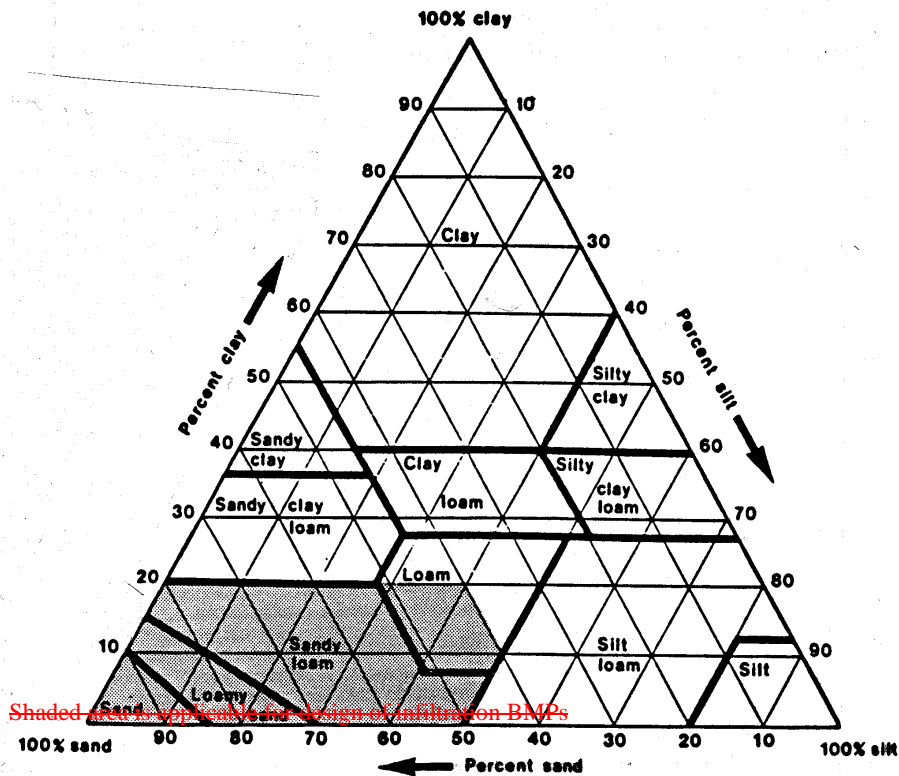


Figure 3-17 U.S.D.A. Textural Triangle

Source: U.S. Department of Agriculture

3.3.6 Design ~~Infiltration Rate Determination~~ **Saturated Hydraulic Conductivity** – Guidelines and Criteria

~~Infiltration-Measured (initial) saturated hydraulic conductivity (K_{sat}) rates can be determined using either in-situ field measurements, or, if the site has soils unconsolidated by glacial advance, by a correlation to grain size distribution from soil samples, textural analysis, or by in-situ field measurements. Short-term infiltration rates up to 2.4 in./hr represent soils that typically have sufficient treatment properties. Long-term infiltration rates are used for sizing the infiltration pond based on maximum pond level and drawdown time. Long-term infiltration rates up to 2.0 inches per hour can also be considered for treatment if SSC-4 and SSC-6 are met, as defined in Section 3.3.7.~~

Historically, infiltration rates have been estimated from soil grain size distribution (gradation) data using the United States Department of Agriculture (USDA) textural analysis approach. ~~To use the USDA textural analysis approach, the grain size distribution test must be conducted in accordance with the USDA test procedure (SOIL SURVEY MANUAL, U.S. Department of Agriculture, October 1993, page 136). This manual only considers soil passing the #10 sieve (2 mm) (U.S. Standard) to determine percentages of sand, silt, and clay for use in Figure 3.27 (USDA Textural Triangle). However, many soil test laboratories use. The latter method uses~~ the ASTM soil size distribution test procedure (ASTM D422), which considers the full range of soil particle sizes, to develop soil size distribution curves. ~~Using the Simplified Approach in Section 3.3.4, the estimate obtained for the measured (initial) K_{sat} is used as the initial infiltration rate. Using the Detailed Approach in Section 3.3.8 The ASTM soil gradation procedure must not be used with Figure 3.27 to perform USDA soil textural analyses., the initial K_{sat} is combined with other information to compute an estimate for an initial infiltration rate.~~

*Three Methods for Determining **Long-term Infiltration Rates** ~~Saturated Hydraulic Conductivity~~ for Sizing Infiltration Facilities*

For designing the infiltration facility the site professional should select one of the three methods described below that will best represent the ~~long-term infiltration measured (a.k.a., initial) saturated hydraulic conductivity (K_{sat}) rate at the site. The long-term~~ Use the measured saturated hydraulic conductivity to determine the design (long-term) infiltration rate ~~should be used. Then use the design (long-term) infiltration rate for routing and sizing the basin/trench, and for checking for compliance with the maximum drawdown time of 48 hours.~~

~~In the Simplified Approach (Section 3.3.4 If the pilot), the design infiltration test (table 3.9) or hindcast approach (table 3.8) rate is selected corroboration with a textural based infiltration rate (table 3.7) is also~~

~~desirable derived by applying~~ appropriate correction factors ~~must be applied to the measured K_{sat}~~ as specified below.

In the Detailed Approach (Section 3.3.8), the design infiltration rate is derived by applying correction factors and additional equations to the measured (initial) K_{sat} . Verification testing of the completed facility is strongly encouraged. (See Site Suitability Criterion # 7-Verification Testing)

1. Large Scale Pilot Infiltration Test (PIT)

Large-scale in-situ infiltration measurements, using the Pilot Infiltration Test (PIT) described below is the preferred method for estimating the measured (initial) saturated hydraulic conductivity (K_{sat}) of the soil profile beneath the proposed infiltration facility. The PIT reduces some of the scale errors associated with relatively small-scale double ring infiltrometer or “stove-pipe” infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology’s Technical Advisory Committee.

Infiltration Test

- Excavate the test pit to the estimated surface elevation of the proposed infiltration facility. Lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5-ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 6 and 12 inches above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: The depth should not exceed the proposed maximum depth of water expected in the completed facility. For infiltration facilities serving large drainage areas, designs with multiple feet of standing water can have infiltration tests with greater than 1 foot of standing water.

Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point on the measuring rod.

Keep adding water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5% variation or less variation in the total flow) while maintaining the same pond water level. The total of the pre-soak time plus one hour after the flow rate has stabilized should be no less than 6 hours.

- After the flow rate has stabilized for at least one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty. Consider running this falling head phase of the test several times to estimate the dependency of infiltration rate with head.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the engineer or certified soils professional. Mounding is an indication that a mounding analysis is necessary.

Data Analysis

Calculate and record the saturated hydraulic conductivity rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

Apply appropriate correction factors to determine the site-specific design infiltration rate. See the discussion of correction factors for infiltration facilities in this [Section 3.3](#), and the discussion of correction factors for bioretention facilities and permeable pavement in [Section 3.4](#).

Example

The area of the bottom of the test pit is 8.5-ft. by 11.5-ft.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or an average of $(9.8 + 12.3) / 2 = 11.1$ inches per hour.

2. Small-Scale Pilot Infiltration Test

A smaller-scale PIT can be substituted for the large-scale PIT in any of the following instances.

- The drainage area to the infiltration site is less than 1 acre.
- The testing is for the LID BMP's of bioretention or permeable pavement that either serve small drainage areas and /or are widely dispersed throughout a project site.

- The site has a high infiltration rate, making a full-scale PIT difficult, and the site geotechnical investigation suggests uniform subsurface characteristics.

Infiltration Test

- Excavate the test pit to the estimated surface elevation of the proposed infiltration facility. In the case of bioretention, excavate to the estimated elevation at which the imported soil mix will lie on top of the underlying native soil. For permeable pavements, excavate to the elevation at which the imported subgrade materials, or the pavement itself, will contact the underlying native soil. If the native soils (road subgrade) will have to meet a minimum subgrade compaction requirement, compact the native soil to that requirement prior to testing. Note that the permeable pavement design guidance recommends compaction not exceed 90% - 92%. Finally, lay back the slopes sufficiently to avoid caving and erosion during the test. Alternatively, consider shoring the sides of the test pit.
- The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular, but accurately document the size and geometry of the test pit.
- Install a vertical measuring rod adequate to measure the ponded water depth and that is marked in half-inch increments in the center of the pit bottom.
- Use a rigid pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates. Use a 3 inch diameter pipe for pits on the smaller end of the recommended surface area, and a 4 inch pipe for pits on the larger end of the recommended surface area.
- Pre-soak period: Add water to the pit so that there is standing water for at least 6 hours. Maintain the pre-soak water level at least 12 inches above the bottom of the pit.
- At the end of the pre-soak period, add water to the pit at a rate that will maintain a 6-12 inch water level above the bottom of the pit over a full hour. The depth should not exceed the proposed maximum depth of water expected in the completed facility.
- Every 15 minutes, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 6 inches and 1 foot) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 – 12 inches).

- After one hour, turn off the water and record the rate of infiltration (the drop rate of the standing water) in inches per hour from the measuring rod data, until the pit is empty.
- A self-logging pressure sensor may also be used to determine water depth and drain-down.
- At the conclusion of testing, over-excavate the pit to see if the test water is mounded on shallow restrictive layers or if it has continued to flow deep into the subsurface. The depth of excavation varies depending on soil type and depth to hydraulic restricting layer, and is determined by the engineer or certified soils professional. The soils professional should judge whether a mounding analysis is necessary.

Data Analysis

See the explanation under the guidance for large-scale pilot infiltration tests.

3. Soil Grain Size Analysis Method

For each defined layer below the infiltration pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than 10 feet, estimate the initial saturated hydraulic conductivity (K_{sat}) in cm/sec using the following relationship (see Massmann 2003, and Massmann et al., 2003). For large infiltration facilities serving drainage areas of 10 acres or more, soil grain size analyses should be performed on layers up to 50 feet deep (or no more than 10 feet below the water table).

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$

(1)

Where, D_{10} , D_{60} and D_{90} are the grain sizes in mm for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number-200 sieve (K_{sat} is in cm/s).

For bioretention facilities, analyze each defined layer below the top of the final bioretention area subgrade to a depth of at least 3 times the maximum ponding depth, but not less than 3 feet (1 meter). For permeable pavement, analyze for each defined layer below the top of the final subgrade to a depth of at least 3 times the maximum ponding depth within the base course, but not less than 3 feet (1 meter).

If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths must be considered when assessing the site's hydraulic conductivity characteristics. Massmann (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration facility can influence the rate of infiltration. Note that only the layers near and above the water table or low permeability zone (e.g., a clay, dense glacial till, or rock layer) need to be considered, as the layers

below the ground water table or low permeability zone do not significantly influence the rate of infiltration. Also note that this equation for estimating K_{sat} assumes minimal compaction consistent with the use of tracked (i.e., low to moderate ground pressure) excavation equipment.

If the soil layer being characterized has been exposed to heavy compaction (e.g., due to heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires) the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt, 2003). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity.

For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well-graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.

If greater certainty is desired, the in-situ saturated conductivity of a specific layer can be obtained through the use of a pilot infiltration test (PIT). Note that these field tests generally provide a K_{sat} combined with a hydraulic gradient (i.e., Equation 5 in Section 3.3.8). In some of these tests, the hydraulic gradient may be close to 1.0; therefore, in effect, the test infiltration rate result is the same as the hydraulic conductivity. In other cases, the hydraulic gradient may be close to the gradient that is likely to occur in the full-scale infiltration facility. The hydraulic gradient will need to be evaluated on a case-by-case basis when interpreting the results of field tests. It is important to recognize that the gradient in the test may not be the same as the gradient likely to occur in the full-scale infiltration facility in the long-term (i.e., when ground water mounding is fully developed).

Once the K_{sat} for each layer has been identified, determine the effective average K_{sat} below the pond. K_{sat} estimates from different layers can be combined using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}} \quad (2)$$

Where, d is the total depth of the soil column, d_i is the thickness of layer “ i ” in the soil column, and K_i is the saturated hydraulic conductivity of layer “ i ” in the soil column. The depth of the soil column, d , typically would include all layers between the pond bottom and the water table. However, for sites with very deep water tables (>100 feet) where ground

water mounding to the base of the pond is not likely to occur, it is recommended that the total depth of the soil column in Equation 2 be limited to approximately 20 times the depth of pond, but not more than 50 feet. This is to ensure that the most important and relevant layers are included in the hydraulic conductivity calculations. Deep layers that are not likely to affect the infiltration rate near the pond bottom should not be included in Equation 2.

Equation 2 may over-estimate the effective K_{sat} value at sites with low conductivity layers immediately beneath the infiltration pond. For sites where the lowest conductivity layer is within five feet of the base of the pond, it is suggested that this lowest K_{sat} value be used as the equivalent hydraulic conductivity rather than the value from Equation 2. Using the layer with the lowest K_{sat} is advised for designing bioretention facilities or permeable pavements. The harmonic mean given by Equation 2 is the appropriate effective hydraulic conductivity for flow that is perpendicular to stratigraphic layers, and will produce conservative results when flow has a significant horizontal component such as could occur due to ground water mounding.

Correction Factors

Correction Factors for PIT results and Grain Size Method - The K_{sat} obtained from the PIT test or Grain Size Method is a measured (initial) rate. This measured rate must be reduced through correction factors that are appropriate for the design situation to produce a design infiltration rate. This adjustment is made in Step 5 of the Design of Infiltration Facilities (Section 3.3.41- USDA Soil Textural Classification

Table 3.7 provides the correlation between USDA soil texture and infiltration rates for estimating infiltration rates for homogeneous soils based on gradations from soil samples and textural analysis. The USDA soil texture—infiltration rate correlation in Table 3.7 is based on the correlation developed by Rawls, et. al. (1982), but with minor changes in the infiltration rates based on WEF/ASCE (1998). The infiltration rates provided through this correlation represent short term conservative rates for homogeneous soils. These rates not consider the effects of site variability and long term clogging due to siltation and biomass buildup in the infiltration facility.

***From WEF/ASCE, 1998:**

****Not recommended for treatment**

*****Refer to SSC-4 and SSC-6 for treatment acceptability criteria**

Based on experience with long term full scale infiltration pond performance, Ecology's Technical Advisory Committee (TAC) recommends that the short term infiltration rates be reduced as shown in Table 3.7, dividing by a correction factor of 2 to 4, depending on the soil textural classification. The correction factors provided in Table 3.7 represent an average degree of long term facility maintenance, TSS

reduction through pretreatment, and site variability in the subsurface conditions. These conditions might include deposits of ancient landslide debris, buried stream channels, lateral grain size variability, and other factors that affect homogeneity).

These correction factors could be reduced, subject to the approval of the local jurisdiction, under the following conditions:

- For sites with little soil variability,
- Where there will be a high degree of long-term facility maintenance,
- Where specific, reliable pretreatment is employed to reduce TSS entering the infiltration facility

In no case shall a correction factor less than 2.0 be used.

Correction factors higher than those provided in Table 3.7 should be considered for situations where long-term maintenance will be difficult to implement, where little or no pretreatment is anticipated, or where site conditions are highly variable or uncertain. These situations require the use of best professional judgment by the site engineer and the approval of the local jurisdiction. An Operation and Maintenance plan and a financial bonding plan may be required by the local jurisdiction.

2. ASTM Gradation Testing at Full Scale Infiltration Facilities

As an alternative to Table 3.7, recent studies by Massmann and Butchart (2000) were used to develop the correlation provided in Table 3.8. These studies compare infiltration measurements from full-scale infiltration facilities to soil gradation data developed using the ASTM procedure (ASTM D422). The primary source of the data used by Massmann and Butchart was from Wiltsie (1998), who included limited infiltration studies only on Thurston County sites. However, Massmann and Butchart also included limited data from King and Clark County sites in their analysis. This table provides recommended long-term infiltration rates that have been correlated to soil gradation parameters using the ASTM soil gradation procedure.

Table 3.8 can be used to estimate long-term design infiltration rates directly from soil gradation data, subject to the approval of the local jurisdiction. As is true of Table 3.7, the long-term rates provided in Table 3.8 represent average conditions regarding site variability, the degree of long-term maintenance and pretreatment for TSS control. The long-term infiltration rates in Table 3.8 may need to be decreased if the site is highly variable, or if maintenance and influent characteristics are not well controlled. The data that forms the basis for Table 3.8 was from soils that would be classified as sands or sandy gravels. No data was available for finer soils at the time the table was developed. Therefore, Table 3.8 should not be used for soils with a d_{10} size (10% passing the size listed) less than 0.05 mm (U.S. Standard Sieve).

⚠ Not recommended for treatment
 ⚠ Refer to SSC-4 and SSC-6 for treatment acceptability criteria

However, additional data based on recent research (Massmann, et al. 2003) for these finer soils are now available and are shown in Figure 3.28.

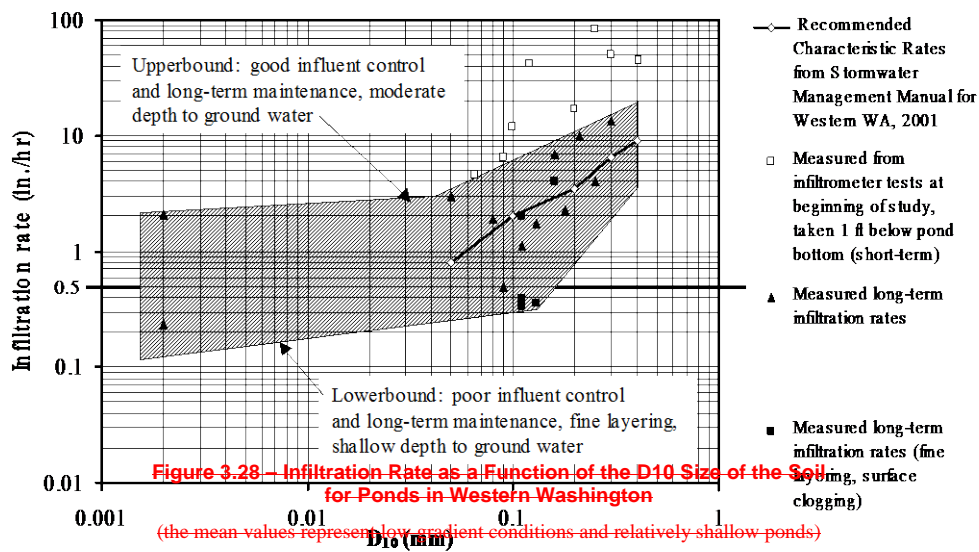


Figure 3.28 provides a plot of this relationship between the infiltration rate and the d10 of the soil, showing the empirical data upon which it is based. The figure provides an upper and lower bound range for this relationship based on the empirical data. These upper and lower bound ranges can be used to adjust the design infiltration rate to account for site-specific issues and conditions.

The long-term rates provided in Table 3.8 represent average conditions regarding site variability, the degree of long-term maintenance, and pretreatment for TSS control, and represent a moderate depth to ground water below the pond. The long-term infiltration rates in Table 3.8 may need to be decreased (i.e., toward the lower bound in Figure 3.28) if the site is highly variable, the ground water table is shallow, there is fine layering present that would not be captured by the soil gradation testing, or maintenance and influent characteristics are not well-controlled. However, if influent control is good (e.g., water entering the pond is pretreated through a biofiltration swale, pre-sedimentation pond, etc.), a good long-term maintenance plan will be implemented, and the water table is moderate in depth, then an infiltration rate toward the upper bound in the figure could be used.

The infiltration rates provided in Tables 3.7, 3.8, and Figure 3.28 represent rates for homogeneous soil conditions. If more than one soil unit is encountered within 6 feet of the base of the facility or 2.5 times the proposed maximum water design depth, use the lowest infiltration rate determined from each of the soil units as the representative site infiltration rate.

If soil mottling, fine silt or clay layers, which cannot be fully represented in the soil gradation tests, are present below the bottom of the infiltration pond, the infiltration rates provided in the tables will be too high and should be reduced. Based on limited full-scale infiltration data (Massmann and Butchart, 2000; Wiltsie, 1998), it appears that the presence of mottling indicates soil conditions that reduce the infiltration rate for homogeneous conditions by a factor of 3 to 4.

The rates shown in Table 3.8 and Figure 3.28 are long-term design rates. No additional correction factor is needed.

3. In-situ Infiltration Measurements

Where feasible, Ecology encourages in-situ infiltration measurements, using a procedure such as the Pilot Infiltration Test (PIT) described in Appendix III-D. Small-scale infiltration tests such as the EPA Falling Head or double-ring infiltrometer test (ASTM D3385-88) are not recommended unless modified versions are determined to be acceptable by Ecology or the local jurisdiction. These small-scale infiltration tests tend to seriously overestimate infiltration rates and, based on recent TAC experience, are considered unreliable.

~~The infiltration rate obtained from the PIT test shall be considered to be a short term rate. This short term rate must be reduced through).~~

Correction factors ~~to~~ account for site variability ~~and~~ number of tests conducted, ~~degree of long term maintenance and influent pretreatment/control, and uncertainty of the test method, and the~~ potential for long-term clogging due to siltation and bio-buildup. [Table 3.3.1](#) ~~summarizes~~ the typical range of correction factors to account for these issues, ~~based on TAC experience, is summarized in Table 3.9. The range of correction factors is for general guidance only.~~ The specific correction factors used shall be determined based on the professional judgment of the licensed engineer or other site professional considering all issues ~~which~~that may affect the ~~long term~~ infiltration rate over the long term, subject to the approval of the local jurisdictional authority.

<p align="center">Table 3.3.1 Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates.</p>	
Issue	Partial Correction Factor
Site variability and number of locations tested	$CF_v = 0.33 \text{ to } 1.0$
Test Method	
Large-scale PIT	$CF_i = 0.75$
Small-scale PIT	$= 0.50$
Other small-scale (e.g. Double ring, falling head)	$= 0.40$
Grain Size Method	$= 0.40$
Degree of influent control to prevent siltation and bio-buildup	$CF_m = 0.9$

Total Correction Factor $(CF_T) = CF_v \times CF_i \times CF_m$

CF_T is used in step 5 of the Design of Infiltration Facilities (Section 3.3.4). The following discussions are to provide assistance in determining the partial correction factors to apply in Table 3.9.

to adjust the measured (initial) saturated hydraulic conductivity.

$$K_{sat \text{ design}} = K_{sat \text{ initial}} \times CF_T$$

Site variability and number of locations tested (CF_v) - The number of locations tested must be capable of producing a picture of the subsurface conditions that fully represents the conditions throughout the facility site. The partial correction factor used for this issue depends on the level of uncertainty that adverse subsurface conditions may occur. If the range of uncertainty is low - for example, conditions are known to be uniform through previous exploration and site geological factors - one pilot infiltration test (or grain size analysis location) may be adequate to justify a partial correction factor at the low/high end of the range.

If the level of uncertainty is high, a partial correction factor near the high/low end of the range may be appropriate. This might be the case where the site conditions are highly variable due to conditions such as a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, (or several grain size test locations), the level of uncertainty may still be high.

A partial correction factor near the high/low end of the range could be assigned where conditions have a more typical variability, but few explorations and only one pilot infiltration test (or one grain size analysis location) is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Degree of long-term maintenance to prevent siltation and bio-buildup

The standard of comparison here is the long-term maintenance requirements provided in Volume V, Chapter 4, and any additional requirements by local jurisdictional authorities. Full compliance with these requirements would be justification to use a partial correction factor at the low end of the range. If there is a high degree of uncertainty that long-term maintenance will be carried out consistently, or if the maintenance plan is poorly defined, a partial correction factor near the high end of the range may be justified.

Uncertainty of test method (CF_t) accounts for uncertainties in the testing methods. For the full scale PIT method, $CF_t = 0.75$; for the small-scale PIT method, $CF_t = 0.50$; for smaller-scale infiltration tests such as the double-ring infiltrometer test, $CF_t = 0.40$; for grain size analysis, $CF_t = 0.40$. These values are intended to represent the difference in each test's ability to estimate the actual saturated hydraulic conductivity. The assumption is the larger the scale of the test, the more reliable the result.

Degree of influent control to prevent siltation and bio-buildup – A partial correction factor near the high end of the range may be justified under the following circumstances:

1. If the infiltration facility is located in a shady area where moss buildup or litter fall buildup from the surrounding vegetation is likely and cannot be easily controlled through long-term maintenance
2. If there is minimal (CF_m) Even with a pre-settling basin or a basic treatment, and facility for pre-treatment, the influent is likely to contain moderately high TSS levels.

If influent into the facility can be well controlled such that the planned long-term maintenance can easily control siltation and biomass buildup, then a partial correction factor near the low end of the range may be justified.

The determination of long-term design infiltration rates from in-situ infiltration test data involves a considerable amount of engineering judgment. Therefore, when reviewing or determining the final long-term design, soil's initial infiltration rate will gradually decline as more and more stormwater, with some amount of suspended material, passes through the soil profile. The maintenance schedule calls for removing sediment when the facility is infiltrating at only 90% of its design capacity. Therefore, a correction factor, CF_m of 0.9 is called for.

This correction is used in Step 5 of the Design of Infiltration Facilities (Section 3.3.4, the local jurisdictional authority should consider the results

~~of both textural analyses and in-situ infiltration tests results when available).~~

3.3.7 Site Suitability Criteria (SSC)

This section provides criteria that must be considered for siting infiltration systems. When a site investigation reveals that any of the applicable criteria cannot be met appropriate mitigation measures must be implemented so that the infiltration facility will not pose a threat to safety, health, and the environment.

For site selection and design decisions a geotechnical and hydrogeologic report should be prepared by a ~~qualified~~licensed engineer with geotechnical and hydrogeologic experience, or a licensed geologist, hydrogeologist, or engineering geologist. The design engineer may utilize a team of certified or registered professionals in soil science, hydrogeology, geology, and other related fields.

SSC-1 Setback Criteria

Setback requirements are generally required by local regulations, uniform building code requirements, or other state regulations.

These Setback Criteria are provided as guidance.

- Stormwater infiltration facilities should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and springs used for public drinking water supplies. Infiltration facilities upgradient of drinking water supplies and within 1, 5, and 10-year time of travel zones must comply with Health Dept. ~~requirements (Washington State Wellhead Protection Program Guidance Document, DOH, 6/2010).~~ Infiltration systems that qualify as Underground Injection Control Wells must comply with Chapter 173-218 and follow “Guidance for UIC Wells that Manage Stormwater~~requirements (Washington Wellhead Protection Program, DOH, 12/93).” Publication No. 05-10-067, Washington Dept. of Ecology, 12/06.~~
- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration system
- From building foundations; ≥ 20 feet downslope and ≥ 100 feet upslope
- From a Native Growth Protection Easement (NGPE); ≥ 20 feet
- From the top of slopes $>15\%$; ≥ 50 feet.
- Evaluate on-site and off-site structural stability due to extended subgrade saturation and/or head loading of the permeable layer, including the potential impacts to downgradient properties, especially on hills with known side-hill seeps.

SSC-2 Ground Water Protection Areas

A site is not suitable if the infiltration facility will cause a violation of Ecology's Ground Water Quality Standards (See SSC-9 for verification testing guidance). Consult local jurisdictions ~~should be consulted~~ for applicable pollutant removal requirements upstream of the infiltration facility, and to determine whether the site is located in an aquifer sensitive area, sole source aquifer, or a wellhead protection zone.

SSC-3 High Vehicle Traffic Areas

An infiltration BMP may be considered for runoff from areas of industrial activity and the high vehicle traffic areas described below. For such applications, provide sufficient pollutant removal (including oil removal) ~~must be provided~~ upstream of the infiltration facility to ensure that ground water quality standards will not be violated and that the infiltration facility is not adversely affected.

High Vehicle Traffic Areas are:

- Commercial or industrial sites subject to an expected average daily traffic count (ADT) ≥ 100 vehicles/1,000 ft² gross building area (trip generation) ~~, and~~.
- Road intersections with an ADT of $\geq 25,000$ on the main roadway ~~, or~~ and $\geq 15,000$ on any intersecting roadway.

SSC-4 Soil Infiltration Rate/Drawdown Time

Infiltration Rates: ~~short-term measured (initial)~~ and design (long-term):

For infiltration facilities used for treatment purposes, the ~~short-term measured (initial)~~ soil infiltration rate should be 2.49 in./hour, or less, ~~to a depth of 2.5 times the maximum design pond water depth, or a minimum of 6 ft. below the base of the infiltration facility. This infiltration rate is also typical for soil textures that possess sufficient physical and chemical properties for adequate treatment, particularly for soluble pollutant removal (see SSC-6). It is comparable to the textures represented by Hydrologic Groups B and C. Long-term, Design (long-term)~~ infiltration rates up to 23.0 inches/hour can also be considered, if the infiltration receptor is not a sole-source aquifer, and in the judgment of the site professional, the treatment soil has characteristics comparable to those specified in SSC-6 to adequately control the target pollutants.

The ~~long-term design~~ infiltration rate should also be used for maximum drawdown time and routing calculations.

Drawdown time:

For infiltration facilities designed strictly for flow control purposes, there isn't a maximum drawdown time. If sizing a treatment facility, document that the 91st percentile, 24-hour runoff water quality design storm volume (indicated by WWHM or MGS Flood, or runoff from a 6-month, 24-hour rain event) can infiltrate through the infiltration basin surface within 48

hours. This can be calculated ~~using~~ multiplying the horizontal projection of the infiltration basin mid-depth dimensions ~~and by~~ the estimated ~~long-term design~~ infiltration rate, and multiplying the result by 48 hours.

This drawdown restriction is intended to meet the following objectives:

- Aerate vegetation and soil to keep the vegetation healthy.
- Enhance the biodegradation of pollutants and organics in the soil.

Note: This is a check procedure, not a method for determining basin size. If the design fails the check procedure, redesign the basin.

SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer

The base of all infiltration basins or trench systems shall be ≥ 5 feet above the seasonal high-water mark, bedrock (or hardpan) or other low permeability layer. A separation down to 3 feet may be considered if the ground water mounding analysis, volumetric receptor capacity, and the design of the overflow and/or bypass structures are judged by the site professional to be adequate to prevent overtopping and meet the site suitability criteria specified in this section.

SSC-6 Soil Physical and Chemical Suitability for Treatment

(Applies to infiltration facilities used as treatment facilities not to facilities used for flow control).

Consider the soil texture and design infiltration rates ~~should be considered~~ along with the physical and chemical characteristics specified below to determine if the soil is adequate for removing the target pollutants. The following soil properties must be carefully considered in making such a determination:

- Cation exchange capacity (CEC) of the treatment soil must be ≥ 5 milliequivalents CEC/100 g dry soil (USEPA Method 9081). *Consider empirical testing of soil sorption capacity, if practicable.* Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. CEC values of >5 meq/100g are expected in loamy sands, according to Rawls, et al. Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is accepted by the local jurisdiction.
- Depth of soil used for infiltration treatment must be a minimum of 18 inches. Depth of soil below permeable pavements serving as pollution-generating hard surfaces may be reduced to one foot if the permeable pavement does not accept run-on from other surfaces.
- Organic Content of the treatment soil (ASTM D 2974): Organic matter can increase the sorptive capacity of the soil for some pollutants. ~~The site professional should evaluate whether the~~ A minimum of 1.0 percent organic matter content is sufficient for control of the target pollutant(s) necessary.

- Waste fill materials ~~should~~shall not be used as infiltration soil media nor ~~should~~shall such media be placed over uncontrolled or non-engineered fill soils.

Engineered soils may be used to meet the design criteria in this chapter and the performance goals in Chapters 3 and 4 of Volume V. Field performance evaluation(s), using ~~acceptable~~ protocols cited in this manual, would be needed to determine feasibility and acceptability by the local jurisdiction. ~~See also Chapter 12 of Volume V.~~

SSC-7 Seepage Analysis and Control

Determine whether there would be any adverse effects caused by seepage zones on nearby building foundations, basements, roads, parking lots or sloping sites.

SSC-8 Cold Climate and Impact of Roadway Deicers

- ~~For cold climate design criteria (snowmelt/ice impacts) refer to D. Caraco and R. Claytor reference.~~

Consider the potential impact of roadway deicers on potable water wells ~~must be considered~~ in the siting determination. Implement mitigation measures ~~must be implemented~~ if the infiltration of roadway deicers ~~can~~could cause a violation of ground water quality standards.

SSC-9 Verification Testing of the Completed Facility

~~Verification testing of the completed full-scale infiltration facility is recommended to confirm that the design infiltration parameters are adequate. The site professional should determine the duration and frequency of the verification testing program including the monitoring program for the potentially impacted ground water. The ground water monitoring wells installed during site characterization (See Section 3.3.5) may be used for this purpose. Long-term (more than two years) in-situ drawdown and confirmatory monitoring of the infiltration facility would be preferable (See King County reference).~~

3.3.8 Steps for Designing Infiltration Facilities - Detailed Approach (Figure 3.29)

This detailed approach was obtained from Massmann (2003). ~~Procedures for~~ The detailed approach includes the process in Figure 3.3.3 ~~are as follows; and the following steps:~~

1. Select a location:

~~This will be based on the ability to convey flow to the location and the expected soil conditions. The minimum setback distances must also be met. See Section 3.3.7 Site Suitability Criteria and setback distances.~~

2. Estimate volume of stormwater, V_{design} :

A continuous hydrograph should be used, requiring a model such as the WWHM, KCRTS, or MGSFlood to perform the calculations.

3. ~~Develop a trial infiltration facility geometry based on length, width, and depth:~~

To accomplish this, either assume an infiltration rate based on previously available data, or use a default infiltration rate of 0.5 inches/hour. This trial geometry should be used to help locate the facility, and for planning purposes in developing the geotechnical subsurface investigation plan.

4. ~~Conduct a geotechnical investigation:~~

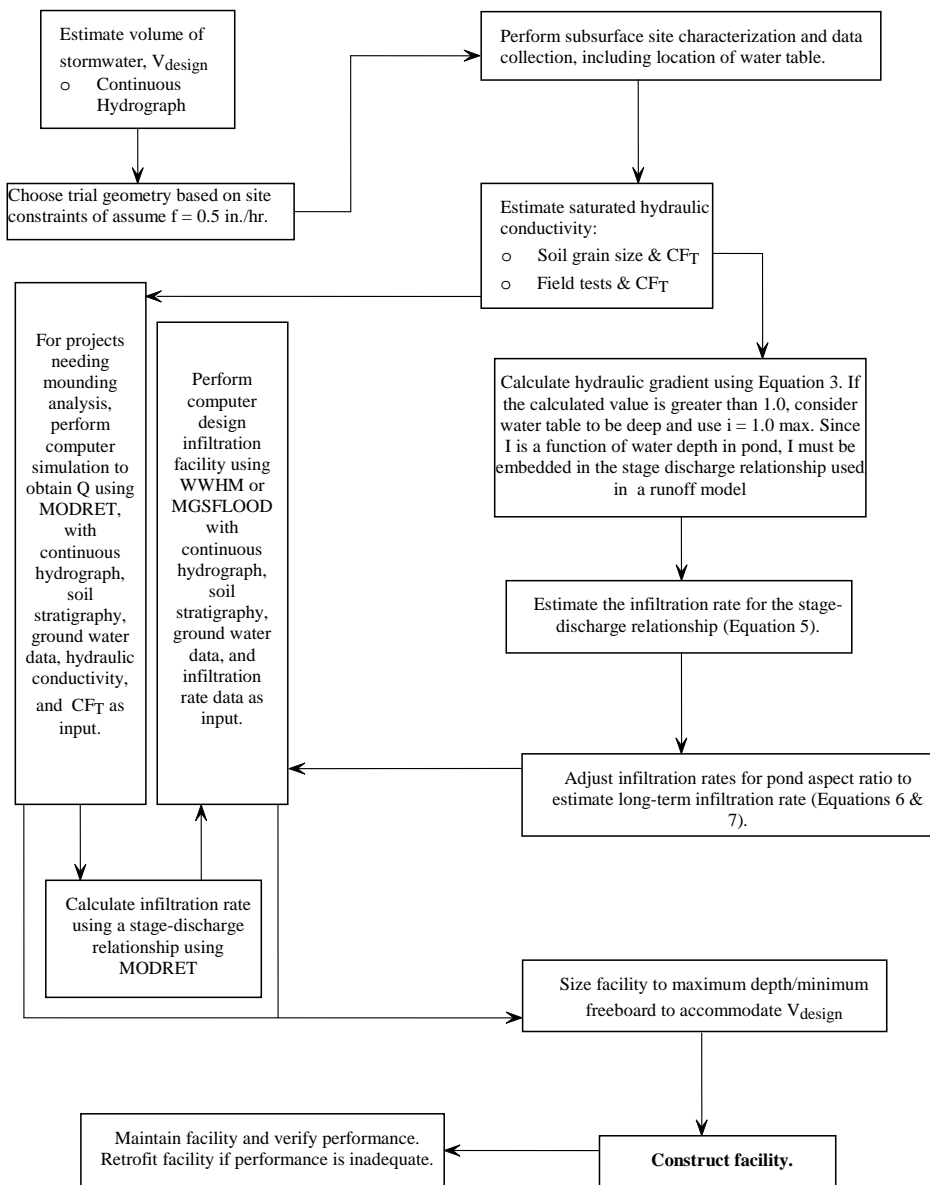
A geotechnical investigation must be conducted to evaluate the site's suitability for infiltration, to establish the infiltration rate for design, and to evaluate slope stability, foundation capacity, and other geotechnical design information needed to design and assess constructability of the facility. Geotechnical investigation requirements are provided below.

The depth, number of test holes or test pits, and sampling described below should be increased if a licensed engineer with geotechnical expertise (P.E.), or a licensed geologist or hydrogeologist judges that conditions are highly variable and make it necessary to increase the depth or the number of explorations to accurately estimate the infiltration system's performance. The exploration program described below may be decreased if the licensed professional judges that conditions are relatively uniform, or design parameters are known to be conservative based on site-specific data or experience, and the borings/test pits omitted will not influence the design or successful operation of the facility.

- ~~For infiltration basins (ponds), at least one test pit or test hole per 5,000 ft² of basin infiltrating surface.~~
- ~~For infiltration trenches, at least one test pit or test hole per 100 feet of trench length.~~
- ~~Subsurface explorations (test holes or test pits) to a depth below the base of the infiltration facility of at least 5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone.~~
- ~~Continuous sampling to a depth below the base of the infiltration facility of 2.5 times the maximum design depth of water proposed for the infiltration facility, or at least 2 feet into the saturated zone, but not less than 6 feet. Samples obtained must be adequate for the purpose of soil gradation/classification testing.~~

~~Ground water monitoring wells installed to locate the ground water table and establish its gradient, direction of flow, and seasonal variations, considering both confined and unconfined aquifers. (Monitoring through at least one wet season is required, unless site historical data regarding ground water levels is available.) In~~

general, a minimum of three wells per infiltration facility, or three hydraulically connected surface or ground water features, are needed to determine the direction of flow and gradient. If gradient and flow direction are not required, and there is low risk of down-gradient impacts, one monitoring well is sufficient. Alternative means of establishing the ground water levels may be considered. 1 – 5. Steps 1 through 5 are the same as indicated for the Simplified Approach – Section 3.3.4



~~If the ground water in the area is known to be greater than 50 feet below the proposed facility, detailed investigation of the ground water regime is not necessary.~~

- ~~Laboratory testing as necessary to establish the soil gradation characteristics and other properties as necessary, to complete the infiltration facility design. At a minimum, one grain size analysis per soil stratum in each test hole must be conducted within 2.5 times the maximum design water depth, but not less than 6 feet. When assessing the hydraulic conductivity characteristics of the site, soil layers at greater depths must be considered if the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, requiring soil gradation/classification testing for layers deeper than indicated above.~~

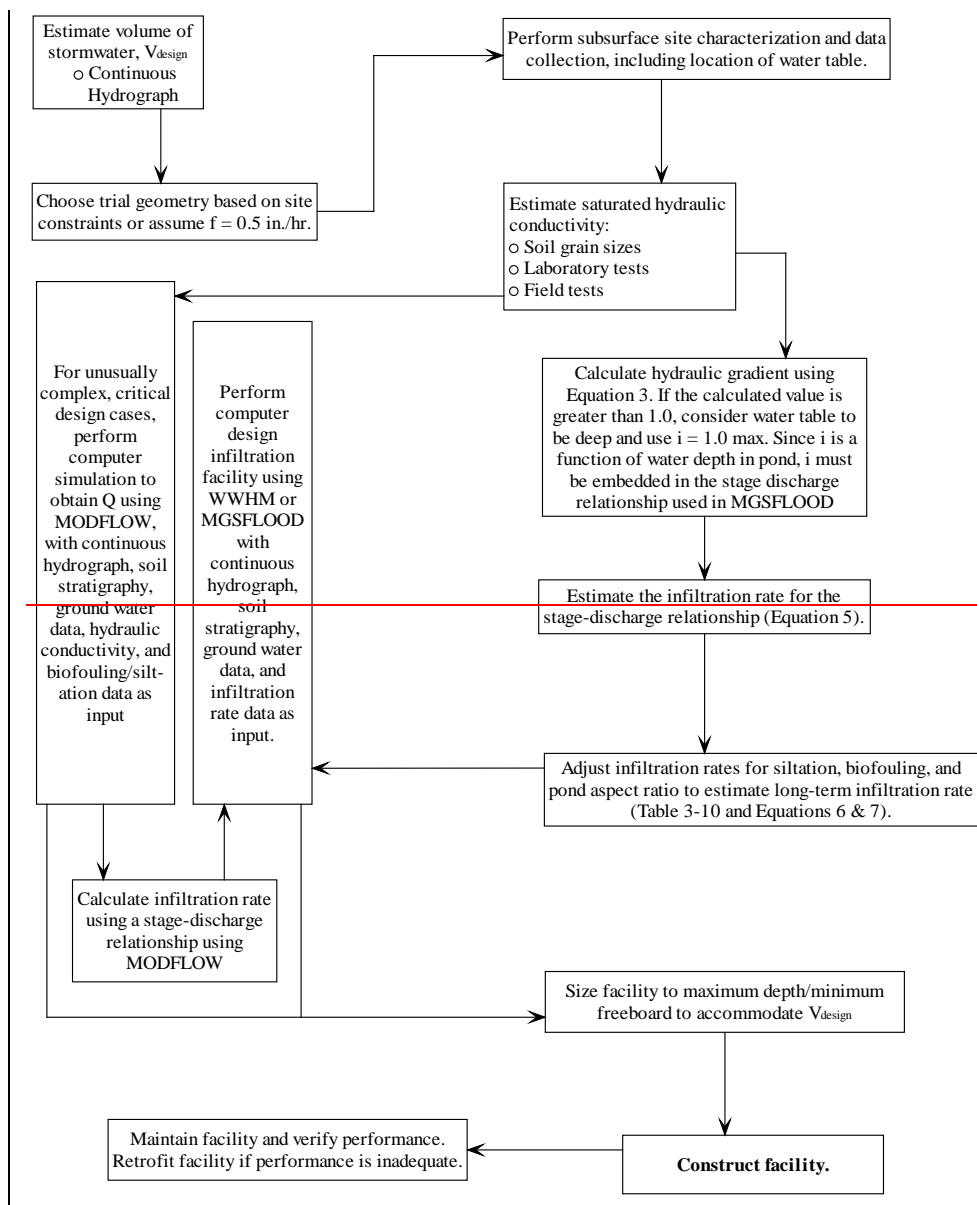


Figure 3.29–3.3 - Engineering Design Steps for Final Design of Infiltration Facilities Using the Continuous Hydrograph Detailed Method

5. From the geotechnical investigation, determine the following, as applicable:

- The stratification of the soil/rock below the infiltration facility, including the soil gradation (and plasticity, if any) characteristics of each stratum.
- The depth to the ground water table and to any bedrock/impermeable layers.
- Seasonal variation of the ground water table.
- The existing ground water flow direction and gradient.
- The hydraulic conductivity or the infiltration rate for the soil/rock at the infiltration facility.
- The porosity of the soil below the infiltration facility but above the water table.
- The lateral extent of the infiltration receptor.
- Impact of the infiltration rate and volume on flow direction and water table at the project site, and the potential discharge point or area of the infiltrating water.

6. Determine the saturated hydraulic conductivity as follows:

For each defined layer below the pond to a depth below the pond bottom of 2.5 times the maximum depth of water in the pond, but not less than 6 feet, estimate the saturated hydraulic conductivity in cm/sec using the following relationship (see Massmann 2003, and Massmann et al., 2003)

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{\text{fines}}$$

Where, D_{10} , D_{60} and D_{90} are the grain sizes in mm for which 10 percent, 60 percent and 90 percent of the sample is more fine and f_{fines} is the fraction of the soil (by weight) that passes the number 200 sieve (K_{sat} is in cm/s).

If the licensed professional conducting the investigation determines that deeper layers will influence the rate of infiltration for the facility, soil layers at greater depths must be considered when assessing the site's hydraulic conductivity characteristics. Massmann (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration facility can influence the rate of infiltration. **Note that only the layers near and above the water table or low permeability zone (e.g., a clay, dense glacial till, or rock layer) need to be considered, as the layers below the ground water table or low permeability zone do not significantly influence the rate of infiltration. Also note that this equation for estimating hydraulic conductivity assumes minimal compaction consistent**

(4)

with the use of tracked (i.e., low to moderate ground pressure) excavation equipment. If the soil layer being characterized has been exposed to heavy compaction, or is heavily over-consolidated due to its geologic history (e.g., overridden by continental glaciers), the hydraulic conductivity for the layer could be approximately an order of magnitude less than what would be estimated based on grain size characteristics alone (Pitt, 2003). In such cases, compaction effects must be taken into account when estimating hydraulic conductivity. For clean, uniformly graded sands and gravels, the reduction in K_{sat} due to compaction will be much less than an order of magnitude. For well graded sands and gravels with moderate to high silt content, the reduction in K_{sat} will be close to an order of magnitude. For soils that contain clay, the reduction in K_{sat} could be greater than an order of magnitude.

For critical designs, the in-situ saturated conductivity of a specific layer can be obtained through field tests such as the packer permeability test (above or below the water table), the piezocone (below the water table), an air conductivity test (above the water table), or through the use of a pilot infiltration test (PIT) as described in Appendix III-D. Note that these field tests generally provide a hydraulic conductivity combined with a hydraulic gradient (i.e., Equation 5). In some of these tests, the hydraulic gradient may be close to 1.0; therefore, in effect, the magnitude of the test result is the same as the hydraulic conductivity. In other cases, the hydraulic gradient may be close to the gradient that is likely to occur in the full scale infiltration facility. This issue will need to be evaluated on a case by case basis when interpreting the results of field tests. It is important to recognize that the gradient in the test may not be the same as the gradient likely to occur in the full scale infiltration facility in the long term (i.e., when ground water mounding is fully developed).

Once the saturated hydraulic conductivity for each layer has been identified, determine the effective average saturated hydraulic conductivity below the pond. Hydraulic conductivity estimates from different layers can be combined using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}} \quad (2)$$

Where, d is the total depth of the soil column, d_i is the thickness of layer “i” in the soil column, and K_i is the saturated hydraulic conductivity of layer “i” in the soil column. The depth of the soil column, d , typically would include all layers between the pond bottom and the water table. However, for sites with very deep water tables (>100 feet) where ground water mounding to the base of the pond is not likely to occur, it is recommended that the total depth of the soil column in Equation 2 be limited to approximately 20 times the depth of pond. This is to ensure that

~~the most important and relevant layers are included in the hydraulic conductivity calculations. Deep layers that are not likely to affect the infiltration rate near the pond bottom should not be included in Equation 2. Equation 2 may over estimate the effective hydraulic conductivity value at sites with low conductivity layers immediately beneath the infiltration pond. For sites where the lowest conductivity layer is within five feet of the base of the pond, it is suggested that this lowest hydraulic conductivity value be used as the equivalent hydraulic conductivity rather than the value from Equation 2. The harmonic mean given by Equation 2 is the appropriate effective hydraulic conductivity for flow that is perpendicular to stratigraphic layers, and will produce conservative results when flow has a significant horizontal component such as could occur due to ground water mounding.~~

4.6. Calculate the hydraulic gradient as follows:

Calculate the steady state hydraulic gradient ~~is calculated~~ as follows:

$$\text{gradient} = i \approx \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} CF_{size} \quad (3)$$

$$\text{gradient} = i \approx \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} CF_{size} \quad (3)$$

Note: The units in this equation vary from the units normally used in this manual.

Where, D_{wt} is the depth from the base of the infiltration facility to the water table in feet, K is the saturated hydraulic conductivity in feet/day, D_{pond} is one-quarter of the maximum depth of water in the facility in feet (see Massmann et al., 2003, for the development of this equation), and CF_{size} , is the correction for pond size. The correction factor was developed for ponds with bottom areas between 0.6 and 6 acres in size. For small ponds (ponds with area equal to 2/3 acre), the correction factor is equal to 1.0. For large ponds (ponds with area equal to 6 acres), the correction factor is 0.2, as shown in Equation 4.

$$CF_{size} = 0.73(A_{pond})^{-0.76} \quad (4)$$

Where, A_{pond} is the area of pond bottom in acres. This equation generally will result in a calculated gradient of less than 1.0 for moderate to shallow ground water depths (or to a low permeability layer) below the facility, and conservatively accounts for the development of a ground water mound. A more detailed ground water mounding analysis using a program such as MODFLOW will usually result in a gradient that is equal to or greater than the gradient calculated using Equation 3. If the calculated gradient is greater than 1.0, the water table is considered to be deep, and a maximum gradient of 1.0 must be used. Typically, a depth to ground water

of 100 feet or more is required to obtain a gradient of 1.0 or more using this equation. Since the gradient is a function of depth of water in the facility, the gradient will vary as the pond fills during the season. The gradient could be calculated as part of the stage-discharge calculation used in the continuous runoff models. As of the date of this update, neither the WWHM or MGSFlood have that capability. However, updates to those models may soon incorporate the capability. Until that time, use a steady-state hydraulic gradient that corresponds with a ponded depth of ¼ of the maximum ponded depth – as measured from the basin floor to the overflow.

5.7. Calculate the preliminary design infiltration rate using Darcy's law as follows:

$$f \equiv K \left(\frac{dh}{dz} \right) = \frac{Ki}{L} \quad (5.7)$$

Where, f is the specific discharge or infiltration rate of water through a unit cross-section of the infiltration facility (L/t), K is the hydraulic conductivity (L/t), dh/dz is the hydraulic gradient (L/L), and "i" is the gradient.

6.8. Adjust the preliminary design infiltration rate or infiltration stage-discharge relationship obtained in Steps 8 and 9 Step 7:

Adjustments of the initial infiltration rate estimate should have been made in Step 5. (As explained in Section 3.3.7) This is done to account for reductions in the rate resulting from long-term siltation and biofouling, taking into consideration the degree of long-term maintenance and performance monitoring anticipated, the degree of influent control (e.g., pre-settling ponds, biofiltration swales, etc.), and the potential for siltation, litterfall, moss buildup, etc. based on the surrounding environment. It should be assumed that an average to high degree of maintenance will be performed on these facilities. A low degree of maintenance should be considered only when there is no other option (e.g., access problems). The infiltration rate estimated in Step 8 and 9 is multiplied by the reduction factors summarized in Table 3-10.

The values in this table assume that final excavation of the facility to the finished grade is deferred until all disturbed areas in the upgradient drainage area have been stabilized or protected (e.g., construction runoff is not allowed into the facility after final excavation of the facility). Ponds located in shady areas where moss and litterfall from adjacent vegetation can build up on the pond bottom and sides, the upgradient drainage area will remain in a disturbed condition long-term, and no pretreatment (e.g., pre-settling ponds, biofiltration swales, etc.) is provided, are one example

~~of a situation with a high potential for biofouling. A low degree of long-term maintenance includes, for example, situations where access to the facility for maintenance is very difficult or limited, or where there is minimal control of the party responsible for enforcing the required maintenance. A low degree of maintenance should be considered only when there is no other option.~~

~~Also adjust this).~~

This step adjusts the preliminary design infiltration rate for the effect of pond aspect ratio by multiplying the infiltration rate determined in Step 9 ~~(Equation 6)~~ by the aspect ratio correction factor F_{aspect} as shown in the following equation:

$$CF_{\text{aspect}} = 0.02A_r + 0.98 \quad (6)$$

Where, A_r is the aspect ratio for the pond (length/width) ~~of the bottom area~~. In no case shall CF_{aspect} be greater than 1.4.

The final design (long-term) infiltration rate will therefore be as follows:

$$f = K \cdot i \cdot CF_{\text{aspect}} \cdot \bullet CF_{\text{silt/bio}} \quad (7)$$

~~The rates calculated based on Equations 5 and 7 are long-term design rates. No additional reduction factor or factor of safety is needed.~~

7-9. Size the facility:

Size the facility to ensure that the ~~desirable~~maximum pond depth is ~~three~~between 2 to 6 feet, with one-foot minimum required freeboard. ~~The maximum allowable pond depth is six feet.~~

Where the infiltration facility is being used to meet treatment requirements, check that the ~~91st percentile, 24-hour runoff~~Water Quality Design Storm Volume (indicated by WWHM or MGS Flood) can infiltrate through the infiltration basin surface within 48 hours. This can be calculated by multiplying a horizontal projection of the infiltration basin mid-depth dimensions by the estimated ~~long-term~~design infiltration rate; and multiplying the result by 48 hours ~~(See SSC-4 in Section 3.3.7.~~
~~Finally, check to make sure that the basin can drain its maximum ponded water depth within 24 hours)~~

10. Ground Water Mounding Analysis:

Ground water Mounding Analysis: On projects where an infiltration facility has a drainage area exceeding 1 acre and has less than fifteen feet depth to seasonal high ground water (as measured from the bottom of the infiltration basin or trench) or other low permeability stratum, determine the final design infiltration rate using an analytical ground water model to investigate the effects of the local hydrologic conditions on facility performance. These larger projects can use the design infiltration rate determined above as input to an approved continuous runoff model (WWHM, MGS Flood, KCRTS) to do an initial sizing. Then complete the

ground water modeling (mounding analysis) of the proposed infiltration facility. Use MODRET or an equivalent model unless the local government approves an alternative analytic technique.

Export the full output hydrograph of the developed condition and use it as input to MODRET. Note that an iterative process may be required beginning with an estimated design rate, WWHM sizing, then ground water model testing. See Figure 3.3.3.

8.11. Construct the facility & Conduct Performance Testing:

Maintain and monitor the facility for performance in accordance with section 3.3.8.

Test and monitor the constructed facility to demonstrate that the facility performs as designed. Use the same test methods for saturated hydraulic conductivity as used in the planning stages so that results are comparable. Perform the testing after stabilizing the construction site. Submit the results and comparisons to the pre-project measured (initial) and design rates to the local stormwater authority that approved the project design. If the rates are lower than the design saturated hydraulic conductivity, the applicant shall implement measures to improve infiltration capability within the footprint of the constructed facility and re-test. If less intensive measures prove unsuccessful, replacement of the top foot of soil – or more if visual observation indicates deeper fouling of the bed with fine sediment – with a soil meeting the design needs (i.e., treatment, flow control, or both) shall be provided. Longer-term monitoring of drawdown times and periodic testing of the facility should provide an indication of when the facility needs maintenance to restore infiltration rates.

3.3.9 General Design, Maintenance, and Construction Criteria for Infiltration Facilities

This section covers design, construction and maintenance criteria that apply to infiltration basins and trenches.

Design Criteria – Sizing Facilities

The size of the infiltration facility can be determined by routing the influent runoff file generated by the continuous runoff model through it. To prevent the onset of anaerobic conditions, an infiltration facility designed for treatment purposes must be designed to drain the ~~94th percentile, 24-hour runoff~~ Water Quality Design volume within 48 hours (see explanation under SSC-4 in Section 3.3.7 ~~simplified or detailed design procedures~~). In general, an infiltration facility would have 2 discharge modes. The primary mode of discharge from an infiltration facility is infiltration into the ground. However, when the infiltration capacity of the

facility is reached, additional runoff to the facility will cause the facility to overflow. Overflows from an infiltration facility must comply with the Minimum Requirement #7 for flow control in Volume I. Infiltration facilities used for runoff treatment must not overflow more than 9% of the influent runoff file. Infiltration facilities can also be used to demonstrate compliance with the LID Performance Standard of Minimum Requirement #5.

In order to determine compliance with the flow control requirements, use the Western Washington Hydrology Model (WWHM), or an appropriately calibrated continuous simulation model based on HSPF, ~~must be used.~~ When using WWHM for simulating flow through an infiltrating facility, represent the facility ~~is represented~~ by using ~~the~~ a Pond ~~from~~ Element and entering the pre-determined infiltration rates. Below are the procedures for sizing a pond (A) to completely infiltrate 100% of runoff; (B) to treat 91% of runoff to meet the water quality treatment requirements, and (C) to partially infiltrate runoff to meet flow duration standard.

(A) For 100% infiltration

1. ~~(1)~~ Input dimensions of your infiltration pond,

Input infiltration rate and safety (rate reduction) factor. When using the Simplified Approach, you may enter the measured (initial) saturated hydraulic conductivity (Ksat) and the Total Correction Factor as determined using Section 3.3.6; OR, enter the estimated final design infiltration rate after application of the correction factor and a safety factor of 1. For the Detailed Approach, you should enter your preliminary design infiltration rate after completing Steps 1 through 7 (in Section 3.3.8). Then enter the correction factor for the pond aspect, as noted in Step 8 (in Section 3.3.8)

2. ~~(3)~~, as the safety factor in the model input

- ~~2-3.~~ Input a riser height and diameter (any flow through the riser indicates that you have less than 100% infiltration and must increase your infiltration pond dimensions).

- ~~3-4.~~ ~~(4)~~ Run only HSPF for Developed Mitigated Scenario (if that is where you put the infiltration pond). Don't need to run duration.

- ~~4-5.~~ ~~(5)~~ Go back to your infiltration pond and look at the Percentage Infiltrated at the bottom right. If less than 100% infiltrated, increase pond dimension until you get 100%.

(B) For 91% infiltration (water quality treatment volume)

The procedure is the same as above, except that your target is 91%.

Infiltration facilities for treatment can be located upstream or downstream of detention and can be off-line or on-line.

On-line treatment facilities placed *upstream or downstream* of a detention facility must be sized to infiltrate 91% of the runoff file volume directed to it.

Off-line treatment facilities placed *upstream* of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by WWHM (or other approved continuous runoff model), to the treatment facility. Within ~~the~~ WWHM, the flow splitter ~~ieon~~element is placed ahead of the pond ~~ieon~~element which represents the infiltration basin. Size the treatment facility ~~must be sized~~ to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

Off-line treatment facilities placed *downstream* of a detention facility must have a flow splitter designed to send all flows at or below the 2-year flow frequency from the detention pond, as predicted by WWHM (or other approved continuous runoff model), to the treatment facility. Within ~~the~~ WWHM, the flow splitter ~~ieon~~element is placed ahead of the pond ~~ieon~~element which represents the infiltration basin. Size the treatment facility ~~must be sized~~ to infiltrate all the runoff sent to it (no overflows from the treatment facility are allowed).

See ChapterSection 4.5 of Volume V for flow splitter design details.

(C) To meet flow duration standard with infiltration ponds

This design will allow something less than 100% infiltration as long as any overflows will meet the flow duration standard. ~~You would need~~Use a discharge structure with orifices and risers similar to a detention facility ~~except that, in addition, you also have~~and include infiltration occurring from the pond~~:-~~.

Additional Design Criteria

- Slope of the base of the infiltration facility should be <3 percent.
- Spillways/overflow structures – Construct a nonerodible outlet or spillway with a firmly established elevation ~~must be constructed to~~ discharge overflow. Calculate ponding depth, drawdown time, and storage volume ~~are calculated~~ from that reference point. Overflow Structure-Refer to Chapter 2~~Chapter 2~~ for design details
- For infiltration treatment facilities, side-wall seepage is not a concern if seepage occurs through the same stratum as the bottom of the facility. However, for engineered soils or for soils with very low permeability, the potential to bypass the treatment soil through the side-walls may be significant. In those cases, line the side-walls ~~must be lined, either with an impervious liner or~~ with at least 18 inches of treatment soil~~;~~ to prevent seepage of untreated flows through the side walls.

Design Criteria – Pretreatment

A facility to remove a portion of the influent suspended solids should precede the infiltration facility. Use either an option under the basic treatment facility menu (See Chapter 2 of Volume V), or a pretreatment option from Chapter 6 of Volume V. The lower the influent suspended solids loading to the infiltration facility, the longer the infiltration facility can infiltrate the desired amount of water or more, and the longer interval between maintenance activity.

In facilities such as infiltration trenches where a reduction in infiltration capability can have significant maintenance or replacement costs, selection of a reliable treatment device with high solids removal capability is preferred. In facilities that allow easier access for maintenance and less costly maintenance activity (e.g., infiltration basins with gentle side slopes), there is a trade-off between using a treatment device with a higher solids removal capability and a device with a lower capability. Generally, treatment options on the basic treatment menu are more capable at solids removal than pretreatment devices listed in Chapter 6 of Volume V. Though basic treatment options may be higher in initial cost and space demands, the infiltration facility should have lower maintenance costs.

Construction Criteria

- Conduct initial basin excavation ~~should be conducted~~ to within 1-foot of the final elevation of the basin floor. Excavate infiltration trenches and basins to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation should remove all accumulation of silt in the infiltration facility before putting it in service. After construction ~~is completed~~ completion, prevent sediment from entering the infiltration facility by first conveying the runoff water through an appropriate pretreatment system such as a pre-settling basin, wet pond, or sand filter.
- Generally, do not use infiltration facilities ~~should generally not be used~~ as temporary sediment traps during construction. If an infiltration facility ~~is to will~~ be used as a sediment trap, ~~it must do~~ not ~~be~~ excavated to final grade until after the stabilizing the upgradient drainage area ~~has been stabilized.~~ Remove any accumulation of silt in the basin ~~must be removed before~~ putting it in service.
- Traffic Control – Relatively light-tracked equipment is recommended for this operation to avoid compaction of the basin floor. Consider the use of draglines and trackhoes ~~should be considered~~ for constructing infiltration basins. Flag or mark the infiltration area ~~should be flagged or marked~~ to keep heavy equipment away.

Maintenance Criteria

~~Provision should be made~~ Make provisions for regular and perpetual maintenance of the infiltration basin/trench, including replacement and/or

reconstruction of the any media ~~that are~~ relied upon for treatment purposes. ~~—Maintenance should be conducted~~ Conduct maintenance when water remains in the basin or trench for more than 24 hours after the end of ~~a rainfall event runoff~~, or when overflows occur more frequently than planned. For example, off-line infiltration facilities should not have any overflows. Infiltration facilities designed to completely infiltrate all flows to meet flow control standards should not overflow. An Operation and Maintenance Plan, approved by the local jurisdiction, should ensure maintaining the desired infiltration rate.

Include adequate access for operation and maintenance ~~must be included~~ in the design of infiltration basins and trenches.

Conduct removal of accumulated debris/sediment in the basin/trench ~~should be conducted~~ every 6 months or as needed to prevent clogging, ~~or when~~. Indications that the facility is not infiltrating adequately include:

- The Water Quality Design Storm Volume does not infiltrate within 48 hours.
- Water remains in the pond for greater than 24 hours after the end of ~~a most moderate~~ rainfall ~~event events~~.

For more detailed information on maintenance, see Volume V, Section 4.6 – Maintenance Standards for Drainage Facilities.

Verification of Performance

During the first 1-2 years of operation verification testing (specified in SSC-9) is strongly recommended, along with a maintenance program that results in achieving expected performance levels. Operating and maintaining ground water monitoring wells (specified in [Section 3.3.7](#) ~~Section 3.3.7~~ - Site Suitability Criteria) is also strongly encouraged.

3.3.10 Infiltration Basins

This section covers design and maintenance criteria specific for infiltration basins. (See [Figure 3.3.4](#) ~~schematic in Figure 3.25~~).

Description:

Infiltration basins are earthen impoundments used for the collection, temporary storage and infiltration of incoming stormwater runoff.

Design Criteria Specific for Basins

- ~~A access should be provided~~ Provide access for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or resuspend sediment any more than ~~is~~ absolutely necessary.
- The slope of the basin bottom should not exceed 3% in any direction.
- Size the basin for a maximum ponding depth of between 2 and 6 feet.

- A minimum of one foot of freeboard is recommended when establishing the design ponded water depth. Freeboard is measured from the rim of the infiltration facility to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.
- Treatment infiltration basins must have sufficient vegetation established on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Provide erosion protection of inflow points to the basin ~~must also be provided~~ (e.g., riprap, flow spreaders, energy dissipators ~~(See Chapter 4))~~). Select suitable vegetative materials ~~for to stabilize~~ the basin floor and side slopes ~~to be stabilized~~. Refer to ~~Chapter 0~~ detention pond guidance earlier in this chapter for recommended vegetation.
- Lining material – Basins can be open or covered with a 6 to 12-inch layer of filter material such as coarse sand, or a suitable filter fabric to help prevent the buildup of impervious deposits on the soil surface. Select a nonwoven geotextile ~~should be selected~~ that will function sufficiently without plugging (see geotextile specifications in Appendix V-C of Volume V). Replace or clean the filter layer ~~can be replaced or cleaned~~ when/if it becomes clogged.
- Vegetation – Stabilize the embankment, emergency spillways, spoil and borrow areas, and other disturbed areas ~~should be stabilized and planted~~ plant, preferably with grass, in accordance with Stormwater Site Plan (See Minimum Requirement #1 of Volume I). Without healthy vegetation, the surface soil pores ~~would will~~ quickly plug.

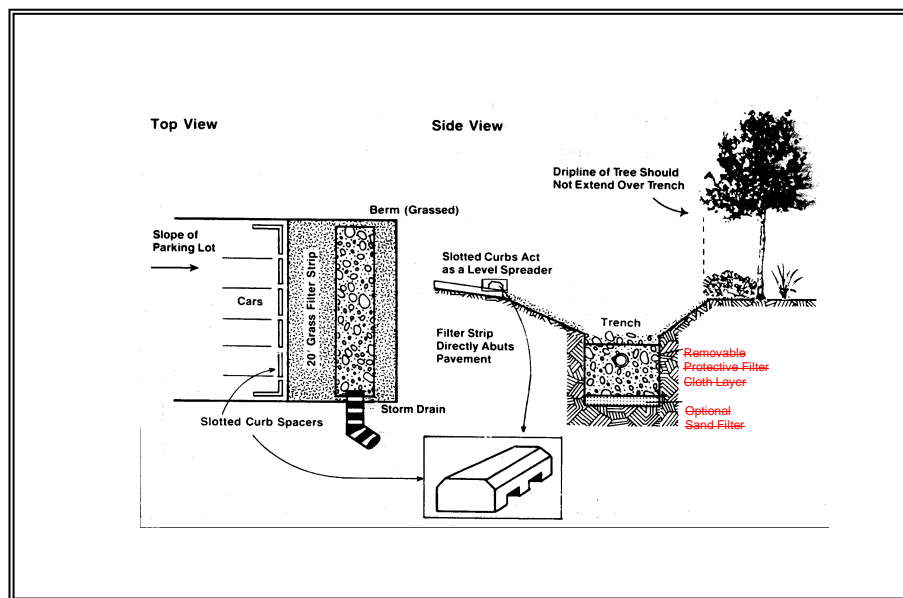
Maintenance Criteria for Basins

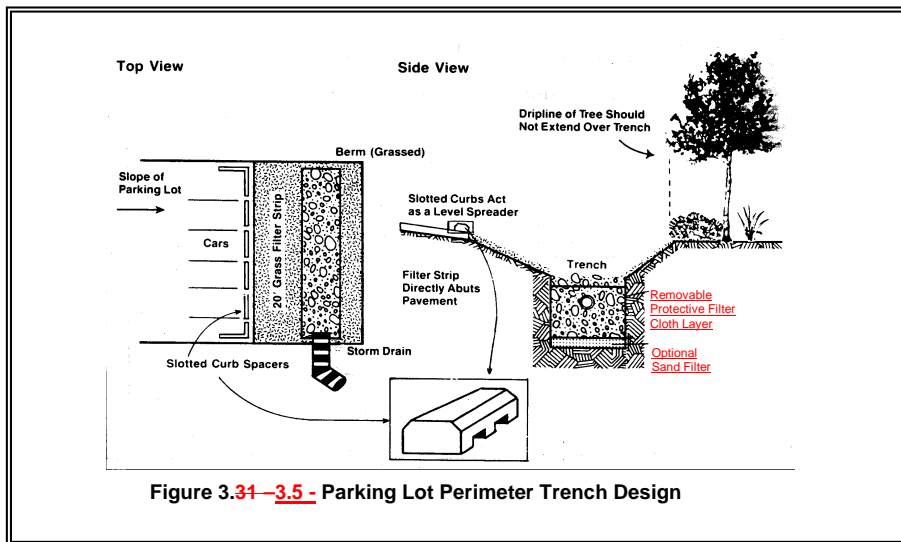
- Maintain basin floor and side slopes to promote dense turf with extensive root growth. This enhances infiltration, prevents erosion and consequent sedimentation of the basin floor, and prevents invasive weed growth. Immediately stabilize and revegetate bare spots ~~are to be immediately stabilized and revegetated~~.
- Do not allow vegetation growth ~~should not be allowed~~ to exceed 18 inches in height. Mow the slopes periodically and check for clogging, and erosion.
- Use the same seed mixtures ~~should be the same~~ as those recommended in Table 3.2.2 ~~Table 3.2~~. The use of slow-growing, stoloniferous grasses will permit long intervals between mowing. Mowing twice a year is generally satisfactory. ~~Fertilizers should be applied~~ Apply fertilizers only as necessary and in limited amounts to avoid contributing to ground water pollution. Consult the local ~~extension agency~~ agricultural or gardening resources such as Washington State University Extension for appropriate fertilizer ~~type~~ type, including slow release fertilizers, and application rates.

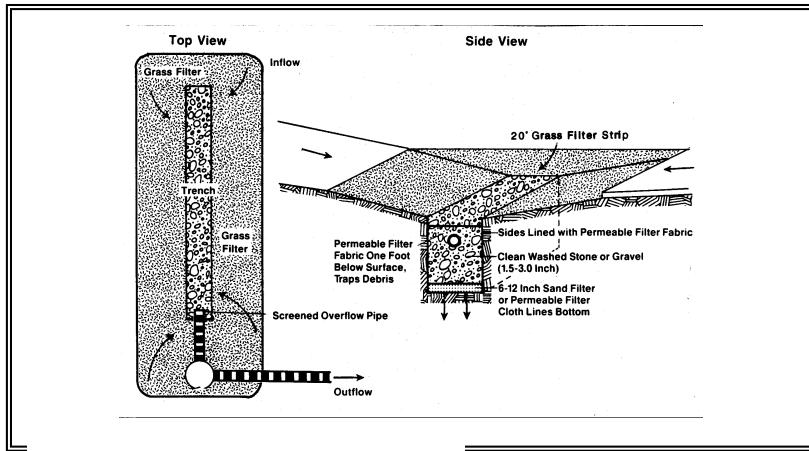
This section covers design, construction, and maintenance criteria specific for infiltration troughs.



Figure 3.30–3.4 - Schematic of an Infiltration Trench

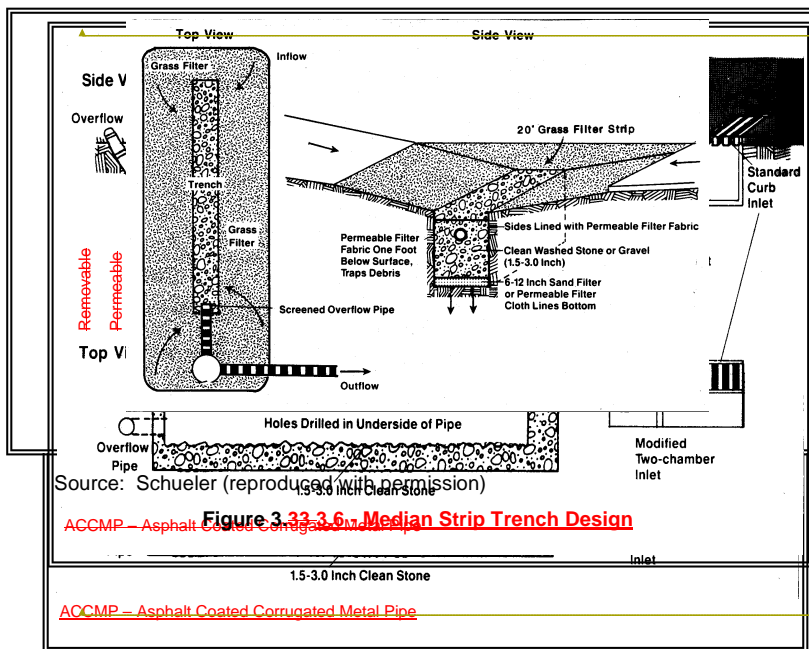






Source: Schueler (reproduced with permission)

Trench Design



Source: Schueler (reproduced with permission)

Figure 3-33-3.6.17 Median Strip Trench Design

ACCMP – Asphalt Coated Corrugated Metal Pipe

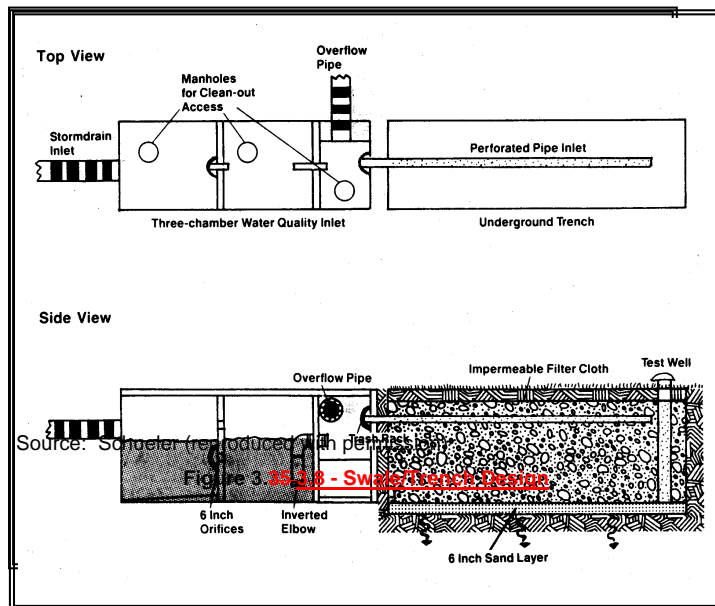
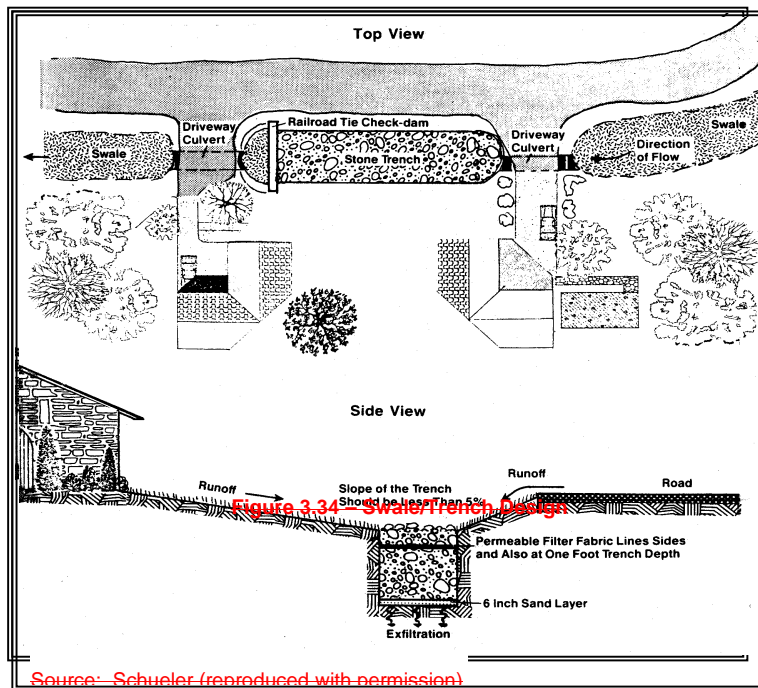
ACCMP – Asphalt Coated Corrugated Metal Pipe

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Figure 3.3.7 - Oversized Pipe Trench Design



Source: Schueler (reproduced with permission)

Figure 3.3.9 - Underground Trench with Oil/Grit Chamber
Design Criteria

- Due to accessibility and maintenance limitations, carefully design and construct infiltration trenches ~~must be carefully designed and constructed~~. Contact the local jurisdiction ~~should be contacted~~ for additional specifications.
- Consider including an access port or open or grated top for accessibility to conduct inspections and maintenance.
- Backfill Material - The aggregate material for the infiltration trench should consist of a clean aggregate with a maximum diameter of 3 inches and a minimum diameter of 1.5 inches. Void space for these aggregates should be in the range of 30 to 40 percent.
- Geotextile fabric liner — Completely encase the aggregate fill material ~~shall be completely encased~~ in an engineering geotextile material. Geotextile should surround all of the aggregate fill material except for the top one-foot, which is placed over the geotextile. Carefully select geotextile fabric with acceptable properties ~~must be carefully selected~~ to avoid plugging (see Appendix V-C of Volume V).
- The bottom sand or geotextile fabric as shown in Figure 3.3.10 ~~the attached figures~~ is optional.

Refer to the Federal Highway Administration Manual “Geosynthetic Design and Construction Guidelines,” Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications. ~~Refer to the Federal Highway Administration Manual “Geosynthetic Design and Construction Guidelines,” Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications.~~ Refer to the NCHRP Report 367, “Long-Term Performance of Geosynthetics in Drainage Applications,” 1994, for long-

term performance data and background on the potential for geotextiles to clog, blind, or to allow piping to occur and how to design for these issues.

- Overflow Channel - Because an infiltration trench is generally used for small drainage areas, an emergency spillway is not necessary. However, provide a non-erosive overflow channel leading to a stabilized watercourse ~~should be provided~~.
- Surface Cover - A stone filled trench can be placed under a porous or impervious surface cover to conserve space.
- Observation Well - Install an observation well ~~should be installed~~ at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. Figure 3.3.10 ~~Figure 3.36~~ illustrates observation well details. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter and it should be constructed flush with the ground elevation. For larger trenches a 12-36 inch diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. Cap the top of the well ~~should be capped~~ to discourage vandalism and tampering.

Construction Criteria

- Trench Preparation - Place excavated materials ~~must be placed~~ away from the trench sides to enhance trench wall stability. ~~Care should also be taken~~ Take care to keep this material away from slopes, neighboring property, sidewalks and streets. It is recommended that this material be covered with plastic. (See Erosion/sediment control Criteria in Volume II, BMP C123 – Plastic Covering).
- Stone Aggregate Placement and Compaction - ~~The~~ Place stone aggregate ~~should be placed~~ in lifts and ~~compacted~~ compact using plate compactors. ~~As a rule of thumb~~ In general, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.
- Potential Contamination - Prevent natural or fill soils from intermixing with the stone aggregate. ~~Potential Contamination – Prevent natural or fill soils from intermixing with the stone aggregate.~~ Remove all contaminated stone aggregate ~~must be removed~~ and replaced with uncontaminated stone aggregate.
- Overlapping and Covering - Following the stone aggregate placement, fold the geotextile ~~must be folded~~ over the stone aggregate to form a 12 inch minimum longitudinal overlap. When overlaps are required between rolls, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.
- VOIDS behind Geotextile - Voids between the geotextile and excavation sides must be avoided. Removing boulders or other

~~obstacles from the trench walls is one source of such voids. When overlaps are required between rolls, the upstream roll should overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.~~

- ~~Voids behind Geotextile – Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Place~~ natural soils ~~should be placed~~ in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. ~~This remedial process will avoid~~ soil piping, geotextile clogging, and possible surface subsidence ~~will be avoided by this remedial process.~~
- ~~Unstable Excavation Sites - Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed. Unstable Excavation Sites – Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trapezoidal, rather than rectangular, cross-sections may be needed.~~

Maintenance Criteria

Monitor sediment buildup in the top foot of stone aggregate or the surface inlet ~~should be monitored~~ on the same schedule as the observation well.

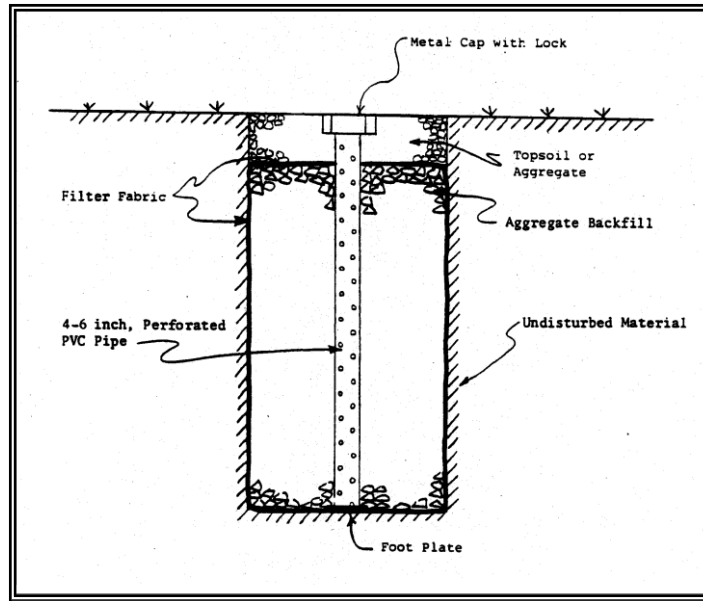


Figure 3.36 3.10 - Observation Well Details

3.4 Stormwater-related Site Procedures and Design Guidance for Bioretention and Permeable Pavement

3.4.1 Purpose

To locate and estimate the effectiveness of these distributed LID facilities in helping to meet the treatment, flow control, and LID requirements.

3.4.2 Description

The site procedures and design guidelines described in this Section are meant to be implemented after a preliminary project layout has been developed. The preliminary project layout should be developed considering the procedures of Chapter 3 in Volume 1 and Chapters 2 and 3 of the *LID Technical Guidance Manual For Puget Sound*. The designer must perform sufficient infiltration tests to confirm the feasibility of proposed bioretention and permeable pavement sites, and to provide a basis for estimating their contribution to meeting the treatment and flow reduction requirements. The same infiltration test sites may suffice for bioretention and permeable pavement as long as the soil receptor is the same. Testing should occur between December 1 and April 1.

The certified soils professional or engineer can exercise discretion concerning the need for and extent of infiltration rate (saturated hydraulic conductivity, K_{sat}) testing. The professional can consider a reduction in the extent of infiltration (K_{sat}) testing if, in their judgment, information exists confirming that the site is unconsolidated outwash material with high infiltration rates, and there is adequate separation from ground water:

- 1 foot separation from the bottom of a rain garden (per the Rain Garden Handbook for Western Washington Homeowners)
- 1 foot or 3 foot minimum separation from the bottom of a bioretention installation depending upon drainage area size (per BMP T7.30 Infeasibility Criteria).
- 1 foot below the bottom of the base course for a permeable pavement(per BMP T5.15).

±

Bioretention and Rain Gardens:

Field Testing Requirements Based upon Project Size:

Projects subject to Minimum Requirements #1 - #5:

In accordance with Section 2.5.5 Minimum Requirement #5 in Volume 1, projects subject only to Minimum Requirements #1 - #5 have to evaluate the feasibility of rain gardens unless a higher priority LID BMP is feasible or the applicant is meeting the LID performance standard through other

BMPs. Perform a Small-Scale Pilot Infiltration Test (see [Section 3.3.6](#)) – or an alternative small scale test specified by the local government – to determine if the minimum measured infiltration rate of 0.3 in/hr is exceeded at the proposed rain garden location. Also determine whether the site has at least one foot minimum clearance to the seasonal high ground water or other hydraulic restriction layer. .

Please refer to Chapter 7 of Volume V for infeasibility criteria for rain gardens. Refer to the “Rain Garden Handbook for Western Washington Homeowners” for design and construction guidance.

Projects subject to Minimum Requirements #1 - #9:

Also in accordance with Section 2.5.5. Minimum Requirement #5 in Volume 1, projects subject to Minimum Requirements #1 - #9 have to evaluate the feasibility of bioretention facilities unless a higher priority LID BMP is feasible or the applicant is meeting the LID performance standard through other BMPs. Infeasibility criteria and design criteria for bioretention are found in Chapter 7 of Volume V.

On a single, smaller commercial property, one bioretention facility will likely be appropriate. In that case, a Small-Scale Pilot Infiltration Test (see [Section 3.3.6](#)) – or an alternative small scale test specified by the local government - should be performed at the proposed bioretention location. Tests at more than one site could reveal the advantages of one location over another.

On larger commercial sites, a small-scale test every 5,000 sq. ft. is advisable. If soil characteristics across the site are consistent, a geotechnical professional may recommend a reduction in the number of tests.

On multi-lot residential developments, multiple bioretention facilities, or a facility stretching over multiple properties are appropriate. In most cases, it is necessary to perform small-scale Pilot Infiltration Tests (PIT), or other small-scale tests as allowed by the local jurisdiction. A test is advisable at each potential bioretention site. Long, narrow bioretention facilities, such as one following the road right-of-way, should have a test location at least every 200 lineal feet, and within each length of road with significant differences in subsurface characteristics.

However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high ground water conditions or a hydraulic restriction layer, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

After concluding an infiltration test, Infiltration sites should be over-excavated 3 feet below the projected infiltration facility’s bottom elevation unless minimum clearances to seasonal high ground water have or will be determined by another method. This overexcavation is to determine if

there are restrictive layers or ground water. Observations through a wet season can identify a seasonal ground water restriction.

If a single bioretention facility serves a drainage area exceeding 1 acre, a ground water mounding analysis may be necessary in accordance with Section 3.3.8.

Assignment of Appropriate Correction Factors to the Sub-grade Soil: (Applicable to projects subject to Minimum Requirements #1 - #9; and to projects that must or choose to demonstrate compliance with the LID Performance Standard of Minimum Requirement #5).

If deemed necessary by a qualified professional engineer, a correction factor may be applied to the measured K_{sat} of the subgrade soils to estimate its design (long term) infiltration rate. (Note: This is separate design issue from the assignment of a correction factor to the overlying, designed bioretention soil mix. See Chapter 7 of Volume V for that design issue).

The overlying bioretention soil mix provides excellent protection for the underlying native soil from sedimentation. Accordingly, the correction factor for the sub-grade soil does not have to take into consideration the extent of influent control and clogging over time. The correction factor to be applied to in-situ, small-scale infiltration test results is determined by the number of tests in relation to the number of bioretention areas and site variability. See Table 3.4.1. Correction factors range from 0.33 to 1 (no correction) and are determined by a licensed geotechnical engineer or licensed engineering geologist.

Tests should be located and be at an adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the bioretention areas are to be located. The correction factor depends on the level of uncertainty that variable subsurface conditions justify. If a pilot infiltration test is conducted for all bioretention areas or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors) one pilot infiltration test may be adequate to justify a correction factor of one. If the level of uncertainty is high, a correction factor near the low end of the range may be appropriate. Two example scenarios where low correction factors may apply include:

- Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
- Conditions are variable, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Table 3.4.1
Correction factors for in-situ Saturated Hydraulic Conductivity measurements to estimate design (long-term) infiltration rates of subgrade soils underlying Bioretention

<u>Site Analysis Issue</u>	<u>Correction Factor</u>
<u>Site variability and number of locations tested</u>	<u>CF_v = 0.33 to 1</u>
<u>Degree of influent control to prevent siltation and bio-buildup</u>	<u>No correction factor required</u>

Project Submission Requirements:

Submit the results of infiltration (K_{sat}) testing and ground water elevation testing (or other documentation and justification for the rates and hydraulic restriction layer clearances) with the Stormwater Site Plan as justification for the feasibility decision regarding bioretention and as justification for assumptions made in the runoff modeling.

Modeling:

For projects that have to demonstrate compliance with Minimum Requirements #6 and/or #7, it is preferable to enter each bioretention device and its drainage area into the approved computer models for estimating their performance.

However, where site layouts involve multiple bioretention facilities, the modeling schematic can become extremely complicated or not accommodated by the available schematic grid.

In those cases, multiple bioretention facilities with similar designs (i.e., soil depth, ponding depth, freeboard height, and drainage area to ponding area ratio), and infiltration rates (Ecology suggests within a factor of 2) may have their drainage areas and ponded areas becombined, and represented in the runoff model as one drainage area and one bioretention device. In this case, use a weighted average of the design infiltration rates at each location. The averages are weighted by the size of their drainage areas.

Each design infiltration rate is the measured infiltration rate (K_{sat}) multiplied by the appropriate correction (reduction) factors. For these native soils below bioretention soils, a site variability correction factor, CF_v, should be considered.

Additional guidance concerning LID modeling will be available during training sessions on WWHM 2012.

Legal Documentation to Track Rain Garden and Bioretention Obligations:

Where drainage plan submittals include assumptions with regard to size and location of rain garden or bioretention facilities, approval of the plat, short-plat, or building permit should identify the rain garden or bioretention obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of those facilities.

Permeable Pavement:

Field Testing Requirements based upon Project Size:

Projects subject to Minimum Requirements #1 - #5:

In accordance with Section 2.5.5 Minimum Requirement #5 in Volume 1, projects subject only to Minimum Requirements #1 - #5 have to evaluate the feasibility of permeable pavement for a development site unless a higher priority BMP is feasible or the applicant is choosing to meet the LID performance standard using other BMPs. A small-scale Pilot Infiltration Tests (PIT) – or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site. Procedures to test for high ground water and infiltration rate (aka, saturated hydraulic conductivity, K_{sat}) are referenced in Chapter 3 of Volume I. Detailed procedures for the Small-Scale Pilot Infiltration Test are in Section 3.3.6 of this volume. Submit results as part of the stormwater site plan to establish a basis for a feasibility decision.

Projects subject to Minimum Requirements #1 - #9:

Projects subject to Minimum Requirements #1 - #9 will likely have to evaluate a site for permeable pavement feasibility. On commercial property that cannot use full dispersion, permeable pavement should be the first choice for parking lots and walkways, unless infeasible or the applicant demonstrates compliance with the LID performance standard through other BMPs. A small-scale Pilot Infiltration Tests (PIT) - or other small-scale tests as allowed by the local jurisdiction - should be performed for every 5,000 sq. ft. of permeable pavement, but not less than 1 test per site.

On residential developments not using full dispersion (BMP T5.30), permeable pavements should be the first choice for residential access roads and walks, and for private walks and driveways on residential lots unless infeasible or the applicant demonstrates compliance with the LID performance standard through other BMPs. Small-scale infiltration tests should be performed at every proposed lot, at least every 200 feet of roadway and within each length of road with significant differences in subsurface characteristics. However, if the site subsurface characterization - including soil borings across the development site - indicate consistent soil characteristics and depths to seasonal high ground water conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

Unless seasonal high ground water elevations across the site have already been determined, upon conclusion of the infiltration testing, infiltration sites should be over-excavated 1 foot to see any restrictive layers or ground water. Observations through a wet season can identify a seasonal ground water restriction.

Perform infiltration testing in the soil profile at the estimated bottom elevation of base materials for the permeable pavement. If no base materials, (e.g., a pervious concrete sidewalk), perform the testing at the estimated bottom elevation of the pavement.

Assignment of Appropriate Correction Factors:

(Applicable to projects subject to Minimum Requirements #1 - #9; and to projects that must or choose to demonstrate compliance with the LID Performance Standard of Minimum Requirement #5).

The correction factor for in-situ, small-scale pilot infiltration test is determined by the number of tests in relation to the size of the permeable pavement installation, site variability and the quality of the aggregate base material. Correction factors range from 0.33 to 1 (no correction).

Tests should be located and be at adequate frequency capable of producing a soil profile characterization that fully represents the infiltration capability where the permeable pavement is located. If used, the correction factor depends on the level of uncertainty that variable subsurface conditions justify. If enough pilot infiltration tests are conducted across the permeable pavement subgrade to provide an accurate characterization, or the range of uncertainty is low (for example, conditions are known to be uniform through previous exploration and site geological factors), then a correction factor of one for site variability may be justified. Additionally, a correction factor of 1 for the quality of pavement aggregate base material may be necessary if the aggregate base is clean washed material with 1% or less fines passing the 200 sieve. See [Table 3.4.2 - Correction factors for in-situ Saturated Hydraulic Conductivity \(\$K_{sat}\$ \) Measurements - to estimate design \(long-term\) infiltration rates.](#)

If the level of uncertainty is high, a correction factor near the low end of the range may be appropriate. Two example scenarios where low correction factors may apply include:

- Site conditions are highly variable due to a deposit of ancient landslide debris, or buried stream channels. In these cases, even with many explorations and several pilot infiltration tests, the level of uncertainty may still be high.
- Conditions are variable, but few explorations and only one pilot infiltration test is conducted. That is, the number of explorations and tests conducted do not match the degree of site variability anticipated.

Table 3.4.2
Correction factors for in-situ Saturated Hydraulic Conductivity (Ksat) measurements to estimate design (long-term) infiltration rates

<u>Site Analysis Issue</u>	<u>Correction Factor</u>
<u>Site variability and number of locations tested</u>	<u>CF_v = 0.33 to 1</u>
<u>Quality of pavement aggregate base material</u>	<u>CF_m = 0.9 to 1</u>

Total correction factor (CF_T) = CF_v x CF_m

Soil Suitability Criteria Confirmation:

Where permeable pavements are used for pollution-generating hard surfaces (primarily roads, driveways, and parking lots), there must be a determination whether the soil suitability criteria of Section 3.3.7 are met. The applicable criteria are:

- Cation Exchange Capacity > 5%
- Organic Content > 1%
- Measured (initial) saturated hydraulic conductivity < 12 in./hr.
- One foot depth of soil with above characteristics

Sites not meeting these criteria should be considered infeasible for permeable pavements for pollution-generating hard surfaces.

The information to make this determination may be obtained from various sources: historic site information, estimated qualities of a general soil type, laboratory analysis of field samples. Local jurisdictions may identify regional areas as infeasible for permeable pavements for pollution-generating hard surfaces based upon knowledge of the region's soil characteristics in regard to the criteria listed above.

Project Submission Requirements:

Submit results of infiltration (K_{sat}) testing, ground water elevation testing (or other documentation and justification for the rates and hydraulic restriction layer clearances) with the Stormwater Site Plan as justification for the feasibility decision regarding permeable pavement, and as justification for assumptions made in the runoff modeling. If necessary, also submit documentation of meeting the soil suitability criteria.

Modeling:

In the runoff modeling, similar designs throughout a development can be summed and represented as one large facility. For instance, walkways can be summed into one facility. Driveways with similar designs (and enforced through deed restrictions) can be summed into one facility. In these instances, a weighted average of the design infiltration rates (where within a factor of two) for each location may be used. The averages are

weighted by the size of their drainage area. The design infiltration rate for each site is the measured K_{sat} multiplied by the appropriate correction factors.

As an alternative, simply enter walks, patios, and driveways with little storage capacity in the gravel bedding beneath them as lawn/landscape areas in the continuous runoff model. Roads and parking lots that have storage in a base course below the wearing surface should use the permeable pavement element in the continuous runoff model.

Legal Documentation to Track Permeable Pavement Obligations:

Where drainage plan submittals include assumptions in regard to size and location of permeable pavement, approval of the plat or short-plat should identify the permeable pavement obligation of each lot; and the appropriate lots should have deed requirements for construction and maintenance of those facilities.

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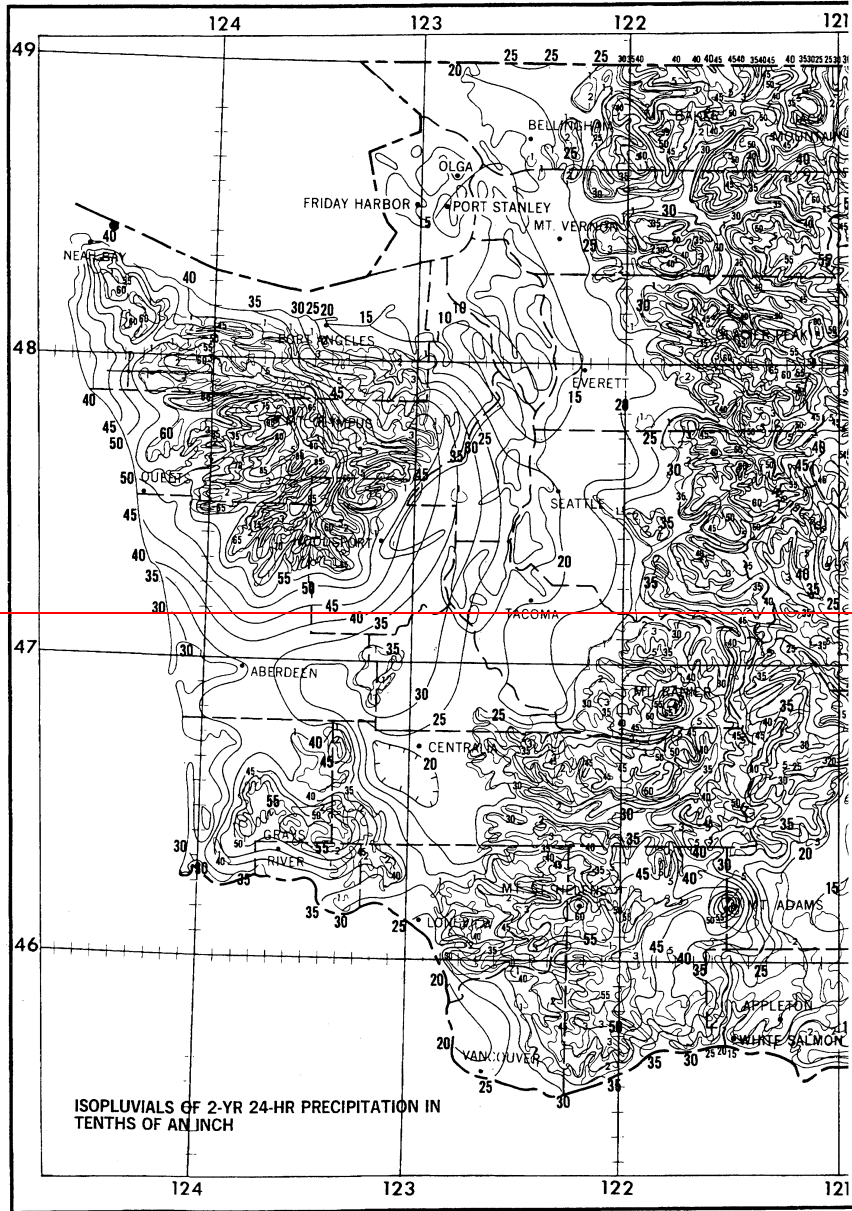
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Appendix III-A Isopluvial Maps for Design Storms

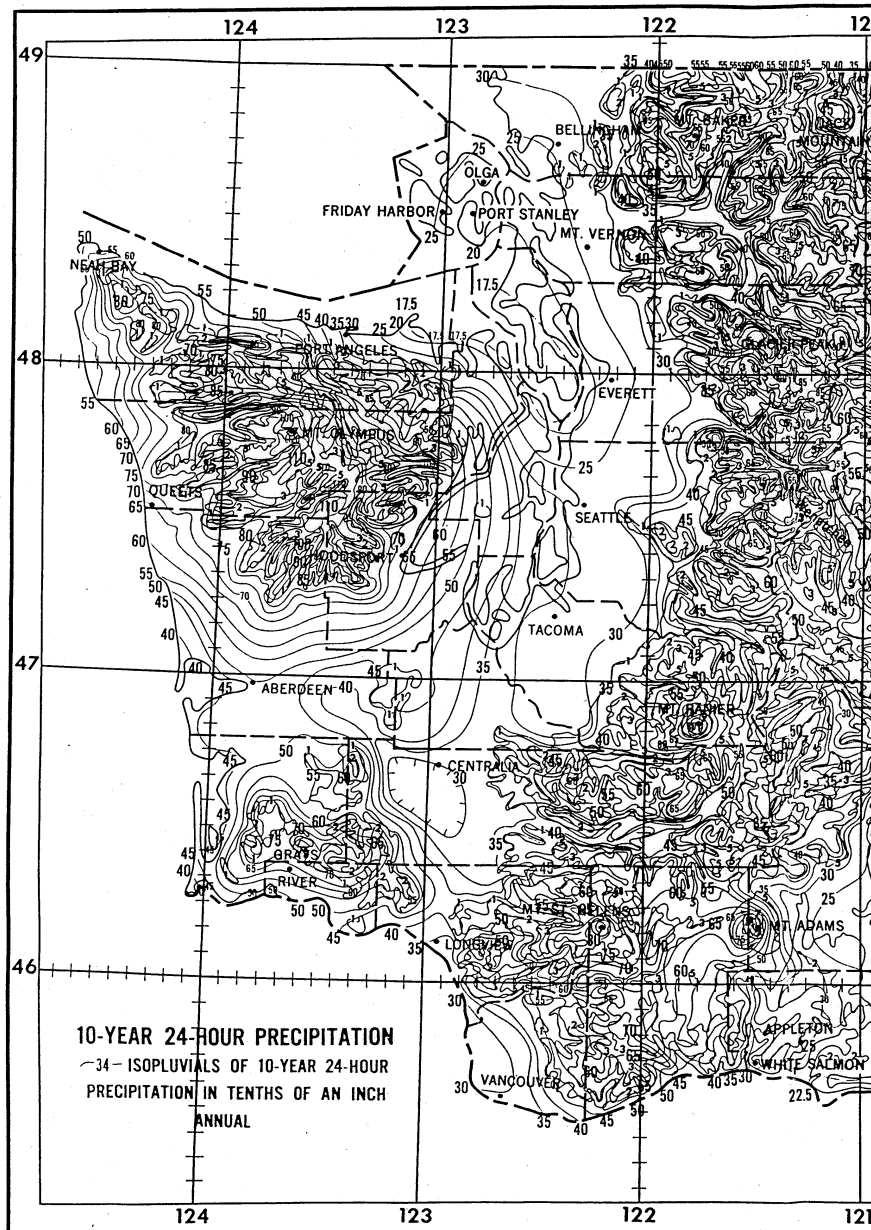
Included in this appendix are the 2, 10 and 100-year, 24-hour design storm and mean annual precipitation isopluvial maps for Western Washington. These have been taken from NOAA Atlas 2 “Precipitation - Frequency Atlas of the Western United States, Volume IX, Washington” and are available on link at the following web address:
http://www.nws.noaa.gov/oh/hdsc/PF_documents/Atlas2_Volume9.pdf

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Western Washington Isopluvial 2-year, 24 hour



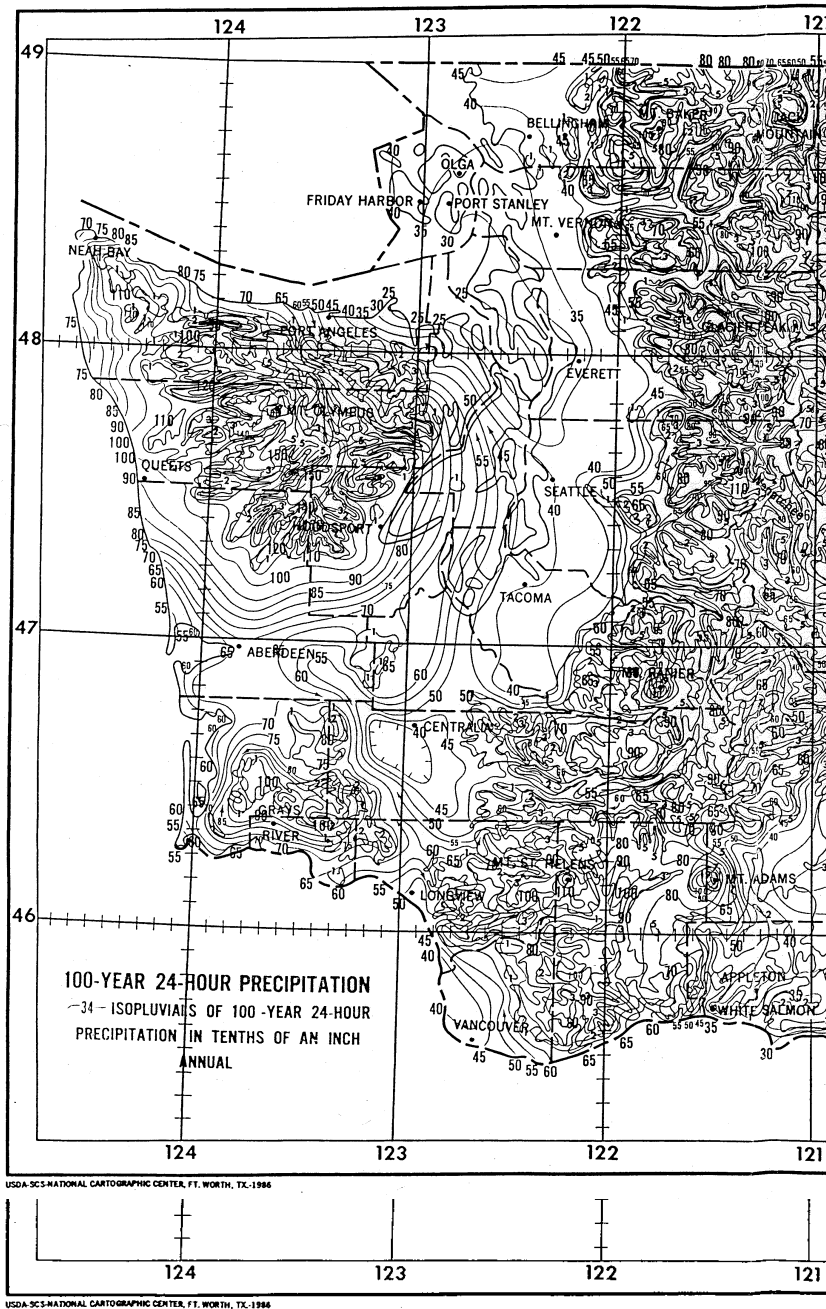
Western Washington Isopluvial 10-year, 24 hour



USDA-SCS-NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX-1986

USDA-SCS-NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX-1986

Western Washington Isopluvial 100-year, 24 hour



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Appendix III-B Western Washington Hydrology Model – Information, Assumptions, and Computation Steps

~~This appendix describes some of the information and assumptions used in the Western Washington Hydrology Model (WWHM) are described). However, since the first version of WWHM was developed and released to public in this document.~~

~~2001, WWHM program has gone through several upgrades incorporating new features and capabilities. It is anticipated that the next upgrade to WWHM will add low impact development (LID) modeling capability. WWHM users should periodically check Ecology's WWHM web site for the latest releases of WWHM, user manual, and any supplemental instructions. The web address for WWHM is:~~

~~<http://www.ecy.wa.gov/programs/wq/stormwater/wwhmtraining/index.html>~~ WWHM Limitations

~~The~~ WWHM has been created for the specific purpose of sizing stormwater control facilities for new development and redevelopment projects in Western Washington. ~~The~~ WWHM can be used for a range of conditions and developments; however, certain limitations are inherent in this software. These limitations are described below.

The WWHM uses the EPA HSPF software program to do all of the rainfall-runoff and routing computations. Therefore, HSPF limitations are included in the WWHM. For example, ~~HSPF does not explicitly model~~ backwater or tailwater control situations ~~are not explicitly modeled by HSPF.~~ This is also true in the WWHM.

~~In addition, the WWHM is limited in its routing capabilities. The user is allowed to input multiple stormwater control facilities and runoff is routed through them. If the proposed development site involves routing through a natural lake or wetland in addition to multiple stormwater control facilities then the user should use HSPF to do the routing computations and additional analysis.~~

~~Routing effects become more important as the drainage area increases. For this reason it is recommended that the WWHM not be used for drainage areas greater than one half square mile (320 acres). The WWHM can be used for small drainage areas down to less than an acre in size.~~

WWHM Information and Assumptions

1. ~~1.~~ Precipitation data.

Length of record.

The WWHM uses long-term (~~43-50 - 70~~ years) precipitation data to simulate the potential impacts of land use development in western Washington. A minimum period of 20 years is ~~required~~ sufficient to simulate enough peak flow events to produce accurate flow frequency results. A 40 to 50-year record is preferred. The actual length of record of each precipitation station varies, but all exceed ~~43~~ 50 years.

Rainfall distribution.

The precipitation data are representative of the different rainfall regimes found in western Washington. ~~A total of~~ More than 17 precipitation stations are used. These stations represent

rainfall at elevations below 1500 feet. WWHM does not include snowfall and melt ~~are not included in the WWHM.~~

The primary source for precipitation data is National Weather Service stations. The secondary source is precipitation data collected by local jurisdictions. During development of WWHM, county engineers at 19 western Washington counties were contacted to obtain local precipitation data. ~~Only King County provided local data.~~

The following precipitation stations have been included in the WWHM:

Precipitation Station	Years of Data	County Coverage
Astoria, OR	1955-1998 = 43	Wahkiakum
Blaine	1948-1998 = 50	Whatcom, San Juan
Burlington	1948-1998 = 50	Skagit, Island
Clearwater	1948-1998 = 50	Jefferson (west)
Darrington	1948-1996 = 48	Snohomish (northeast)
Everett	1948-1996 = 48	Snohomish (excluding northeast)
Frances	1948-1998 = 50	Pacific
Landsburg	1948-1997 = 49	King (east)
Longview	1955-1998 = 43	Cowlitz, Lewis (south)
McMillian	1948-1998 = 50	Pierce
Montesano	1955-1998 = 43	Grays Harbor
Olympia	1955-1998 = 43	Thurston, Mason (south), Lewis (north)
Port Angeles	1948-1998 = 50	Clallam (east)
Portland, OR	1948-1998 = 50	Clark, Skamania
Quilcene	1948-1998 = 50	Jefferson (east), Mason (north), Kitsap
Sappho	1948-1998 = 50	Clallam (west)
SeaTac	1948-1997 = 49	King (west)

The records were reviewed for length, quality, and completeness of record. Annual totals were checked along with hourly maximum totals. Using these checks, data gaps and errors were corrected, where possible. A "Quality of Record" summary was produced for each precipitation record reviewed.

The reviewed and corrected data were placed in multiple WDM (Watershed Data Management) files. One WDM file was created per county and contains all of the precipitation data to be used by the WWHM for that particular county. A local government that believes that it has a more accurate precipitation record to use with the WWHM should petition Ecology to allow use of that record, and to possibly incorporate that record into the WWHM. This may be more easily done in the future if the WWHM is upgraded to allow use of custom precipitation time series.

Computational time step.

The computational time step used in the WWHM ~~is~~has been one hour. The one-hour time step was selected to better represent the temporal variability of actual precipitation than daily data. Future upgrades (2012) to WWHM will incorporate 15-minute precipitation time series.

Based on more frequent (15-minute) rain data collected over 25 years in Seattle, a relationship has been developed and incorporated in WWHM for converting the 60-minute water quality design flows to 15-minute flows. The 15-minute water quality design flows are more appropriate and must be used for design of water quality treatment facilities that are expected to have a hydraulic residence time of less than one hour. Future upgrades to WWHM will likely use 15-minute precipitation times eries and as such the conversion of 60 minute water quality design flows to 15-minute flows would not be necessary.

2. ~~2.~~ Precipitation multiplication factors.

Precipitation multiplication factors increase or decrease recorded precipitation data to better represent local rainfall conditions. This is particularly important when the precipitation gage is located some distance from the study area.

Precipitation multiplication factors were developed for western Washington. The factors are based on the ratio of the 24-hour, 25-year rainfall intensities for the representative precipitation gage and the surrounding area represented by that gage's record. The 24-hour, 25-year rainfall intensities were determined from the NOAA Atlas 2 (*Precipitation-Frequency Atlas of the Western United States, Volume IX – Washington, 1973*).

These multiplication factors were created for the Puget Sound lowlands plus all western Washington valleys and hillside slopes below 1500 feet elevation. The factors were placed in the WWHM database and linked to each county's map. They are transparent to the general user—and the default range is set to 0.8 – 2. The advanced user will have the ability to change the precipitation multiplication factor for a specific site. However, such changes will be recorded in the WWHM output.

3. ~~3.~~ Pan evaporation data.

Pan evaporation data are used to determine the potential evapotranspiration (PET) of a study area. Actual evapotranspiration (AET) is computed by the WWHM based on PET and available moisture supply. AET accounts for the precipitation that returns to the atmosphere without becoming runoff. Soil moisture conditions and runoff are directly influenced by PET and AET.

Evaporation is not highly variable like rainfall. Puyallup pan evaporation data are used for all of the 19 western Washington counties.

Pan evaporation data were assembled and checked for the same time period as the precipitation data and placed in the appropriate county WDM files.

Pan evaporation data are collected in the field, but PET is used by the WWHM. PET is equal to pan evaporation times a pan evaporation coefficient. Depending on climate, pan evaporation coefficients for western Washington range from 0.72 to 0.82.

NOAA Technical Report NWS 33, *Evaporation Atlas for the Contiguous 48 United States*, was used as the source for the pan evaporation coefficients. Pan evaporation coefficient values are shown on Map 4 of that publication.

As with the precipitation multiplication factors, the pan evaporation coefficients have been placed in the WWHM database and linked to each county's map. They will be transparent to the general user. The advanced user will have the ability to change the coefficient for a specific site. However, such changes will be recorded in the WWHM output.

4. ~~4.~~ Soil data.

Soil type, along with vegetation type, greatly influences the rate and timing of the transformation of rainfall to runoff. Sandy soils with high infiltration rates produce little or no surface runoff; almost all runoff is from ~~groundwater-ground water~~. Soils with a compressed till layer slowly infiltrate water and produce larger amounts of surface runoff during storm events.

The WWHM uses three ~~predominate~~predominant soil type to represent the soils of western Washington: till, outwash, and saturated

Till soils have been compacted by glacial action. Under a layer of newly formed soil lies a compressed soil layer commonly called "hardpan". This hardpan has very poor infiltration capacity. As a result, till soils produce a relatively large amount of surface runoff and interflow. A typical example of a till soil is an Alderwood soil (SCS class C).

Outwash soils have a high infiltration capacity due to their sand and gravel composition.

Outwash soils have little or no surface runoff or interflow. Instead, almost all of their runoff is in the form of ~~groundwater-ground water~~. An Everett soil (SCS class A) is a typical outwash soil.

Outwash soils over high ~~groundwater-ground water~~ or an impervious soil layer have low infiltration rates and act like till soils. Where ~~groundwater-ground water~~ or an impervious soil layer is within 5 feet from the surface, outwash soils may be modeled as till soils in the WWHM.

Saturated soils are usually found in wetlands. They have a low infiltration rate and a high ~~groundwater-ground water~~ table. When dry, saturated soils have a high storage capacity and produce very little runoff. However, once they become saturated they produce surface runoff, interflow, and ~~groundwater-ground water~~ in large quantities. Mukilteo muck (SCS class D) is a typical saturated soil.

The user will be required to investigate actual local soil conditions for the specific development planned. The user will then input the number of acres of outwash (A/B), till (C), and saturated (D) soils for the site conditions.

Alluvial soils are found in valley bottoms. These are generally fine-grained and often have a high seasonal water table. There has been relatively little experience in calibrating the HSPF model to runoff from these soils, so in the absence of better information, these soils may be modeled as till soils.

Additional soils will be included in the WWHM if appropriate HSPF parameter values are found to represent other major soil groups.

The three ~~predominate~~predominant soil types are represented in the WWHM by specific HSPF parameter values that represent the hydrologic characteristics of these soils. More information on these parameter values is presented below.

5. ~~5.~~ Vegetation data.

As with soil type, vegetation types greatly influence the rate and timing of the transformation of rainfall to runoff. Vegetation intercepts precipitation, increases its ability to percolate through the soil, and evaporates and transpires large volumes of water that would otherwise become runoff.

~~The WWHM will represent~~represents the vegetation of western Washington with three ~~predominate~~predominant vegetation categories: forest, pasture, and lawn (also known as grass).

Forest vegetation represents the typical second growth Douglas fir found in the Puget Sound lowlands. Forest has a large interception storage capacity. This means that a large amount of precipitation is caught in the forest canopy before reaching the ground and becoming available for runoff. Precipitation intercepted in this way is later evaporated back into the atmosphere. Forest also has the ability to transpire moisture from the soil via its root system. This leaves less water available for runoff.

Pasture vegetation is typically found in rural areas where the forest has been cleared and replaced with shrub or grass lots. Some pasture areas may be used to graze livestock. The interception storage and soil evapotranspiration capacity of pasture are less than forest. Soils may have also been compressed by mechanized equipment during clearing activities. Livestock can also compact soil. Pasture areas typically produce more runoff (particularly surface runoff and interflow) than forest areas.

Lawn vegetation is representative of the suburban vegetation found in typical residential developments. Soils have been compacted by earth moving equipment, often with a layer of topsoil removed. Sod and ornamental bushes replace native vegetation. The interception storage and evapotranspiration of lawn vegetation is less than pasture, ~~more runoff results.~~

Predevelopment default land conditions are forest, although the user has the option of specifying pasture if there is documented evidence that pasture vegetation was native to the predevelopment site. If this option is used, the change will be recorded in the WWHM output.

Forest vegetation is represented by specific HSPF parameter values that represent the forest hydrologic characteristics. As described above, the existing regional HSPF parameter values for forest are based on undisturbed second-growth Douglas fir forest found today in western Washington lowland watersheds.

Postdevelopment vegetation will reflect the new vegetation planned for the site. The user has the choice of forest, pasture, and landscaped vegetation. Forest and pasture are only appropriate for postdevelopment vegetation in parcels separate from standard residential or non-standard residential/commercial ~~developments~~. Development areas must only be designated as forest or pasture where legal restrictions can be documented that protect these areas from future disturbances. ~~The WWHM~~ assumes the pervious land portion of developed areas is covered with lawn vegetation, as described above.

6. ~~6~~-Development land use data.

The WWHM user must enter land use information for the pre-developed condition and the proposed development condition into the model. ~~There are 6 basic~~WWHM users must select the appropriate land use categoriescategory and ~~3 soil types available in the WWHM2~~slope, where slope of 0-5% is flat, 5-15% is moderate, and greater than 15% is steep. The land use categories ~~are include:~~ Impervious ~~Area (areas such as Roads, Roof, Streets, Driveways, Sidewalks, Parking, Landscaped Area~~Ponds; and Pervious areas such as Lawn (this includes lawn, garden, areas with ornamental plants, and any natural areas not legally protected from future

disturbance)). Forest, and Pasture, and Pond. The soils types available are A/B (outwash), C/D (Till), and Saturated (wetland).

Forest and pasture vegetation areas are only appropriate for separate undeveloped parcels dedicated as open space, wetland buffer, or park within the total area of the standard residential development. ***Development areas must only be designated as forest or pasture where legal restrictions can be documented that protect these areas from future disturbances.***

Impervious, as the name implies, allows no infiltration of water into the pervious soil. All runoff is surface runoff. Impervious land typically consists of paved roads, sidewalks, driveways, and parking lots. Roofs are also impervious.

For the purposes of hydrologic modeling, only effective impervious area is categorized as impervious. Effective impervious area (EIA) is the area where there is no opportunity for surface runoff from an impervious site to infiltrate into the soil before it reaches a conveyance system (pipe, ditch, stream, etc.). An example of an EIA is a shopping center parking lot where the water runs off the pavement and directly goes into a catch basin where it then flows into a pipe and eventually to a stream. In contrast, some homes with impervious roofs collect the roof runoff into roof gutters and send the water down downspouts. When the water reaches the base of the downspout it can be directed either into a pipe (which is connected to the local storm sewer), dumped onto a splash block, or directed into a dispersion trench. Roof water sent to a dispersion trench has the opportunity to spread out into the yard and soak into the soil. Such roofs are not considered to be effective impervious area if the criteria in Section 3.1.2 ~~Section 3.1.2.~~ are met (see below for more information).

The non-effective impervious area uses the adjacent or underlying soil and vegetation properties. Vegetation often varies by the type of land use. The assumption is made in the WWHM that the EIA equals the TIA (total impervious area). This is consistent with King County's determination of EIA acres for new developments. Where appropriate, the TIA can be reduced through the use of runoff credits (more on that below).

In addition, WWHM2 offers the following 2 optional features: Earlier versions of WWHM (WWHM1 and WWHM2) provided the 2 optional features below for modeling of Standard Residential development and obtaining flow credits for incorporating low impact development (LID) techniques below. Later upgrades to WWHM have provided for direct input of the standard residential development details by the WWHM users. An upcoming (2012) upgrade to WWHM will enable direct modeling of some LID techniques through use of new Elements. Other LID techniques will continue to be modeled in accordance with Appendix C of the Stormwater Management Manual for Western Washington.

Standard Residential: For housing developments where lot-specific details (e.g., size of roof and driveway) are not yet determined, the earlier versions of WWHM providesprovided a set of default assumptions about the amount of impervious area per lot and its division between driveways and rooftops under the "Standard Residential" development land use type. Later versions of WWHM (e.g., WWHM3) do not have this option programmed in the model but the land use assumptions for the "Standard Residential" development are given below.

Ecology has selected a standard impervious area of 4200 square feet per residential lot, with 1000 square feet of that as driveway, walkways, and patio area, and the remainder as rooftop area. The rest of the lot acres will be assumed to be landscaped area (including lawn). The user

inputs the number of residential lots and the total acreage of the residential lots (public right-of-way acreages and non-residential lot acreages excluded). The number of residential lots and the associated number of acres will be used to compute the average number of residential lots per acre. This value together with the number of residential lots and the impervious area in the public right-of-way will be used by the model to calculate the TIA for the proposed development. The areas covered by streets, parking areas, and sidewalk areas are input separately by the user.

Runoff Credits: Please note that the modeling of runoff credits using low impact development techniques will be updated. A new version of WWHM, WWHM 2012, is currently in development and will provide LID modeling capabilities in accordance to with this manual. The following LID credit modeling is based on modeling in earlier versions of WWHM (WWHM2 and WWHM3).

Runoff credits can be obtained using any or all of the low impact development methods listed below. The ~~WWHM2~~ WWHM has an automated procedure for taking credits for infiltrating or dispersing roof runoff - methods #1 and #2 below. Credits for using methods 3, 4, 6, 7, and 8, and 9 must be taken by following the guidance in Appendix C. Methods 5, 6, and 10 also have guidance in Appendix C for taking credits. However, Ecology anticipates that these techniques will have new “Elements” in the 2012 WWHM update that will allow for better representation of how they function to reduce surface runoff. Roof areas using method #5 -rainwater harvesting systems designed in accordance with the guidance in Appendix C need not be entered into the model. Also, if using method 9 ~~11~~ – Full dispersion – the runoff model need not be used for the area that meets the criteria in Appendix C.

1. Infiltrate roof runoff
2. Disperse roof runoff
3. Disperse driveway and other hard surface runoff
- ~~3,4~~ Porous pavement for driveways and walks
5. Porous pavement for roads and parking lots
- ~~4,6~~ Vegetated Roofs
- ~~5,7~~ Rainwater Harvesting
- ~~6,8~~ Reverse slope sidewalks
- ~~7,9~~ Low impact foundations
- ~~8,10~~ Rain Gardens (Bioretention Areas)
- ~~9,11~~ Full dispersion

1. ~~4~~ Infiltrate Roof Runoff

Credit is given for disconnecting the roof runoff from the development’s stormwater conveyance system and infiltrating on the individual residential lots. The WWHM assumes that this infiltrated roof runoff does not contribute to the runoff flowing to the stormwater detention pond site. It disappears from the system and does not have to be mitigated. See Section 3.1.1 ~~Section 3.1.1.2~~ of Volume III for design requirements for downspout infiltration systems.

2. ~~2.~~ Disperse Roof Runoff

Credit is also given for disconnecting the roof runoff from the development's stormwater conveyance system and dispersing it on the lawn/landscaped surface of individual lots. If the runoff is dispersed using a dispersion trench designed according to the requirements of Section 3.1.2, Section 3.1.2, of Volume III, on single-family lots greater than 22,000 square feet, and the vegetative flow path of the runoff is 50 feet or longer through undisturbed native or compost-amended soils, the roof area can be entered into the model as landscaped area rather than impervious surface.

3. ~~3.~~ Disperse driveway and other hard surface runoff:

If runoff is dispersed in accordance with the guidance in BMP T5.11 or BMP T5.12, the driveway or other hard surface may be modeled as landscaped area.

4. & 5. Porous pavement ~~for driveways and walks~~

The third option for runoff credit is the use of porous pavement for private driveways, sidewalks, streets, and parking areas. ~~The WWHM2 currently includes an option for obtaining credits for the use of porous pavements on Streets/Sidewalk/Parking. The credit given under this option is believed to be too small.~~ Until such time as ~~WWHM2~~ WWHM is upgraded to WWHM3 directly model porous pavements, the LID credit guidance in Appendix C should be followed. It will direct you to enter a certain percentage of the pervious pavement area into the landscaped area category rather than the street/sidewalk/parking lot category. Even after the WWHM update, those methods are appropriate to use where the pervious pavement does not have a significant depth of base course for storage.

Follow similar procedures ~~should be followed~~ for vegetated roofs, reverse slope sidewalks, and low impact foundations. The LID credit guidance of Appendix C directs how these surfaces should be entered into the model. If you do not know the specific quantities of the different land cover types for your development (e.g., the individual lots will be sold to builders who will determine layout and size of home), you should start with the assumption of 4200 sq. ft. of impervious area per lot – including 1,000 sq. ft. for driveways, and begin making adjustments in those totals as allowed in the LID guidance of Appendix C

Other Development Options and Model Features

~~The~~ WWHM allows the flexibility of bypassing a portion of the development area around a flow control facility and/or having offsite/off-site inflow that is entering the development area pass through the flow control facility.

Bypass occurs when a portion of the development does not drain to a stormwater detention facility. ~~On-site~~ On-site runoff from a proposed development project may bypass the flow control facility provided that all of the following conditions are met.

1. Runoff from both the bypass area and the flow control facility converges within a quarter-mile downstream of the project site discharge point, ~~and,~~
2. The flow control facility is designed to compensate for the uncontrolled bypass area such that the net effect at the point of convergence downstream is the same with or without bypass, ~~and,~~

3. The 100-year peak discharge from the bypass area will not exceed 0.4 cfs, ~~and,~~
4. Runoff from the bypass area will not create a significant adverse impact to downstream drainage systems or properties, ~~and,~~
5. Water quality requirements applicable to the bypass area are met.

~~Offsite~~Off-site Inflow occurs when an upslope area outside the development drains to the flow control facility in the development. If the existing 100-year peak flow rate from any upstream ~~offsite~~off-site area is greater than 50% of the 100-year developed peak flow rate (undetained) for the project site, then the runoff from the ~~offsite~~off-site area must not flow to the ~~onsite~~on-site flow control facility. The bypass of ~~offsite~~off-site runoff must be designed so as to achieve both of the following:

1. Any existing contribution of flows to an ~~onsite~~on-site wetland must be maintained, ~~and,~~
2. ~~Offsite~~Off-site flows that are naturally attenuated by the project site under predeveloped conditions must remain attenuated, either by natural means or by providing additional ~~onsite~~on-site detention so that peak flows do not increase.

Application of WWHM in Re-developments Projects

WWHM allows only forest or pasture as the predevelopment land condition in the Design Basin screen. This screen does not allow other types of land uses such as impervious and landscaped areas to be entered for existing condition. However, WWHM can be used for redevelopment projects by modeling the existing developed areas that are not subject to the flow control requirements of Volume I as ~~offsite~~off-site areas. For the purposes of predicting runoff from such an existing developed area, enter the existing area in the ~~Offsite~~Off-site Inflow screen. This screen is designed to predict runoff from impervious and landscaped areas in addition to the forest and pasture areas. If the existing 100-year peak flow rate from the existing developed areas that are not subject to flow control is greater than 50% of the 100-year developed peak flow rate (undetained but subject to the flow control requirements of Volume I), then the runoff from the ~~offsite~~off-site area must not be allowed to flow to the ~~onsite~~on-site flow control facility.

7. ~~7.~~ PERLND and IMPLND parameter values.

In WWHM (and HSPF) pervious land categories are represented by PERLNDs; impervious land categories (EIA) by IMPLNDs. An example of a PERLND is a till soil covered with forest vegetation. This PERLND has a unique set of HSPF parameter values. For each PERLND there are 16 parameters that describe various hydrologic factors that influence runoff. These range from interception storage to infiltration to active ~~groundwater~~ground water evapotranspiration. Only four parameters are required to represent IMPLND.

The PERLND and IMPLND parameter values to be used in the WWHM are listed below. These values are based on regional parameter values developed by the U.S. Geological Survey for watersheds in western Washington (Dinicola, 1990) plus additional HSPF modeling work conducted by AQUA TERRA Consultants.

PERLND Parameters

	TF	TP	TL	OF	OP	OL	SF	SP	SL
Name									
LZSN	4.5	4.5	4.5	5.0	5.0	5.0	4.0	4.0	4.0

INFILT	0.08	0.06	0.03	2.0	1.6	0.80	2.0	1.8	1.0
LSUR	400	400	400	400	400	400	100	100	100
SLSUR	0.10	0.10	0.10	0.10	0.10	0.10	0.001	0.001	0.001
KVARY	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.5	0.5
AGWRC	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996	0.996
INFEXP	2.0	2.0	2.0	2.0	2.0	2.0	10.0	10.0	10.0
INFILD	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
BASETP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGWETP	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.7
CEPSC	0.20	0.15	0.10	0.20	0.15	0.10	0.18	0.15	0.10
UZZSN	0.5	0.4	0.25	0.5	0.5	0.5	3.0	3.0	3.0
NSUR	0.35	0.30	0.25	0.35	0.30	0.25	0.50	0.50	0.50
INTFW	6.0	6.0	6.0	0.0	0.0	0.0	1.0	1.0	1.0
IRC	0.5	0.5	0.5	0.7	0.7	0.7	0.7	0.7	0.7
LZETP	0.7	0.4	0.25	0.7	0.4	0.25	0.8	0.8	0.8

PERLND types:

TF = Till Forest

TP = Till Pasture

TL = Till Lawn

OF = Outwash Forest

OP = Outwash Pasture

OL = Outwash Lawn

SF = Saturated Forest

SP = Saturated Pasture

SL = Saturated Lawn

PERLND parameters:

LZSN = lower zone storage nominal (inches)

INFILT = infiltration capacity (inches/hour)

LSUR = length of surface overland flow plane (feet)

SLSUR = slope of surface overland flow plane (feet/feet)

KVARY = ~~groundwater~~ ~~ground water~~ exponent variable (inch⁻¹)

AGWRC = active ~~groundwater~~ ~~ground water~~ recession constant (day⁻¹)

INFEXP = infiltration exponent

INFILD = ratio of maximum to mean infiltration

BASETP = base flow evapotranspiration (fraction)

AGWETP = active ~~groundwater~~ ~~ground water~~ evapotranspiration (fraction)

CEPSC = interception storage (inches)

UZZSN = upper zone storage nominal (inches)

NSUR = roughness of surface overland flow plane (Manning's n)

INTFW = interflow index

IRC = interflow recession constant (day⁻¹)

LZETP = lower zone evapotranspiration (fraction)

A more complete description of these PERLND parameters is found in the HSPF User Manual (Bicknell et al, 1997).

PERLND parameter values for other additional soil/vegetation categories will be investigated and added to the WWHM, as appropriate.

IMPLND Parameters

	EIA
--	-----

Name	
LSUR	400
SLSUR	0.01
NSUR	0.10
RETSC	0.10

IMPLND parameters:

LSUR = length of surface overland flow plane (feet)

SLSUR = slope of surface overland flow plane (feet/feet)

NSUR = roughness of surface overland flow plane (Manning's n)

RETSC = retention storage (inches)

A more complete description of these IMPLND parameters is found in the HSPF User Manual (Bicknell et al, 1997).

The PERLND and IMPLND parameter values will be transparent to the general user. The advanced user will have the ability to change the value of a particular parameter for that specific site. However, such changes will be recorded in the WWHM output.

Surface runoff and interflow will be computed based on the PERLND and IMPLND parameter values. ~~Groundwater~~Ground water flow can also be computed and added to the total runoff from a development if there is a reason to believe that ~~groundwater~~ground water would be surfacing (such as where there is a cut in a slope). However, the default condition in WWHM assumes that no ~~groundwater~~ground water flow from small catchments reaches the surface to become runoff. This is consistent with King County procedures (King County, 1998).

8. ~~8.~~Guidance for flow-control-related standards.

~~Flow-control~~Use flow-related standards ~~are used~~ to determine whether or not a proposed stormwater facility will provide a sufficient level of mitigation for the additional runoff from land development. Guidance is provided on the standards that must be met to comply with the Ecology Stormwater Management Manual.

There are ~~two~~three flow-control-related standards stated in ~~the Ecology Manual~~Volume I: Minimum Requirement #5 – On-site Stormwater Management; Minimum Requirement #7 - Flow Control and Minimum Requirement #8 - Wetlands Protection ~~(See Volume I).~~ Minimum Requirement #7 specifies,

Minimum Requirement #5 allows the user to demonstrate compliance with the LID Performance Standard of matching developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow frequency and to 50% of the 2-year peak flow. If the post-development flow duration ranges for which the postdevelopment runoff cannot values exceed any of the predevelopment runoff. Minimum Requirement #8 specifies that discharges to wetlands must maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated beneficial uses. flow levels between 8% and 50% of the 2-year predevelopment peak flow values, then the LID performance standard not been met.

Minimum Requirement #7 specifies that stormwater discharges to streams shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. In general, matching discharge

durations between 50% of the 2-year and 50-year will result in matching the peak discharge rates in this range.

| ~~The~~ WWHM uses the predevelopment peak flow value for each water year to compute the predevelopment 2- through 100-year flow frequency values. The postdevelopment runoff 2- through 100-year flow frequency values are computed from the outlet of the proposed stormwater facility. The user must enter the stage-surface area-storage-discharge table (HSPF FTABLE) for the stormwater facility. The model then routes the postdevelopment runoff through the stormwater facility. As with the predevelopment peak flow values, the model will select the maximum developed flow value for each water year ~~will be selected by the model~~ to compute the developed 2- through 100-year flow frequency.

The actual flow frequency calculations are made using the federal standard Log Pearson Type III distribution described in Bulletin 17B (United States Water Resources Council, 1981). This standard flow frequency distribution is provided in U.S. Geological Survey program J407, version 3.9A-P, revised 8/9/89. The Bulletin 17B algorithms in program J407 are included in the WWHM calculations.

| Minimum Requirement #7 is based on flow duration. ~~The~~ WWHM will use the entire predevelopment and ~~postdevelopment~~post-development runoff record to compute flow duration. The standard requires that ~~postdevelopment~~post-development runoff flows must not exceed the flow duration values of the predevelopment runoff between the predevelopment flow values of 50 percent of the 2-year flow and 100 percent of the 50-year flow.

Flow duration is computed by counting the number of flow values that exceed a specified flow level. The specified flow levels used by WWHM in the flow duration analysis are listed below.

1. 50% of the 2-year predevelopment peak flow.
2. 100% of the 2-year predevelopment peak flow.
3. 100% of the 50-year predevelopment peak flow.

In addition, flow durations are computed for 97 other incremental flow values between 50 percent of the 2-year predevelopment peak flow and 100 percent of the 50-year predevelopment peak flow.

There are three criteria by which flow duration values are compared:

1. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 50% and 100% of the 2-year predevelopment peak flow values (100 Percent Threshold) then the flow duration requirement has not been met.
2. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 100% of the 2-year and 100% of the 50-year predevelopment peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow duration requirement has not been met.
3. If more than 50 percent of the flow duration levels exceed the 100 percent threshold then the flow duration requirement has not been met.

The results are provided in the WWHM report.

Minimum Requirement #8 specifies that total discharges to wetlands must ~~maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated beneficial uses. Criteria for determining maximum allowed exceedences in alterations to wetland hydroperiods are provided in guidelines cited in Guide Sheet 2B of the Puget Sound Wetland Guidelines (Azous and Horner, 1997).~~

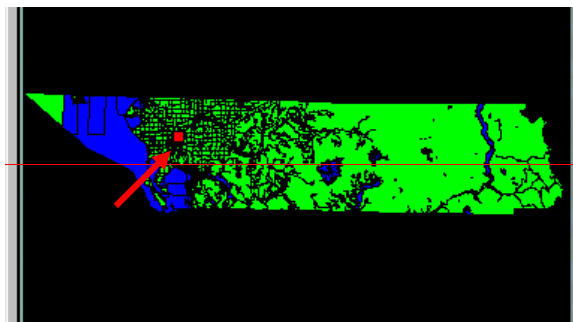
~~Because wetland hydroperiod computations are relatively complex and are site specific, they have not yet been included in the WWHM2. HSPF is required for wetland hydroperiod analysis. Ecology intends to include the ability to perform hydroperiod computations in WWHM3.~~

WWHM Computation Steps: ~~For sizing a detention pond. Follow steps~~ deviate by more than 20% on a single event basis, and must not deviate by more than 15% on a monthly basis. Flow components feeding the wetland under Quick Start in WWHM2 under Help/Contents. These are also reproduced below:

Quick Start

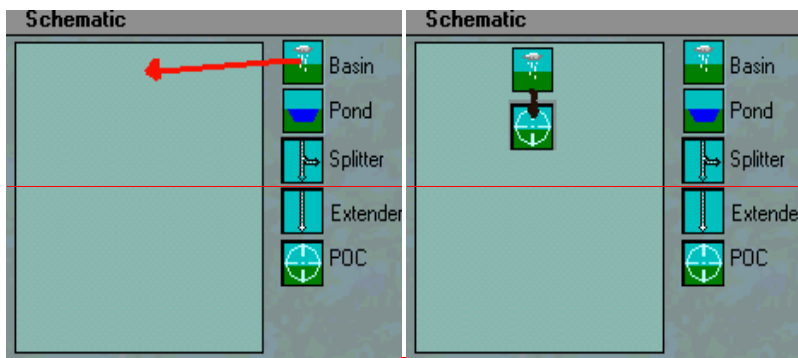
Here is a brief set of steps to demonstrate pond sizing using the WWHM2.

1. On the map screen (the first screen that shows up) click somewhere within the county boundaries:



Tool-bar

2. On the Tool bar (above the map screen) click the second button to switch to the Scenario Editor.



Schematic

3. Drag and drop the Basin Icon somewhere towards the top of the Schematic. You should then have a basin in your schematic flowing to the Point of Compliance (POC). The POC represents outflow or both Pre-and Post-development scenarios are assumed to be the sum of all flow the surface, interflow, and ground water flows from your the project.

4. — Left click on the basin you just added. This will open a window on the right where you can enter land use for site. The WWHM is being revised to more easily allow this basin-comparison.

Basin Information

Basin Name: Basin 1

Groundwater

Flows to: Outflow

Land Use/
Vegetative Cover

	Soil Type		
	A/B	C/D	Saturated
	Outwash	Till	Saturated
Impervious Area (Roof)	0	0	0
Streets/Sidewalks/Parking	0	0	0
Landscaped Area	0	0	0
Forest	0	0	0
Pasture	0	0	0
Pond	0	0	0

Standard Residential Land Use

Credits

2

UPDATE

Basin-Information

5. Enter 10 acres in the field for Till Forest, and then click the Update button. You have now set your pre-developed conditions to 10 acres of Till Forest.



Change Scenarios

6. Now press the Developed Unmitigated button just below the schematic. Now you can enter basins and land use for your Developed unmitigated Scenario.

Now drag and drop a basin as you did in step 3. Click on it to enter land use as in step 4. This time instead of 10 acres of till forest, enter:

- 5 acres of Streets/Sidewalks/Parking.
- 3 acres of Landscaped Area.
- 1 acre of Impervious Area (Roof).
- 1 acre of Pond.

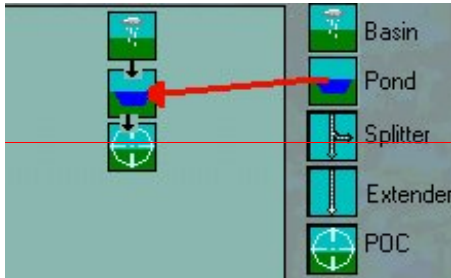
Be sure it's all in the middle column indicating it's on till soils as in the pre-developed Scenario. The screen should look like this:

Land Use/ Vegetative Cover	Soil Type		
	A/B	C/D	Saturated
	Outwash	Till	Saturated
Impervious Area (Roof)	0	1	0
Streets/Sidewalks/Parking	0	5	0
Landscaped Area	0	3	0
Forest	0	0	0
Pasture	0	0	0
Pond	0	1	0
Standard Residential Land Use			
Credits			

Developed Land Use

Then click the update button.

4. Now click the Developed Mitigated button below the schematic. This brings you to the final Scenario where your detention facility will be placed. Notice that your Developed basin is already there. Now drag and drop a pond into the space just below the basin. The schematic should look like this:



Drag-and-drop a pond

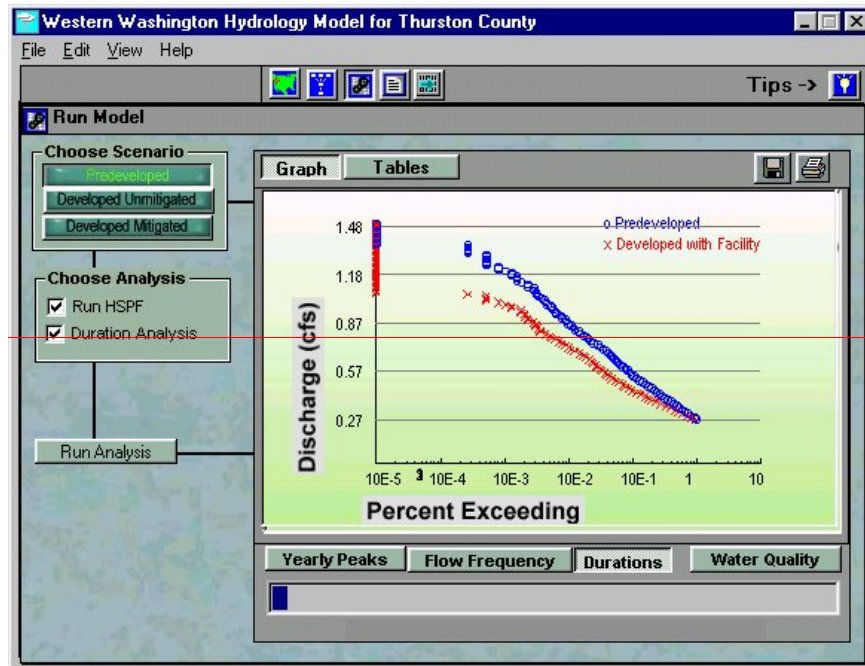
8. Click on the pond to open the pond-editing window. You can edit any aspect of the pond from here, but for now, just click the Auto-Pond button at the bottom. This will open up the **Pond Wizard** window:

Pond Wizard

First choose an outlet structure from the drop-down list in the middle of the Pond Wizard form. Select the first option (1 Orifice & Rectangular Notch):

Next, press the Create Pond button. You will see a progress bar pop-up to indicate that HSPF is running the model and the pond wizard is creating a pond according to the results.

9. The Pond Wizard will then automatically bring you to the **Run Model** screen.



Run-Model Screen

You can view the results in graphs or tables. For yearly peaks, select a scenario to view (upper left) and click the yearly peaks button. Flow frequency and durations always show pre-developed vs. developed mitigated.

If you wish to change the pond and re-run the model, take the following steps:

Go back to the Scenario editor (2nd Tool bar button).

Choose the Developed Mitigated Scenario.

Click on your pond.

Change one or more pond values and click Update.

Go back to the Run Model screen (3rd Tool bar button).

Choose the developed mitigated Scenario.

Check the Run HSPF and Duration Analysis check boxes.

Click Run Analysis.

References for Western Washington Hydrology Model

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Appendix III-C Washington State Department of Ecology Low Impact Development ~~Design and Flow Modeling~~ Guidance

The Washington State Department of Ecology (Ecology) ~~encourages~~requires the use of the Western Washington Hydrology Model (WWHM) and other approved runoff models (currently approved alternative models are the King County Runoff Time Series and MGS Flood) for estimating surface runoff and sizing stormwater control and treatment facilities. ~~This guidance suggests~~Part 1 of this appendix explains how to represent various LID techniques within ~~those models~~WWHM 3 so that their benefit in reducing surface runoff can be estimated. The lower runoff estimates should translate into smaller stormwater treatment and flow control facilities. In certain cases, use of various techniques can result in the elimination of those facilities.

~~The flow control credits presented in this chapter were developed by an LID credit committee comprised of stormwater managers from various local jurisdictions, WSDOT, WSU and Ecology.~~

~~This section identifies seven categories of LID techniques. For each category, the guidance lists basic design criteria that Ecology considers necessary in order to justify use of the suggested runoff “credit” or “runoff model representation.” More detailed design guidance is available in the Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual), published by the Puget Sound Action Team and the Washington State University Cooperative Extension.~~

As Puget Sound gains more experience with and knowledge of LID techniques, the design criteria will evolve. Also, our ability to model their performance will change as our modeling techniques improve. Therefore, we anticipate this guidance will be updated periodically to reflect the new knowledge and modeling approaches. ~~Meanwhile, we encourage all to use the guidance, and to give us feedback on its usefulness and accuracy. Comments can be sent to Ed O’Brien of the Washington State Department of Ecology at:~~

~~Note that the terminology for grass has changed in the WWHM. The term grass has been replaced with landscaped area.~~

7One such update should be available later this year (2012). The updated guidance will explain modeling techniques to be used with the latest publicly available version of the WWHM (tentative name: WWHM 2012). A summary of the modeling techniques planned for WWHM 2012 is included as Part 2 in this appendix. Because WWHM 2012 and the updated LID modeling guidance won't be released until later this year, municipal stormwater permittees are not obligated to require its use this permit term. However, because WWHM 2012 will make modeling LID developments easier and more technically accurate; and because it will include a number of other updates and improvements (e.g., updated rainfall files), Ecology will encourage its use. We anticipate that most local governments will choose to require its use or an equivalent program (e.g., an updated MGS Flood) once they are readily available. Ecology intends to make sure that sufficient training opportunities are available on WWHM 2012, so that municipal staff and designers have adequate opportunity to become familiar with it prior to the deadlines in the municipal permits for adopting and applying updated stormwater requirements.

In previous editions of the manual, Appendix III-C included a summary of design criteria for each LID BMP. The reader is now directed to Volume V for those design criteria.

Part 1: Guidance for Use with WWHM 3

C.1 Permeable Pavements

~~7.1.1 Credits —~~

~~7.1.C.1.1 Porous Asphalt or Concrete~~

~~Description of Public Road or Public Parking lot~~

Model Surface as

- | | |
|--|--|
| 1. 1- Base material laid above surrounding grade: | |
| a) a) Without underlying perforated drain pipes to collect stormwater | Grass over underlying soil type (till or outwash) |
| b) b) With underlying perforated drain pipes for stormwater collection: | |
| at or below bottom of base layer | Impervious surface |
| elevated within the base course | Impervious surface |
| 2. 2- Base material laid partially or completely below surrounding grade: | |
| a) a) Without underlying perforated drain pipes underlying soil type | Option 1: Grass over |
| | Option 2: Impervious surface routed to an infiltration basin ¹ <u>a Gravel Trench/Bed</u> ² |
| b) With underlying perforated drain pipes: | |
| at or below bottom of base layer | Impervious surface |
| elevated within the base course ³ | Model as impervious surface routed to an infiltration basin ¹ <u>a Gravel Trench/Bed</u> ¹ |

¹ See section 7.8 for detailed instructions concerning how to represent the base material below grade as an infiltration basin in the Western Washington Hydrology Model.

² See section C.11 for detailed instructions concerning how to represent the base material below grade as a gravel trench/bed in the Western Washington Hydrology Model.

³ If the perforated pipes function is to distribute runoff directly below the wearing surface, and the pipes are above the surrounding grade, follow the directions for 2a above.

~~Description of Private Facilities (driveways, parking lots, walks, patios)~~

~~1. Base material below grade without~~ ~~50% grass on underlying underlying~~
~~perforated drain pipes~~ ~~soil; 50% impervious~~

~~2. Base material below grade with~~ ~~Impervious surface~~
~~underlying perforated drain pipes~~

~~7.1C.1.2 Grid/lattice systems (non-concrete) and Paving Blocks~~

~~Description of Public Road or Public Parking lot~~

Model Surface as

1. ~~1.~~ Base material laid above surrounding grade

a) ~~a)~~ Without underlying perforated drain pipes

Grid/lattice systems: grass on
underlying soil (till or outwash).

Paving Blocks: 50% grass on
underlying soil; 50% impervious.

b) ~~b)~~ With underlying perforated drain pipes

Impervious surface

2. ~~2.~~ Base material laid partially or completely below surrounding grade

a) Without underlying perforated drain pipes

Option 1:
Grid/lattice as grass on underlying soil.
Paving blocks as 50% grass; 50% impervious.
Option 2:
Impervious surface routed to a Gravel
Trench/Bed.¹

b) With underlying perforated drain pipes

at or below bottom of base layer

Impervious surface

elevated within the base course²

Model as impervious surface routed to a
Gravel Trench/Bed.¹

~~Description of Private Facilities (driveways, parking lots, walks, patios)~~

~~Base material laid partially or completely below surrounding grade~~

~~a) Without underlying perforated drain pipes~~ ~~0% grass; 50% impervious~~

b) With underlying drain pipes ————— Impervious surface

7.1.2 Design Criteria for Permeable Pavements

Subgrade

- Compact the subgrade to the minimum necessary for structural stability. Use static dual wheel small mechanical rollers or plate vibration machines for compaction. Do not allow heavy compaction due to heavy equipment operation. The subgrade should not be subject to truck traffic.
- Use on soil types A through C.

Geotextile

- Use geotextile between the subgrade and base material/separation layer to keep soil out of base materials.
- The geotextile should pass water at a greater rate than the subgrade soils.

Separation or Bottom Filter Layer (recommended but optional)

- A layer of sand or crushed stone (0.5 inch or smaller) graded flat is recommended to promote infiltration across the surface, stabilize the base layer, protect underlying soil from compaction, and serve as a transition between the base course and the underlying geotextile material.

Base material

- Many design combinations are possible. The material must be free draining. For more detailed specifications for different types of permeable pavement, see section 6.2: Permeable Paving.
 - Driveways (recommendation):
 - ✓ > 4" layer of free draining crushed rock, screened gravel, or washed sand.
 - ✓ < 5% fines (material passing thru #200 sieve) based on fraction passing #4 sieve.
 - Roads & Parking lots: The standard materials and quantities used for asphalt roads should be followed. For example:
 - ✓ Pierce Co. cites larger rock on bottom, smaller on top (e.g., 2" down to 5/8"); compacted; minimal fines; 8 inches total of asphaltic concrete and base material.
 - ✓ WSDOT lists coarse crushed stone aggregate (AASHTO Grading No. 57: 1.5 inch and lower); stabilized or unstabilized with modest compaction; meets fracture requirements.
 - ✓ FHWA suggests three layers between the porous pavement and geotextile. Typical layers would be:
 - Filter course: 13 mm diameter gravel, 25 to 50 mm thick.
 - Stone reservoir: 40-75 mm diameter stone.
 - Filter course: 13 mm diameter gravel, 50 mm thick.

Wearing layer

- ~~For all surface types, a minimum initial infiltration rate of 10 inches per hour is necessary. To improve the probability of long-term performance, significantly higher infiltration rates are desirable.~~
- ~~Porous Asphalt: Products must have adequate void spaces through which water can infiltrate. A void space within the range of 12—20% is common.~~
- ~~Porous Concrete: Products must have adequate void spaces through which water can infiltrate. A void space within the range of 15—21% is common.~~
- ~~Grid/lattice systems filled with gravel, sand, or a soil of finer particles with or without grass: The fill material must be at least a minimum of 2 inches of sand, gravel, or soil. It should be underlain with 6 inches or more of sand or gravel to provide an adequate base. The fill material should be at or slightly below the top elevation of the grid/lattice structure. Modular grid openings must be at least 40% of the total surface area of the modular grid pavement. Provisions for removal of oil and grease contaminated soils should be included in the maintenance plan.~~
- ~~Paving blocks: 6 inches of sand or aggregate materials should fill spaces between blocks and must be free draining. Do not use sand for the leveling layer or filling spaces with EcoStone.~~
- ~~The block system should provide a minimum of 12% free draining surface area (area between the blocks).~~
- ~~Provisions for removal of oil and grease contaminated soils should be included in the maintenance plan.~~

Drainage conveyance

Roads should still be designed with adequate drainage conveyance facilities as if the road surface was impermeable. Roads with base courses that extend below the surrounding grade should have a designed drainage flow path to safely move water away from the road prism and into the roadside drainage facilities. Use of perforated storm drains to collect and transport infiltrated water from under the road surface will result in less effective designs and less flow reduction credit.

Acceptance test

- ~~Driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.~~
- ~~Roads may be initially tested with the bucket test. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 10 inches per hour minimum rate.~~

Limitations

- ~~No run-on from pervious surfaces is preferred. If runoff comes from minor or incidental pervious areas, those areas must be fully stabilized.~~
- ~~Slope impervious runoff away from the permeable pavement to the maximum extent practicable. Sheet flow from up-gradient impervious areas is not recommended, but permissible if porous surface flow path \geq impervious surface flow path. (Note: Impermeable surface that drains to a permeable pavement can also be modeled as noted above as long as the flow path restriction is met.~~

- Do not use at “high-use” sites, auto-commercial services (gas stations, mini-marts, commercial fueling stations, auto body and auto repair shops, auto wash), commercial truck parking areas, areas with heavy industrial activity (as defined by USEPA regulations), or areas with high pesticide use.
- Soils must not be tracked onto the wear layer or the base course during construction.
- Slopes:
 - Asphalt: Works best on level slopes and up to 2%. Do not use on slopes $\geq 5\%$.
 - Concrete: Maximum recommended slope of 6%.
 - Interlocking pavers: Maximum recommended slope of 10%.
 - Grid/lattice systems: Maximum generally in 5-6% range.
- Do not use in areas subject to heavy, routine sanding for traction during snow and ice accumulation.
- Comply with local building codes for separation distances from buildings and wells. Inquire with the local jurisdiction concerning applicable setbacks.

Maintenance

- Inspect project upon completion to correct accumulation of fine material. Conduct periodic visual inspections to determine if surfaces are clogged with vegetation or fine soils. Clogged surfaces should be corrected immediately.
- Surfaces should be swept with a high-efficiency or vacuum sweeper twice per year; preferably, once in the autumn after leaf fall, and again in early spring. As long as annual infiltration rate testing demonstrates that a rate of 10 inches per hour or greater is being maintained, the sweeping frequency can be reduced to once per year. For porous asphalt and concrete surfaces, high pressure hosing should follow sweeping once per year.

7.2 Dispersion

~~7C.2.1 Full Dispersion for the Entire Development Site (fulfills~~

~~Residential Developments that implement BMP T5.30 do not have to use approved runoff models to demonstrate compliance. They are assumed to fully meet the treatment and flow control requirements.~~

~~Developments that preserve 65% of a site (or a threshold discharge area of a site) in a forested or native condition, can disperse runoff from the developed portion of the site into the native vegetation area as long as the developed areas draining to the native vegetation do not have impervious areas that exceed 10% of the entire site. Runoff must be dispersed into the native area in accordance with the BMPs cited in BMP T5.30 of Volume V—Chapter 5. Additional impervious areas are allowed, but should not drain to the native vegetation area and are subject to the thresholds, treatment and flow control requirements of this stormwater manual.~~

~~7C.2.2 Full Dispersion for All or Part of the Development Site~~

~~Those portions of residential developments that maintain ratios of:~~

~~$\geq 65\%$ forested or native condition; and~~

~~≤ 10% effective impervious surface of the area draining into the native vegetation area may disperse runoff into the native area in accordance with the BMPs cited in~~ implement BMP T5.30 of Volume V – Chapter 5. Examples of such ratios are:

~~* Where these lawn/landscape areas are established on till soils, and exceed 50% of the total site, they should be developed using guidelines in BMP T5.13 of Volume V – Chapter 5, or a locally do not have to use approved alternative soil quality and depth specification.~~

~~Within the context of this dispersion option, the only impervious surfaces that are ineffective are those that are routed into an appropriately sized dry well or into an infiltration basin that meets the runoff models to demonstrate compliance. They are assumed to fully meet the treatment and flow control standard and does not overflow into the forested or native vegetation area.~~

~~**Note:** For options in 7.2.1 and 7.2.2, native vegetation areas must be protected from future development. Protection must be provided through legal documents on record with the local government. Examples of adequate documentation include: a conservation easement, conservation parcel, deed restriction.~~

~~7~~requirements. C.2.3 Partial Dispersion on residential lots and commercial buildings

If roof runoff is dispersed on single-family lots or commercial lots ~~greater than 22,000 square feet,~~ according to the design criteria and guidelines in BMP T5.4010B of Volume ~~V – Chapter 5~~III, and the vegetative flow path is 50 feet or larger through undisturbed native landscape or lawn/landscape area that meets the guidelines in BMP T5.13, the ~~roof area may be modeled as landscaped area. This is done by clicking on the "Credits" button in the WWHM and entering the percent of roof area that is being dispersed. user has two options.~~

Option 1: The roof area may be modeled as landscaped area. Do this in WWHM on the Mitigated Scenario screen by entering the roof area into one of the entry options for dispersal of impervious area runoff.

Option #2: The user may apply the “lateral flow icons.” In this option, the “Lateral Flow Impervious Area” icon is used to represent the roof area(s). That icon is then connected to a “Lateral Flow Basin” icon that represents the pervious area into which the roof is being dispersed. The user should direct surface runoff and interflow from the “lateral flow basin” to a treatment system, retention/detention basin, or directly to a point of compliance.

Whether option #1 or #2 is used, the vegetated flow path is measured from the downspout or dispersion system discharge point to the ~~downstream property line, stream, wetland, or other impervious surface~~downgradient edge of the vegetated area. That flow path must be at least 50 feet to use these options.

Where BMP T5.11 (concentrated flow dispersion) or BMP T5.12 (sheet flow dispersion) of Volume V – Chapter 5 is used to disperse runoff ~~from impervious areas other than roofs~~ into a native vegetation area or an area that meets the guidelines in BMP T5.13 of Volume V – Chapter 5, the ~~impervious area may be modeled same two options as landscaped area. This can be done by entering described above are available. The user may model the impervious area as landscaped area rather than entering it as impervious area., or the “lateral flow” icons may be used. As above, the vegetated flow path from the dispersal point to the downgradient edge of the vegetated area must be at least 50 feet.~~

7.2.4 Road Projects

1) Uncollected or natural dispersion into adjacent vegetated areas **C.3 Downspout Full Infiltration**

Roof areas (i.e., sheet flow into the dispersion area):

Full dispersion credit (i.e., no other treatment or flow control required) for sites served by downspouts that meet the following criteria:

a) *Outwash soils* (Type A—sands and sandy gravels, possibly some Type B—loamy sands) that have an initial saturated drain to infiltration rate of 4 inches per hour or greater. The dry wells or infiltration rate must be based on one of the following: (1) A D_{10} -size (10% passing the size listed) greater than 0.06 mm (based on the estimated infiltration rate indicated by the upper-bound line in Figure 3.28 of Volume III—Chapter 3 for the finest soil within a three foot depth; (2) field results using procedures (Pilot Infiltration Test) identified in Appendix V-B of Volume V.

- 20 feet of impervious flow path needs 10 feet of dispersion area width.
- Each additional foot of impervious flow path needs 0.25 feet of dispersion area width.

b) *Other soils:* (Types C and D and some Type B not meeting the criterion in 1a above)

- Dispersion area must have 6.5 feet of width for every 1 foot width of impervious area draining to it. A minimum distance of 100 feet is necessary.

c) *Criteria applicable to all soil types:*

- Depth to the average annual maximum groundwater elevation should be at least 3 feet.
- Impervious surface flow path must be ≤ 75 ft. Pervious flow path must be ≤ 150 ft. Pervious flow paths trenches that are up-gradient road-side slopes that run onto the road and down-gradient road-side slopes that precede the dispersion area.
- Lateral slope of impervious drainage area should be $\leq 8\%$. Road-side slopes must be $\leq 25\%$. Road-side slopes do not count as part of the dispersion area unless native vegetation is re-established and slopes are less than 15%. Road shoulders that are paved or graveled to withstand occasional vehicle loading count as impervious surface.
- Longitudinal slope of road should be $\leq 5\%$.
- Length of dispersion area should be equivalent to length of road.
- Average longitudinal (parallel to road) slope of dispersion area should be $\leq 15\%$.
- Average lateral slope of dispersion area should be $\leq 15\%$.

2) Channelized (collected and re-dispersed) stormwater into areas with (a) native vegetation or (b) cleared land in areas outside of Urban Growth Areas that do not have a natural or man-made drainage system.

Full dispersion credit (i.e., no other treatment or flow control required) is given to projects that meet the following criteria:

a) *Outwash soils* (Type A—sands and sandy gravels, possibly some Type B—loamy sands) that have an initial saturated infiltration rate of 4 inches per hour or greater. The infiltration rate must be based on one of the following: (1) A D_{10} -size (10% passing the size listed) greater than 0.06 mm (based on the estimated infiltration rate indicated by the upper bound line in Figure 3.28 of

Volume III—Chapter 3 for the finest soil within a three foot depth; 2 field results using procedures (Pilot Infiltration Test) identified in Appendix V-B of Volume V.

- Dispersion area should be at least 1/2 of the impervious drainage area.

b) *Other soils:* (Types C and D and some Type B not meeting the criterion in 2a above)

- Dispersion area must have 6.5 feet of width for every 1 foot width of impervious area draining to it. A minimum distance of 100 feet is necessary.

c) *Other criteria applicable to all soil types:*

- Depth to the average annual maximum groundwater elevation should be at least three feet.
- Channelized flow must be redispersed to produce longest possible flow path.
- Flows must be evenly dispersed across the dispersion area.
- Flows must be dispersed using rock pads and dispersion techniques as specified in BMP T5.30, of Volume V—Chapter 5.
- Approved energy dissipation techniques may be used.
- Limited to onsite (associated with the road) flows.
- Length of dispersion area should be equivalent to length of the road.
- Average longitudinal and lateral slopes of the dispersion area should be $\leq 8\%$.

3) Engineered dispersion of stormwater runoff into an area with engineered soils

Full dispersion credit (i.e., no other treatment or flow control required) is given to projects that meet the following criteria:

Stormwater can be dispersed via sheet flow or via collection and re-dispersionsized in accordance with the techniques specified in BMP T5.30 in Volume V—Chapter 5. guidance in BMP T5.10A do not have to be entered into the runoff model. They are assumed to fully infiltrate the roof runoff.

- Depth to the average annual maximum groundwater elevation should be at least three feet.
- Type C and D soils must be compost-amended following guidelines in BMP T5.13 of Volume V—Chapter 5. The guidance document *Guidelines and Resources for Implementing Soil Quality and Depth—BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* can be used, or an approved equivalent soil quality and depth specification approved by the Department of Ecology. The guidance document is available at <http://www.soilsforsalmon.org>.
 - Dispersion area must meet the 6.5 to 1 ratio for full dispersion credit.
- Type A and B soils that meet the 4 inches per hour initial saturated infiltration rate minimum (See Section 7.2.4.2.a above) must be compost-amended in accordance with guidelines in BMP T5.13 of Volume V—Chapter 5. Compost may be incorporated into the soil in accordance with the guidance document cited above, or can be placed on top the native soil.
 - 20 feet of impervious flow path needs 10 feet of dispersion area width.
 - Each additional foot of impervious flow path needs 0.25 feet of dispersion area width.
- Average longitudinal (parallel to road) slope of dispersion area should be $\leq 15\%$.
- Average lateral slope of dispersion area should be $\leq 15\%$.
- The dispersion area should be planted with native trees and shrubs.

•

4) Other Characteristics for Dispersal areas

- Dispersal areas must be outside of the urban growth area; or if inside the urban growth area, in legally protected areas (easements, conservation tracts, public parks).
- If outside urban growth areas, legal agreements should be reached with property owners of dispersal areas subject to stormwater that has been collected and is being re-dispersed.
- An agreement with the property owner is advised for uncollected, natural dispersion via sheet flow that represents a continuation of past practice. If not a continuation of past practice, an agreement should be reached with the property owner.

7.3.C.4 Vegetated Roofs

7.3.C.4.1 Option 1 Design Criteria

- 3 inches to 8 inches of soil/growing media

Runoff Model Representation

- 50% till landscaped area; 50% impervious area

7.3.C.4.2 Option 2 Design Criteria

- ≥ 8 inches of soil/media

Runoff Model Representation

- 50% till pasture; 50% impervious area

Note: These modeling recommendations differ from those in the LID Manual.

7.3.3 Other Necessary Design Criteria

- Soil or growth media that has a high field capacity, and a saturated hydraulic conductivity that is ≥ 1 inch/hour (i.e., equivalent to a sandy loam or soil with a higher hydraulic conductivity).
- Drainage layer that allows free drainage under the soil/media.
- Vegetative cover that is both drought and wet tolerant.
- Waterproof membrane between the drain layer and the structural roof support.
- Maximum slope of 20%.

7.4C.5 Rainwater Harvesting

7.4.1 Design Criteria

- 100% reuse of the annual average runoff volume (use continuous runoff model to get annual average for drainage area).
- System designs involving interior uses must have a monthly water balance that demonstrates adequate capacity for each month and reuse of all stored water annually.

Runoff Model Representation:

Do not enter drainage area into the runoff model.

7.4.2 Other Criteria

- Restrict use to 4 homes/acre housing and lower densities when the captured water is solely for outdoor use.

7.5 Note: This applies only to drainage areas for which a monthly water balance indicates no overflow of the storage capacity.

C.6 Reverse Slope Sidewalks

Reverse slope sidewalks are sloped to drain away from the road and onto adjacent vegetated areas.

7.5.1 Design Criteria:

- ≥ 10 feet of vegetated surface downslope that is not directly connected into the storm drainage system.
- Vegetated area receiving flow from sidewalk must be native soil or meet guidelines in BMP T5.13 of Volume V—Chapter 5.

7.5.2 Runoff Model Representation:

- Enter sidewalk area as landscaped area over the underlying soil type.
- Alternatively, use the “lateral flow” icons. Use the “Lateral Flow Impervious Area” icon for the sidewalk, and use the “Lateral Flow Basin” icon for the downgradient vegetated area.

C.7.6 Minimal Excavation Foundations

- Low impact foundations are defined as those techniques that do not disturb, or minimally disturb the natural soil profile within the footprint of the structure. Where residential roof runoff is dispersed on the upgradient side of a structure, this preserves most in accordance with the design criteria and guidelines in BMP T5.10B of the hydrologic properties of Volume III—Chapter 3, the tributary roof area may be modeled as pasture on the native soil.
- In “step forming,” the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards. Where “step forming” is used on a slope, the square footage of roof that can be modeled as pasture must be reduced to account for lost soils. The following equation (suggested by Rick Gagliano of Pin Foundations, Inc.) can be used to reduce the roof area that can be modeled as pasture.

$$A_1 - dC(.5) \times A_1 = A_2$$

$$\frac{dP}{dP}$$

$$A_1 = \text{roof area draining to up gradient side of structure}$$

$$dC = \text{depth of cuts into the soil profile}$$

dP = permeable depth of soil (The A horizon plus an additional few inches of the B horizon where roots permeate into ample pore space of soil).

A₂ = roof area that can be modeled as pasture on the native soil. The rest of the roof is modeled as impervious surface unless it is dispersed in accordance with the next bullet.

- If roof runoff is dispersed downgradient of the structure in accordance with the design criteria and guidelines in BMP T5.10B of Volume III – Chapter 3, AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in BMP T5.13 of Volume V – Chapter 5, the tributary roof areas may be modeled as landscaped area. Alternatively, use the lateral flow elements to send roof runoff onto the lawn/landscape area that will be used for dispersion.

C.8 Tree Retention and Planting

C.8.1 Tree Retention Flow Control Credit

Flow control credits for retained trees are provided in [Table C.1](#) by tree type. These credits can be applied to reduce impervious or other hard surface area requiring flow control. Credits are an example of a minimal excavation foundation given as a percentage of the existing tree canopy area. The minimum credit for existing trees ranges from 50 to 100 square feet.

Comment [cg1]: Add link

Table C.1
Flow Control Credits for Retained Trees.

<u>Tree Type</u>	<u>Credit</u>
<u>Evergreen</u>	<u>20% of canopy area (minimum of 100 sq. ft./tree)</u>
<u>Deciduous</u>	<u>10% of canopy area (minimum of 50 sq. ft./tree)</u>

Impervious Area Mitigated = Σ Canopy Area x Credit (%) / 100.

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.

C.8.2 Newly Planted Tree Flow Control Credits

Flow control credits for newly planted trees are provided in [Table C.2](#) by tree type. These credits can be applied to reduce the impervious or other hard surface area requiring flow control. Credits range from 20 to 50 square feet per tree.

Comment [cg2]: Add link

Table C.2.
Flow Control Credits for Newly Planted Trees.

<u>Tree Type</u>	<u>Credit</u>
<u>Evergreen</u>	<u>50 sq. ft. per tree</u>
<u>Deciduous</u>	<u>20 sq. ft. per tree</u>

7.6

Impervious Area Mitigated = Σ Number of Trees x Credit (%) / 100.

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.

C.9 Soil Quality and Depth

All areas that meet the soil quality and depth requirement may be entered into the model as pasture rather than lawn/landscaping.

C.10. Bioretention

C.10.1 Runoff Model Representation

Pothole design (bioretention cells)

Bioretention is represented by using the “Gravel trench/bed” icon with a steady-state infiltration rate. Proper infiltration rate selection is described below. The user inputs the dimensions of the gravel trench. Layer 1 on the input screen is the bioretention soil layer. Enter the soil depth and a porosity of 40%. Layer 2 is the free standing water above the bioretention soil. Enter the maximum depth of free standing water (i.e., up to the invert of an overflow pipe or a spillway, whatever engages first for surface release of water), and 100% for porosity. Bioretention with underlying perforated drain pipes that discharge to the surface can also be modeled as gravel trenches/beds with steady-state infiltration rates. However, the only volume available for storage (and modeled as storage as explained herein) is the void space within the imported material (usually sand or gravel) below the bioretention soil and below the invert of the drain pipe.

Using one of the procedures explained in Volume III - Chapter 3 of this manual, estimate the initial measured (a.k.a., short-term) infiltration rate of the native soils beneath the bioretention soil and any base materials. Because these soils are protected from fouling, no correction factor will be applied.

If using the default bioretention soil mix from Chapter 7 of Volume V, 6 inches per hour is the initial infiltration rate. The long-term rate is either 1.5 inches per hour or 3 inches per hour depending upon the size of the drainage area into the bioretention facility. See Chapter 7 of Volume V. If using a custom imported soil mix other than the default, its saturated hydraulic conductivity (used as the infiltration rate) must be determined using the procedures described in Chapter 7 of Volume V. The long-term infiltration rate is one-fourth or one-half of that rate depending upon the size of the drainage area. See Chapter 7 of Volume V.

Linear Design: (bioretention swale or slopes)

Swales

Where a swale design has a roadside slope and a back slope between which water can pond due to an elevated, and an overflow/drainage pipe at the lower end of the swale, the swale may be modeled as a gravel trench/bed with a steady state infiltration rate. This method does not apply to swales that are underlain by a drainage pipe.

If the long-term infiltration rate through the imported bioretention soil is lower than the infiltration rate of the underlying soil, the surface dimensions and slopes of the swale should be entered into the WWHM as the trench dimensions and slopes. The effective depth is the distance from the soil surface at the bottom of the swale to the invert of the overflow/drainage pipe. If the

infiltration rate through the underlying soil is lower than the estimated long-term infiltration rate through the imported bioretention soil, the trench/bed dimensions entered into the WWHM should be adjusted to account for the storage volume in the void space of the bioretention soil. Use 40 percent porosity for bioretention planting mix soils recommended above for Layer 1 in WWHM.

This procedure to estimate storage space should only be used on bioretention swales with a 1% slope or less. Swales with higher slopes should more accurately compute the storage volume in the swale below the drainage pipe invert.

C.10.2 WWHM Routing and Runoff File Evaluation

In WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage be exceeded. So in the Riser/Weir screen, for the Riser head enter a value slightly smaller than the effective depth of the trench (say 0.1 ft below the Effective Depth); and for the Riser diameter enter a large number (say 10,000 inches) to ensure that there is ample capacity for overflows.

Within the model, route the runoff into the gravel trench by grabbing the gravel trench icon and placing it below the tributary "basin" area. Be sure to include the surface area of the bioretention area in the tributary "basin" area. Run the model to produce the effluent runoff file from the theoretical gravel trench. For projects subject to the flow control standard, compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. A conveyance system should be designed to route all overflows from the bioretention areas to centralized treatment facilities, and to flow control facilities if flow control applies to the project.

C.10.3 Modeling of Multiple Bioretention facilities

Where multiple bioretention facilities are scattered throughout a development, it may be possible to cumulatively represent a group of them that have similar characteristics as one large bioretention facility serving the cumulative area tributary to those facilities. For this to be a reasonable representation, the design of each bioretention facility in the group should be similar (e.g., same depth of soil, same depth of surface ponded water, roughly the same ratio of impervious area to bioretention volume). In addition, the group should have similar (0.5x to 1.5x the average) controlling infiltration rates (i.e., either the long-term rate of the bioretention soil, or the initial rate of the underlying soil) that can be averaged as a single rate.

C.11 WWHM Instructions for Estimating Runoff Losses in Road Base Material Volumes that are Below Surrounding Grade

Introduction

This section applies to roads or parking lots that have been constructed with a permeable pavement and whose underlying base materials extend below the surrounding grade of land. The over-excavated volume can temporarily store water before it infiltrates or overflows to the surrounding ground surface. This section describes design criteria and modeling approaches for such designs.

Pre-requisite

Before using this guidance to estimate infiltration losses, the designer should have sufficient information to know whether adequate depth to a seasonal high ground water table, or other infiltration barrier (such as bedrock) is available. The minimum depth necessary is 3 feet as measured from the bottom of the base materials.

C.11.1 Instructions for Roads on Zero to 2% Grade

For road projects whose base materials extend below the surrounding grade, the below grade volume of base materials may be modeled in WWHM as a Gravel trench/bed with a set infiltration rate. The pervious pavement area is entered as a basin with an equivalent amount of impervious area that is routed to the gravel trench/bed.

First, place a “basin” icon in the “Schematic” grid. Enter the appropriate pre-developed and post-developed descriptions of your project site (or threshold discharge area of the project site).

Assume that your pervious pavement surfaces are impervious surfaces. By placing a Gravel trench/bed icon below the basin icon in the Schematic grid, we are routing the runoff from the road and any other tributary area into the below grade volume that is represented by the Gravel trench/bed.

Enter the dimensions of the Gravel trench/bed: the length of the base materials that are below grade (parallel to the road); the width of the below grade material volume; and the depth. The available storage is the void volume in the gravel base layer below the pervious pavement. Enter the void ratio for the gravel base in the Layer 1 field. For example, for a project with a gravel base of 32% porosity, enter 0.32 for the Layer 1 porosity. If the below grade base course has perforated drainage pipes elevated above the bottom of the base course, but below the elevation of the surrounding ground surface, the “Layer 1 Thickness” is the distance from the invert of the lowest pipe to the bottom of the base course.

Also in WWHM3, the Gravel trench/bed facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So for the “Riser Height”, enter a value slightly smaller than the effective depth of the base materials (say 0.1 ft below the Effective Total Depth); and for the “Riser Diameter” enter a large value (say 10,000 inches) to ensure that there is ample capacity should overflows from the trench occur.

For all infiltration facilities, WWHM3 has a button that asks, “Use Wetted Surface Area?” The answer should remain “NO.”

Using one of the procedures explained in Chapter 3, estimate the initial measured (a.k.a., short-term) infiltration rate of the native soils beneath the base materials. Enter that into the “measured infiltration rate” field. For the Infiltration Reduction Factor, enter 0.5.

Run the model to produce the overflow runoff file from the gravel trench. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. Design the road base materials to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.

C.11.2 Instructions for Roads on Grades above 2%

Road base material volumes that are below the surrounding grade and that are on a slope can be modeled as a gravel trench with an infiltration rate and a nominal depth. Represent the below

grade volume as the gravel trench. Grab the gravel trench icon and place it below the “basin” icon so that the computer model routes all of the runoff into the gravel trench.

The dimensions of the gravel trench are: the length (parallel to and beneath the road) of the base materials that are below grade; the width of the below grade base materials; and an Effective Total Depth of 1 inch. In WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So, enter 0.04 ft (½ inch) for the “Riser Height” and a large Riser Diameter (say 1000 inches) to ensure that there is no head build up.

Note: If a drainage pipe is embedded and elevated in the below grade base materials, the pipe should only have perforations on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space.

Estimate the infiltration rate of the native soils beneath the base materials. See the previous section (Instructions for Roads on Zero to 2% Grade) for estimating options and for how to enter infiltration rates and infiltration reduction factors for the gravel trench. In the “Material Layers” field, enter ½ inch for Layer 1 Thickness and its appropriate porosity. For all infiltration facilities, WWHM3 has a button that asks, “Use Wetted Surface Area?” The answer should remain “NO.”

Run the model to produce the effluent runoff file from the gravel trench (base materials). Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. The road base materials should be designed to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.

C.11.3 Instructions for Roads on a Slope with Internal Dams within the Base Materials that are Below Grade

In this option, a series of infiltration basins is created by placing relatively impermeable barriers across the below grade base materials at intervals downslope. The barriers inhibit the free flow of water down the grade of the base materials. The barriers must not extend to the elevation of the surrounding ground. Provide a space sufficient to pass water from upgradient to lower gradient basins without causing flows to surface out the sides of the base materials that are above grade.

Each stretch of trench (cell) that is separated by barriers can be modeled as a gravel trench. This is done by placing the “Gravel trench/bed” icons in series in WWHM. For each cell, determine the average depth of water within the cell (Average Cell Depth) at which the barrier at the lower end will be overtopped.

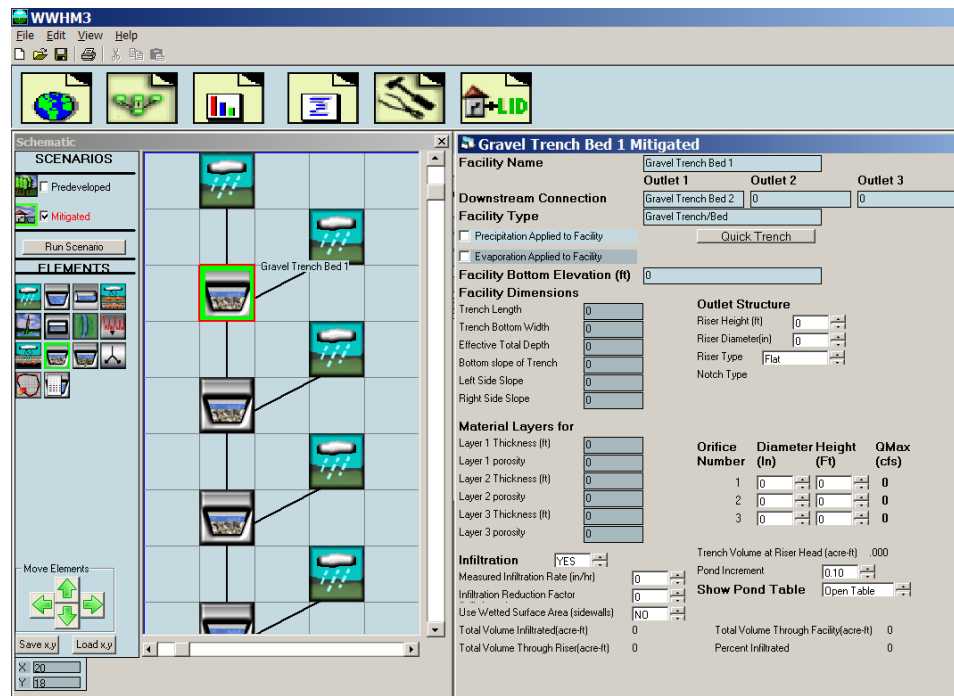
Specify the dimensions of each cell of the below-grade base materials using the “Gravel trench/bed” dimension fields for: the “Trench Length” (length of the cell parallel to the road); the “Trench Bottom Width” (width of the bottom of the base material); and the Effective Total Depth (the Average Cell Depth as determined above).

Also in WWHM3, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. For each trench cell, the available storage is the void space within the Average Cell Depth. WWHM calculates the storage/void volume of the trench cell using the porosity values entered in the “Layer porosity” fields. The value for the “Riser Height” should be slightly below the “Effective Total Depth” (say by about 1/8” to ¼”).

For the **Riser diameter**, enter a large number (say 10,000 inches) to ensure that there is ample capacity should overflows from the below-grade trench occur.

Each cell should have its own tributary drainage area that includes the road above it, any project site pervious areas whose runoff drains onto and through the road, and any off-site areas. Each drainage area is represented with a “basin” icon.

Below is the computer graphic representation of a series of Gravel trench/beds and the Basins that flow into them.



It is possible to represent a series of cells as one infiltration basin (using a single gravel trench icon) if the cells all have similar length and width dimensions, slope, and Average Cell Depth. A single “basin” icon is also used to represent all of the drainage area into the series of cells.

On the Gravel Trench screen under “Infiltration”, there is a field that asks the following “Use Wetted Surface Area?” By default, it is set to “NO”. It should stay “NO” if the below-grade base material trench has sidewalls steeper than 2 horizontal to 1 vertical.

Using the procedures explained above for roads on zero grade, estimate the infiltration rate of the native soils beneath the trench. Also as explained above, enter the appropriate values into the “Measured Infiltration Rate” and “Infiltration Reduction Factor” boxes.

Run the model to produce the effluent runoff file from the below grade trench of base materials. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved size a downstream

retention or detention facility (using the WWHM standard procedures) and locate it in the field. Design the road base materials to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.

Part 2: Summary of WWHM 2012 Representation of LID BMPs

Downspout Dispersion – BMP T5.10B

Where BMP T5.10B – Downspout Dispersion - is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, and the vegetated flow path is at least 50 feet, the connected roof area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple downspout dispersions in a project site. If such guidance is not forthcoming, in situations where multiple downspout dispersions will occur, Ecology may allow the roof area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Concentrated Flow Dispersion – BMP T5.11

Where BMP T5.11- Concentrated Flow Dispersion - is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, and the vegetated flow path is at least 50 feet, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple concentrated flow dispersions in a project site. If such guidance is not forthcoming, in situations where multiple concentrated flow dispersions will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Sheet Flow Dispersion – BMP T5.12

Where BMP T5.12 – Sheet Flow Dispersion - is used to disperse impervious area runoff into an undisturbed native landscape area or an area that meets BMP T5.13 – Soil Quality and Depth, the impervious area should be modeled as a lateral flow impervious area. Do this in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

Ecology may develop guidance for representing multiple sheet flow dispersions in a project site. If such guidance is not forthcoming, in situations where multiple sheet flow dispersions will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Post-Construction Soil Quality and Depth – BMP T5.13

Enter area as pasture

Bioretention – BMP T7.30

Use new bioretention element for each type: cell, swale, or planter box.

The equations used by the elements are intended to simulate the wetting and drying of soil as well as how the soils function once they are saturated. This group of LID elements uses the modified Green Ampt equation to compute the surface infiltration into the amended soil. The water then moves through the top amended soil layer at the computed rate, determined by Darcy's and Van Genuchten's equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), the model determines when water will begin to infiltrate into the second soil layer (lower layer). This occurs when the matric head is less than the gravity head in the first layer (top layer). The second layer is intended to prevent loss of the amended soil layer. As the second layer approaches field capacity, the water begins to move into the third layer – the gravel underlayer. For each layer, the user inputs the depth of the layer and the type of soil.

For the Ecology-recommended soil specifications for each layer in the design criteria for bioretention, the model will automatically assign pre-determined appropriate values for parameters that determine water movement through that soil. These include: wilting point, minimum hydraulic conductivity, maximum saturated hydraulic conductivity, and Van Genuchten number.

If a user opts to use soils that deviate from the recommended specifications, the default parameter values do not apply. The user will have to use the Gravel Trench element to represent the bioretention facility and follow the procedures identified for WWHM3.

Permeable Pavements – BMP T5.15

Use new porous pavement element.

User specifies pavement thickness & porosity, aggregate base material thickness & porosity, maximum allowed ponding depth & infiltration rate into native soil. For grades greater than 2%, see additional guidance.

Vegetated Roofs – BMP T5.17

Use new green roof element

User specifies media thickness, vegetation type, roof slope, and length of drainage.

Impervious Reverse Slope Sidewalks – BMP T5.18

Use the lateral flow elements to send the impervious area runoff onto the lawn/landscape area that will be used for dispersion.

Ecology may develop guidance for representing multiple impervious reverse slope sidewalks in a project site. If such guidance is not forthcoming, in situations where multiple impervious reverse slope sidewalks will occur, Ecology may allow the impervious area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Minimal Excavation Foundations – BMP T5.19

- Where residential roof runoff is dispersed on the up gradient side of a structure in accordance with the design criteria and guidelines in ~~BMP T5.10 of Volume V – Chapter 510B~~, the tributary roof area may be modeled as pasture on the native soil.
- In “step forming,” the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards. Where “step forming” is used on a slope, the square footage of roof that can be modeled as pasture must be reduced to account

for lost soils. ~~In “step forming,” the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards.~~ The following equation (suggested by Rick Gagliano of Pin Foundations, Inc.) can be used to reduce the roof area that can be modeled as pasture.

$$A_1 - \frac{dC(.5)}{dP} \times A_1 = A_2$$

A_1 = roof area draining to up gradient side of structure

dC = depth of cuts into the soil profile

dP = permeable depth of soil (The A horizon plus an additional few inches of the B horizon where roots permeate into ample pore space of soil).

A_2 = roof area that can be modeled as pasture on the native soil. The rest of the roof is modeled as impervious surface unless it is dispersed in accordance with the next bullet.

- If roof runoff is dispersed down gradient of the structure in accordance with the design criteria and guidelines in BMP T5.10 ~~of Volume V—Chapter 5~~10B, AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in BMP T5.13 ~~of Volume V—Chapter 5~~, the tributary roof areas ~~may~~should be modeled as ~~landscaped~~a lateral flow impervious area. This is done in WWHM on the Mitigated Scenario screen by connecting the dispersed impervious area to the lawn/landscape lateral flow soil basin element representing the area that will be used for dispersion.

~~7.6.2 Limitations~~

- ~~To minimize soil compaction, heavy equipment cannot be used within or immediately surrounding the building. Terracing of the foundation area may be accomplished by tracked, blading equipment not exceeding 650 psf.~~

7.7 Bioretention areas (rain gardens)

The design criteria provided below outlines basic guidance on bioretention design specifications, procedures for determining infiltration rates, and flow control guidance. For details on design specifications see section 6.1: Bioretention Areas of the Low Impact Development Technical Guidance Manual for Puget Sound (LID Manual).

7.7.1 Design Criteria

Soils

- The soils surrounding bioretention facilities are a principle design element for determining infiltration capacity, sizing and rain garden type. The planting soil mix placed in the cell or swale is a highly permeable soil mixed thoroughly with compost amendment, and a surface mulch layer.
- Soil depth should be a minimum of 18 inches to provide acceptable minimum pollutant attenuation and good growing conditions for selected plants.
- The texture for the soil component of the bioretention soil mix should be a loamy sand (USDA Soil Textural Classification). Clay content for the final soil mix should be less than 5 percent. The final soil mix (including compost and soil) should have a minimum short term hydraulic conductivity of 1.0 inches/hour per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 80 percent compaction per ASTM Designation D 1557.
- The final soil mixture should have a minimum organic content of approximately 10 percent by dry weight.
- The pH for the soil mix should be between 5.5 and 7.0.

Mulch layer

- Bioretention areas can be designed with or without a mulch layer.

Compost

- Material must be in compliance with WAC chapter 173-350-220. This code is available online at <http://www.ecy.wa.gov/programs/swfa/facilities/350.html>.
- pH between 5.5 and 7.0.
- Carbon nitrogen ratio between 20:1 and 35:1 (35:1 CN ratio recommended for native plants)
- Organic matter content should be between 35% and 65%.

Installation

- Minimize compaction of the base and sidewalls of the bioretention area. Excavation should not be allowed during wet or saturated conditions. Excavation should be performed by machinery operating adjacent to the bioretention facility and no heavy equipment with narrow tracks, narrow tires or large lugged, high pressure tires should be allowed on the bottom of the bioretention facility.

- On-site soil mixing or placement should not be performed if soil is saturated. The bioretention soil mixture should be placed and graded by excavators and/or backhoes operating adjacent to the bioretention facility.

Plant materials

- Plants should be tolerant of ponding fluctuations and saturated soil conditions for the length of time anticipated by the facility design, and drought during the summer months.
- In general, the predominant plant material utilized in bioretention areas are facultative species adapted to stresses associated with wet and dry conditions.

Maximum ponding depth

- A maximum ponding depth of 12 inches is recommended.
- A maximum surface pool drawdown time of 24 hours is recommended.
- Ponding depth and system drawdown should be specified so that soils dry out periodically in order to:
 - Restore hydraulic capacity to receive flows from subsequent storms.
 - Maintain infiltration rates.
 - Maintain adequate soil oxygen levels for healthy soil biota and vegetation.
 - Provide proper soil conditions for biodegradation and retention of pollutants.

7.7.2 Limitations

- A minimum of 3 feet of clearance is necessary between the lowest elevation of the bioretention soil, or any underlying gravel layer, and the seasonal high groundwater elevation or other impermeable layer if the area tributary to the rain garden meets or exceeds any of the following limitations:
 - 5,000 square feet of pollution-generating impervious surface; or
 - 10,000 square feet of impervious area; or
 - ¾ acres of lawn and landscape.
- If the tributary area to an individual rain garden does not exceed the areal limitations above, a minimum of 1 foot of clearance is adequate between the lowest elevation of the bioretention soil (or any underlying gravel layer) and the seasonal high groundwater elevation or other impermeable layer.

7.7.3 Runoff Model Representation

Pothole design (bioretention cells)

The rain garden is represented as a pond with a steady-state infiltration rate. Proper infiltration rate selection is described below. The pond volume is a combination of the above-ground volume available for water storage and the volume available for storage within the imported soil. The above-ground volume is the size of the “pothole” that accommodates standing water. A minimum ponding depth of 6 inches is recommended. The soil storage volume is determined by multiplying the volume occupied by the imported soil by the soil’s percent porosity. Use 40 percent porosity for bioretention planting mix soils recommended in section 6.1.2.3: Bioretention components of the LID Manual. That volume is presumed to be added directly below the surface

soil profile of the rain garden. The theoretical pond dimensions are represented in the Pond Information/Design screen. The Effective Depth is the distance from the bottom of the theoretical pond to the height of the overflow. This depth is less than the actual depth because of the volume occupied by the soil. Approximate side slopes can be individually entered. On the Pond Information/Design screen, there is a button, which asks, "Use Wetted Surface Area?" Pushing that button is an affirmative response. Do not push the button if the rain garden has sidewalls steeper than 2 horizontal to 1 vertical.

Rain gardens with underlying perforated drain pipes that discharge to the surface can also be modeled as ponds with steady state infiltration rates. However, the only volume available for storage (and modeled as storage as explained herein) is the void space within the imported material (usually sand or gravel) below the invert of the drain pipe.

Linear Design: (bioretention swale or slopes)

Ecology may develop guidance for representing multiple downspout dispersions in a project site. If such guidance is not forthcoming, in situations where multiple downspout (down gradient) dispersions will occur, Ecology may allow the roof area to be modeled as a landscaped area so that the project schematic in WWHM becomes manageable.

Full dispersion – BMP T5.30

Full downspout infiltration – BMP T5.10A

Rainwater Harvesting – BMP T5.20

If BMP design criteria are followed, the area draining to the three BMPs listed immediately above is not entered into the runoff model.

Newly planted trees – BMP T5.16

Retained trees – BMP T5.16

If BMP design criteria are followed, the total impervious/hard surface areas entered into the runoff model may be reduced by an amount indicated in the criteria for the tree BMPs listed immediately above.

Perforated Stub-out Connection – BMP T5.10C

Any flow reduction is variable and unpredictable. No computer modeling techniques are allowed that would predict any reduction in flow rates and volumes from the connected area. ~~Swales~~

Where a swale design has a roadside slope and a back slope between which water can pond due to an elevated, and an overflow/drainage pipe at the lower end of the swale, the swale may be modeled as a pond with a steady state infiltration rate. This method does not apply to swales that are underlain by a drainage pipe.

If the long term infiltration rate through the imported bioretention soil is lower than the infiltration rate of the underlying soil, the surface dimensions and slopes of the swale should be entered into the WWHM as the pond dimensions and slopes. The effective depth is the distance from the soil surface at the bottom of the swale to the invert of the overflow/drainage pipe. If the infiltration rate through the underlying soil is lower than the estimated long term infiltration rate through the imported bioretention soil, the pond dimensions entered into the WWHM should be adjusted to account for the storage volume in the void space of the bioretention soil. Use 40

percent porosity for bioretention planting mix soils recommended in section 6.1.2.3: Bioretention components of the LID Manual. For instance, if the soil is 40% voids, and the depth of the imported soils is 2 feet throughout the swale, the depth of the pond is increased by 0.8 feet. If the depth of imported soils varies within the side slopes of the swale, the theoretical side slopes of the pond can be adjusted.

~~This procedure to estimate storage space should only be used on bioretention swales with a 1% slope or less. Swales with higher slopes should more accurately compute the storage volume in the swale below the drainage pipe invert.~~

Slopes

Where a bioretention design involves only a sloped surface such as the slope below the shoulder of an elevated road, the design can also be modeled as a pond with a steady state infiltration rate. This procedure only applies in instances where the infiltration rate through the underlying soil is less than the estimated long term infiltration rate of the bioretention imported soil. In this case, the length of the bioretention slope should correspond to the maximum wetted cross sectional area of the theoretical pond. The effective depth of the theoretical pond is the void depth of the bioretention soil as estimated by multiplying the measured porosity times the depth of the bioretention soils. Use 40 percent porosity for bioretention planting mix soils recommended in section 6.1.2.3: Bioretention components of the LID Manual.

7.7.4 Infiltration Rate Determinations

The assumed infiltration rate for the pond must be the lower of the estimated long term rate of the imported soil or the initial (a.k.a. short term or measured) infiltration rate of the underlying soil profile. Using one of the procedures explained below, the initial infiltration rates of the two soils must be determined. Then after applying an appropriate correction factor to the imported soil of the rain garden, the designer can compare and determine the lower of the long term infiltration rate of the imported soil, and the initial infiltration rate of the underlying native soil. The underlying native soil does not need a correction factor because the overlying imported soil protects it. Below are explanations for how to determine infiltration rates for the imported and underlying soils, and how to use them with the WWHM.

7.7.4.1 Imported Soil for the rain garden

1. Method for imported soil in a rain garden with a tributary area of or exceeding any of the following limitations: 5,000 square feet of pollution-generating impervious surface; or 10,000 square feet of impervious surface; or $\frac{3}{4}$ acres of lawn and landscape:
 - Use ASTM D 2434 Standard Test Method for Permeability of granular Soils (Constant Head) with a compaction rate of 80% using ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
 - Use 4 as the infiltration reduction correction factor.
 - Compare this rate to the infiltration rate of the underlying soil (as determined using one of the methods below). If the long term infiltration rate of the imported soil is lower, enter that infiltration rate and the correction factor into the corresponding boxes on the pond information/design screen of the WWHM.

2. ~~Method for imported soil in a rain garden with a tributary area less than 5,000 square feet of pollution-generating impervious surface; and less than 10,000 square feet of impervious surface; and less than ¾ acres of lawn and landscape:~~
 - ~~○ Use ASTM D 2434 Standard Test Method for Permeability of granular Soils (Constant Head) with a compaction rate of 80% using ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.~~
 - ~~○ Use 2 as the infiltration reduction correction factor.~~
 - ~~○ Compare this rate to the infiltration rate of the underlying soil (as determined using one of the methods below). If the long-term infiltration rate of the imported soil is lower, enter that infiltration rate and the correction factor into the corresponding boxes on the pond information/design screen of the WWHM.~~

7.7.4.2 Underlying Soil:

- ~~Method 1: Use Table 3.7 of the 2004 SMMWW to determine the short-term infiltration rate of the underlying soil. Soils not listed in the table cannot use this approach. Compare this short-term rate to the long-term rate determined above for the bioretention imported soil. If the short-term rate for the underlying soil is lower, enter it into the measured infiltration rate box on the pond information/design screen in the WWHM. Enter 1 as the infiltration reduction factor.~~
- ~~Method 2: Determine the D₁₀ size of the underlying soil. Use the “upperbound line” in Figure 3-26a of Volume III—Chapter 3 to determine the corresponding infiltration rate. If this infiltration rate is lower than the long-term infiltration rate determined for the imported bioretention soil, enter the rate for the underlying soil into the measured infiltration rate box on the pond information/design screen. Enter 1 as the infiltration reduction factor.~~
- ~~Method 3: Measure the in-situ infiltration rate of the underlying soil using procedures (Pilot Infiltration Test) identified in Appendix V-B of Volume V. If this rate is lower than the long-term infiltration rate determined for the imported bioretention soil, enter the underlying soil infiltration rate into the corresponding box on the pond information/design screen of the WWHM. Enter 1 as the infiltration reduction factor.~~

7.7.5 WWHM Routing and Runoff File Evaluation

~~In WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage be exceeded. So in the Riser/Weir screen, for the Riser head enter a value slightly smaller than the effective depth of the pond (say 0.1 ft below the Effective Depth); and for the Riser diameter enter a large number (say 10,000 inches) to ensure that there is ample capacity for overflows.~~

~~Within the model, route the runoff into the pond by grabbing the pond icon and placing it below the tributary “basin” area. Be sure to include the surface area of the bioretention area in the tributary “basin” area. Run the model to produce the effluent runoff file from the theoretical pond. For projects subject to the flow control standard, compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. A conveyance system should be designed to route all overflows from the bioretention areas to centralized treatment facilities, and to flow control facilities if flow control applies to the project.~~

7.7.6 Modeling of Multiple Rain Gardens

~~Where multiple rain gardens are scattered throughout a development, it may be possible to represent those as one rain garden (a “pond” in the WWHM) serving the cumulative area tributary to those rain gardens. For this to be a reasonable representation, the design of each rain garden should be similar (e.g., same depth of soil, same depth of surface ponded water, roughly the same ratio of impervious area to rain garden volume).~~

~~7.7.7 Other Rain Garden Designs~~

~~Guidance for modeling other bioretention designs is not yet available. Where compost amended soils are used along roadsides, Section 7.2: Dispersion, can be applied.~~

7.8 WWHM Instructions for Estimating Runoff Losses in Road Base Material Volumes that are Below Surrounding Grade

Introduction

~~This section applies to roads or parking lots that have been constructed with a permeable pavement and whose underlying base materials extend below the surrounding grade of land. The over excavated volume can temporarily store water before it infiltrates or overflows to the surrounding ground surface. This section describes design criteria and modeling approaches for such designs.~~*Pre-requisite*

~~Before using this guidance to estimate infiltration losses, the designer should have sufficient information to know whether adequate depth to a seasonal high groundwater table, or other infiltration barrier (such as bedrock) is available. The minimum depth necessary is 3 feet as measured from the bottom of the base materials.~~

7.8.1 Instructions for Roads on Zero to 2% Grade

~~For road projects whose base materials extend below the surrounding grade, a portion of the below grade volume of base materials may be modeled in the WWHM as a pond with a set infiltration rate.~~

~~First, place a “basin” icon in the “Schematic” grid on the left side of the “Scenario Editor” screen. Left clicking on the basin icon will create a “basin information” screen on the right in which you Enter the appropriate pre-developed and post-developed descriptions of your project site (or threshold discharge area of the project site). By placing a pond icon below the basin icon in the Schematic grid, we are routing the runoff from the road and any other tributary area into the below grade volume that is represented by the pond.~~

~~The dimensions of the infiltration basin/pond to be entered in the Pond Information/Design screen are: the length of the base materials that are below grade (parallel to the road); the width of the below grade material volume; and the Effective Depth. Note that the storage/void volume of the below grade base has to be estimated to account for the percent porosity of the gravel. This can be done by multiplying the below grade depth of base materials by the fractional porosity (e.g., a project with a gravel base of 32% porosity would multiply the below grade base material depth by 0.32). This is the Effective Depth. If the below grade base course has perforated drainage pipes elevated above the bottom of the base course, but below the elevation of the surrounding ground surface, the Effective Depth is the distance from the invert of the lowest pipe to the bottom of the base course multiplied by the fractional porosity.~~

~~Also in WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So in the Riser/Weir screen, for the Riser head enter a value slightly smaller than the effective depth of the base materials (say 0.1 ft below the Effective Depth); and for the Riser diameter enter a large value (say 10,000 inches) to ensure that there is ample capacity should overflows from the trench occur.~~

~~On the Pond Information/Design screen, there is a button that asks, “Use Wetted Surface Area?” Pushing that button is an affirmative response. Do not push the button.~~

~~Using the procedures explained in Volume III—Chapter 3 and Appendix V-B of the 2004 SMMWW, estimate the long term infiltration rate of the native soils beneath the base materials. If using Method 1 from Chapter 3 of Volume III, enter the appropriate “short term infiltration~~

rate” from Table 3.7 into the “measured infiltration rate” box on the “Pond Information Design” screen of WWHM. Enter the correction factor from that table as the “Infiltration Reduction Factor.” If using Method 2, enter the appropriate long-term infiltration rate from Table 3.8 into the “measured infiltration rate” box. Enter “1” as the correction factor. Note that Table 3.8 is restricted to the soil types in the table. For soils with a D_{10} size smaller than .05 mm, use the “lowerbound” values from Figure 3-26a in Volume III—Chapter 3. If using Method 3, enter the measured in-situ infiltration rate as the “Measured Infiltration Rate” in the Pond Information/Design Screen. Also enter the appropriate cumulative correction factor determined from Table 3.9 as the “Infiltration Reduction Factor.” Wherever practicable, Ecology recommends using Method 3, in-situ infiltration measurements (Pilot Infiltration Test) in accordance with Appendix V-B of Volume V—Chapter 5.

~~Run the model to produce the overflow runoff file from the base materials infiltration basin. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. The road base materials should be designed to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.~~

7.8.2 Instructions for Roads on Grades above 2%

Road base material volumes that are below the surrounding grade and that are on a slope can be modeled as a pond with an infiltration rate and a nominal depth. Represent the below-grade volume as a pond. Grab the pond icon and place it below the “basin” icon so that the computer model routes all of the runoff into the infiltration basin/pond.

The dimensions of the infiltration basin/pond to be entered in the Pond Information/Design screen are: the length (parallel to and beneath the road) of the base materials that are below grade; the width of the below-grade base materials; and an Effective Depth of 1 inch. In WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. So in the Riser/Weir screen, enter 0.04 ft (1/2 inch) for the Riser head and a large Riser diameter (say 1000 inches) to ensure that there is no head build up.

~~Note: If a drainage pipe is embedded and elevated in the below-grade base materials, the pipe should only have perforations on the lower half (below the spring line) or near the invert. Pipe volume and trench volume above the pipe invert cannot be assumed as available storage space.~~

Estimate the infiltration rate of the native soils beneath the base materials. See the previous section (Instructions for Roads on Zero to 2% Grade) for estimating options and for how to enter infiltration rates and infiltration reduction factors into the “Pond Information/Design” Screen of WWHM. Enter the appropriate information for the theoretical pond of 1/2-inch maximum depth.

On the Pond Information/Design screen, there is a button that asks, “Use Wetted Surface Area?” Pushing that button is an affirmative response. Do not push the button.

~~Run the model to produce the effluent runoff file from the base materials. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. The road~~

~~base materials should be designed to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.~~

7.8.3 Instructions for Roads on a Slope with Internal Dams within the Base Materials that are Below Grade

~~In this option, a series of infiltration basins is created by placing relatively impermeable barriers across the below-grade base materials at intervals. The barriers inhibit the free flow of water down the grade of the base materials. The barriers must not extend to the elevation of the surrounding ground. Provide a space sufficient to pass water from upgradient to lower gradient basins without causing flows to surface out the sides of the base materials that are above grade.~~

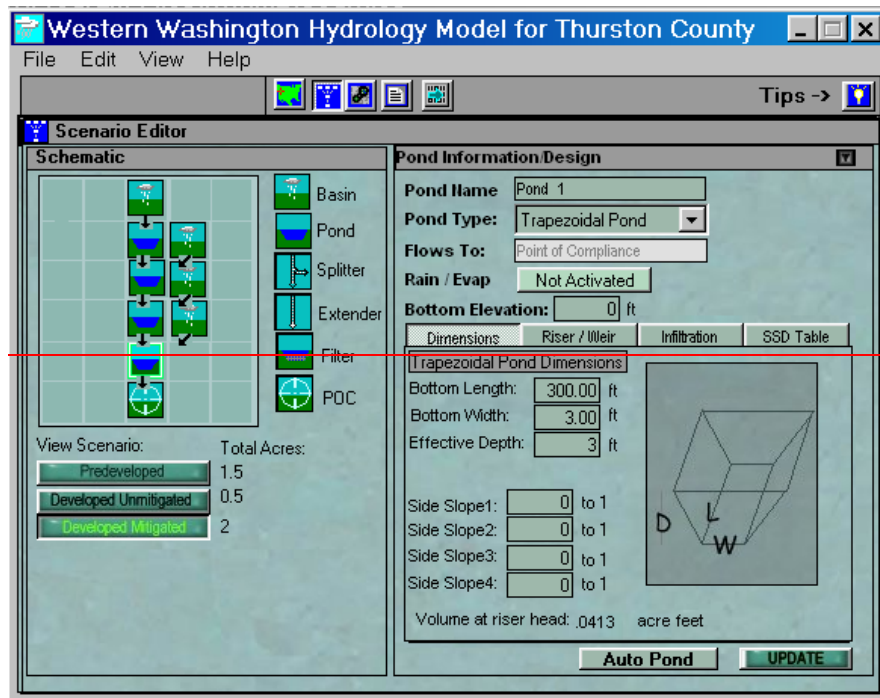
~~Each stretch of trench (cell) that is separated by barriers can be modeled as an infiltration basin. This is done by placing pond icons in series in the WWHM. For each cell, determine the average depth of water within the cell (Average Cell Depth) at which the barrier at the lower end will be overtopped.~~

~~Specify the dimensions of each cell of the below-grade base materials in WWHM on the screen, which asks for pond dimensions. The dimensions of the infiltration cell to be entered in the Pond Information/Design screen are: the length of the cell (parallel to the road); the width; and the Effective Depth (In this case, it is OK to use the total depth of the base materials that are below grade).~~

~~Also in WWHM2, all infiltrating facilities must have an overflow riser to model overflows that occur should the available storage get exceeded. For each trench cell, the available storage is the void space within the Average Cell Depth. So, the storage/void volume of the trench cell has to be estimated to account for the percent porosity of the base materials. For instance, if the base materials have a porosity of 32%, the void volume can be represented by reducing the Average Cell Depth by 68% (1-32%). This depth is entered in the Riser/Weir screen as the Riser head. The gross adjustment works because WWHM2 (as March 2004) does not adjust infiltration rate as a function of water head. If the model is amended such that the infiltration rate becomes a function of water head, this gross adjustment will introduce error and therefore other adjustments should be made.) For the **Riser diameter** in the Riser/Weir screen, enter a large number (say 10,000 inches) to ensure that there is ample capacity should overflows from the below-grade trench occur.~~

~~Each cell should have its own tributary drainage area that includes the road above it, any project site pervious areas whose runoff drains onto and through the road, and any offsite areas. Each drainage area is represented with a "basin" icon.~~

~~Up to four pond icons can be placed in a series to represent the below-grade trench of base materials. The computer graphic representation of this appears as follows:~~



It is possible to represent a series of cells as one infiltration basin (using a single pond icon) if the cells all have similar length and width dimensions, slope, and Average Cell Depth. A single "basin" icon is also used to represent all of the drainage area into the series of cells.

On the Pond Information/Design screen (see screen below), there is a button, which asks, “Use Wetted Surface Area?” Pushing that button is an affirmative response. Do not push the button if the below-grade base material trench has sidewalls steeper than 2 horizontal to 1 vertical.

Pond Information Design

Pond Name: Pond 1

Pond Type: Trapezoidal Pond

Flows To: Point of Compliance

Rain / Evap: Not Activated

Bottom Elevation: 0 ft

Dimensions | Riser / Weir | **Infiltration** | SSD Table

Infiltration: On/Off ☒

Measured Infiltration Rate (in/hr): 1

Infiltration Reduction Factor: 1

Use Wetted Surface Area?

Volume Calculations for infiltration facilities

Total Volume infiltrated (acre ft)	03.254
Total Runoff volume from Riser (acre ft)	01.318
Total Volume (acre ft)	4.572
Percentage Infiltrated:	71.18

Auto Pond UPDATE

Using the procedures explained above for roads on zero grade, estimate the infiltration rate of the native soils beneath the trench. Also as explained above, enter the appropriate values into the “Measured Infiltration Rate” and “Infiltration Reduction Factor” boxes of the “Pond Information/Design” screen.

Run the model to produce the effluent runoff file from the below grade trench of base materials. Compare the flow duration graph of that runoff file to the target pre-developed runoff file for compliance with the flow duration standard. If the standard is not achieved a downstream retention or detention facility must be sized (using the WWHM standard procedures) and located in the field. The road base materials should be designed to direct any water that does not infiltrate into a conveyance system that leads to the retention or detention facility.

Appendix III-D

Procedure for Conducting a Pilot Infiltration Test

The Pilot Infiltration Test (PIT) consists of a relatively large scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small scale double ring infiltrometer or “stove-pipe” infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology’s Technical Advisory Committee.

Infiltration Test

- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where water availability is a problem smaller areas may be considered as determined by the site professional.
- Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5 ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth should not exceed the proposed maximum depth of water expected in the completed facility.

Every 15-30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

Add water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level. (usually 17 hours)

After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty.

Data Analysis

Calculate and record the infiltration rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

~~Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.~~

~~Apply appropriate correction factors for site heterogeneity, anticipated level of maintenance and treatment to determine the site-specific design infiltration rate (see Table 7.3).~~

Example

~~The area of the bottom of the test pit is 8.5 ft. by 11.5 ft.~~

~~Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or an average of $(9.8 + 12.3) / 2 = 11.1$ inches per hour.~~

~~Applying a correction factor of 5.5 for gravelly sand in table 6.3 the design long-term infiltration rate becomes 2 inches per hour, anticipating adequate maintenance and pre-treatment.~~

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Volume IV **Source Control BMPs**

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Chapter 1 - Introduction

1.1 Purpose of this Volume

~~The purpose of this volume is to provide~~ provides guidance for selecting BMPs to meet the Minimum Requirement that “all known, available, and reasonable source control BMPs shall be applied to all projects” (see Volume I, Minimum Requirement #3). This volume can assist local governments and businesses to control urban sources of both conventional and toxic pollutants in stormwater (see Appendix IV-B). Application of the source control BMPs contained in this volume can help attain State water quality standards to protect beneficial uses of receiving waters.

Best Management Practices (BMPs) ~~are to meet Minimum Requirement #3, in Volume I. Best Management Practices (BMPs) means~~ schedules of activities, prohibitions of practices, maintenance procedures, and ~~other physical, structural, and/or managerial practices, that when used singly or in combination, that~~ prevent or reduce the release of pollutants and other adverse impacts to waters of Washington State. ~~As described in Volume I of this stormwater manual, BMPs for long-term management of stormwater at developed sites can be divided into three main categories: BMPs can be used singularly or in combination.~~

Stormwater source control BMPs focus on preventing stormwater pollution from occurring. As opposed to other BMP types that attempt to reduce the volume, timing, or existing pollution in stormwater flows (refer to volumes II, III, V).

Facilities covered under Ecology’s Industrial Stormwater General Permit, Boatyard General Permit, or Sand and Gravel General Permit should also consult this volume to identify applicable (mandatory) and recommended operational and structural BMPs. All three permits require permittees to develop and implement Stormwater Pollution Prevention Plans (SWPPPs). Industrial SWPPPs and Boatyard SWPPPs must include Operational Source Control BMPs and Structural Source Control BMPs listed as “applicable” in this volume.

- ~~—Applying the source control BMPs in this volume can also help local governments and business control urban sources of conventional and toxic pollutants in stormwater (see Appendix IV-B)~~ BMPs addressing the volume and timing of stormwater flows;
- BMPs addressing prevention of pollution from potential sources; and
- BMPs addressing treatment of runoff to remove sediment and other pollutants.

~~This volume of the stormwater manual focuses mainly on the second category, prevention of water quality impacts from potential pollutant sources. Source control BMPs are structures or operations that are~~

~~intended to prevent pollutants from coming into contact with stormwater through physical separation of areas or careful management of activities that are sources of pollutants. This volume also identifies certain treatment BMPs that apply to specific types of pollutant sources.~~

~~BMPs for controlling stormwater flows and treating runoff are presented in Volumes III and V respectively.~~

~~) and aid them in meeting State water quality standards to protect beneficial uses of receiving waters.~~

~~Local governments may require commercial, industrial, and multifamily properties to use the source control BMPs in this volume through ordinances or other documents.~~

1.2 Content and Organization of this Volume

Volume IV of the stormwater manual contains two chapters. [Chapter 1](#) ~~Chapter 1~~ serves as an introduction and provides descriptions of operational and structural source control BMPs. It distinguishes between applicable (mandatory) BMPs, and recommended BMPs. It describes the relationship between the source control BMPs in this volume and regulatory requirements. ~~Chapter 2 presents operational BMPs that are~~ [In Chapter 2, Section 2.1](#) ~~applicable to~~ [presents operational BMPs that are generally appropriate for](#) commercial and industrial establishments. [Section 2.2](#) ~~generally, and section 2.2 presents~~ [contains](#) operational and structural BMPs ~~that are~~ designed to address specific types of pollutant sources.

The appendices ~~to~~ [in](#) this volume contain ~~more detailed~~ [additional](#) information on selected topics. In particular, [Appendix IV-A](#) ~~Appendix IV-A~~ lists common pollutant sources associated with specific businesses and public agencies.

1.3 How to Use this Volume

[Use](#) this volume ~~should be consulted~~ to select specific BMPs for source control for inclusion in [Permanent Stormwater Site Control](#) Plans (~~see as required in~~ [Volume I](#), [Section 3.1.5](#)).

[Operators under Ecology's Industrial Stormwater General Permit, Boatyard General Permit, or Sand and Gravel General Permit should use this volume to identify applicable \(mandatory\) and recommended operational and structural source control BMPs for inclusion in their Stormwater Pollution Prevention Plans \(SWPPPs\).](#)

[Operators of commercial, industrial, and multifamily properties not under an Ecology permit should use this volume in developing their SWPPPs and](#)

should check with their jurisdiction about local requirements related to source control BMPs and SWPPPs.

Within this volume, the reader should interpret the term “applicable” when referring to specific operational or structural source controls as meaning “mandatory” or “required”.

Users may consult ~~Appendix IV-A~~ [Appendix IV-A](#) regarding their specific businesses and activities and to identify their common pollutant sources. ~~Information contained in Chapter 2~~ [Then refer to Chapter 2](#) of this volume ~~can then be used~~ to identify source control BMPs for a given type of pollutant source. [Chapter 2](#) ~~Chapter 2~~ also contains design criteria for source control BMPs. Some users will wish to refer to additional appendices for specific information on regulatory requirements affecting their projects.

This volume identifies some source control treatment BMPs that apply to specific types of pollutant sources. For a more complete discussion of treatment ~~BMPs~~ [BMP](#) design information ~~users should~~ refer to Volume V.

~~The BMPs described in this volume can also satisfy permit requirements under the National Pollutant Discharge Elimination System (NPDES).~~

1.4 Operational and Structural Source Control BMPs

There are two categories of source control BMPs: operational and structural.

Operational source control BMPs are non-structural practices that prevent or reduce pollutants from entering stormwater. Examples include formation of a pollution prevention team, good housekeeping practices, preventive maintenance procedures, spill prevention and cleanup, employee training, inspections of pollutant sources, and record keeping. They can also include process changes, raw material/product changes, and recycling wastes. [Section 2.1 contains a general discussion of operational source controls that are frequently used.](#)

[Most stormwater experts consider](#) operational source control BMPs ~~are considered~~ the most cost-effective ~~pollutant minimization practices~~ [practice to reduce pollution.](#)

Structural source control BMPs are physical, structural, or mechanical devices or facilities ~~that are~~ intended to prevent pollutants from entering stormwater. ~~Examples of~~ Structural source control BMPs typically include:

- Enclosing and/or covering the pollutant source (e.g. within a building or other enclosure, a roof over storage and working areas, temporary tarp, etc.).
- Physically segregating the pollutant source to prevent run-on of uncontaminated stormwater.

- Devices that direct ~~only~~ contaminated stormwater to appropriate treatment BMPs (e.g., discharge to a sanitary sewer if allowed by the local sewer authority).

1.5 Treatment BMPs for Specific Pollutant Sources

This volume also identifies specific treatment BMPs that apply to particular pollutant sources, such as fueling stations, railroad yards, material storage and transfer of materials areas, etc. ~~After identifying the applicable treatment BMPs, the reader can refer to Volume V for design information.~~

Treatment BMPs are intended to remove pollutants from stormwater. Examples include settling basins or vaults, oil/water separators, biofilters, wet ponds, constructed wetlands, infiltration systems, and emerging technologies such as media filtration.

~~For industries covered under the Baseline Facilities required to install additional treatment BMPs to comply with Ecology's Industrial Stormwater General Permit for Industrial Activities, treatment BMPs must be implemented if "action" values of certain pollutants are exceeded despite the application of operational and source control measures. The industry may request a waiver from applying (or other General Stormwater Permits) should consider the treatment BMPs based on feasibility identified in Volume IV and V when selecting and site specific water quality conditions. See Appendix IV-E for more information. designing treatment BMPs. In addition, facilities should consider the sediment control and treatment BMPs in Volume II if turbidity and/or sediment reduction is required.~~

1.6 Distinction between Applicable BMPs and Recommended BMPs

This volume uses the terminology "applicable BMPs" and "recommended BMPs" to address an important distinction. This section explains the use of these terms.

1.6.1 Applicable (Mandatory) BMPs

~~Under the Puget Sound Water Quality Management Plan, cities and counties are directed to adopt Ecology's stormwater manual, or a manual that is substantially equivalent. The NPDES General Phase I Municipal Stormwater Permits for municipal, industrial and construction stormwater discharges also require the adoption or Permit requires local governments to use of Ecology's stormwater manual or an equivalent manual. (See Volume I, Chapter 2). operational and structural source control BMPs for pollutant generating sources.~~

BMPs identified in this volume as applicable (mandatory) must be included (or an equivalent BMP) in local government manuals to be considered equivalent to Ecology's stormwater manual. Ecology expects local governments to require those BMPs described as applicable at new developments and redevelopment sites.

~~The applicable BMPs will also be required if they are incorporated into NPDES permits, or if they are included by Local governments in a stormwater program for existing facilities. The applicable may require commercial, industrial, and multifamily properties to implement the BMPs in this volume may also be. Operators of these property types should check with their jurisdiction about local requirements related to source control BMPs and SWPPPs.~~

All sites covered under the Industrial Stormwater General Permit must include and implement the applicable (mandatory) BMPs in their Industrial SWPPP.

Industrial sites covered by individual industrial stormwater permits must comply with the specific source control and treatment BMPs listed in their permits. Operators under individual industrial stormwater permits may include additional BMPs from this manual, if desired.

All sites covered under the Boatyard Stormwater General Permit must include and implement the applicable (mandatory) BMPs in their Boatyard SWPPP.

Facilities covered under the Sand and Gravel General Permit must include source control BMPs as necessary in their Sand and Gravel SWPPP to achieve AKART and compliance with the stormwater discharge limits in their permit.

Other facilities that are not required by ~~other an~~ NPDES permit or local government to use the BMPs described in this volume are encouraged to implement both applicable and recommended BMPs.

Regulatory programs such as the State Environmental Policy Act (SEPA), water quality certification under Section 401 of the Clean Water Act, and Hydraulic Project Approvals (HPAs) ~~may require use of the BMPs described in this volume.~~

1.6.2 Recommended BMPs

This volume also contains recommended BMPs. ~~These are not expected to be mandatory, but are offered~~ Ecology offers these BMPs as approaches that go beyond or complement the ~~minimum~~ applicable (mandatory) BMPs. Implementing the recommended BMPs may improve control of pollutants and provide a more comprehensive and environmentally effective stormwater management program. Ecology encourages all operators to review their SWPPPs and use recommended BMPs where possible.

Facilities covered under the Industrial Stormwater General Permit who trigger a corrective action should consider implementing one or more recommended BMPs as a means to fulfill their corrective action requirements and achieve benchmark values.

1.7 Regulatory Requirements Affecting Stormwater Pollutant Control

Refer to Appendices IV-D and IV-E for information on related requirements ~~by~~from the following ~~governments~~organizations:

- Local government or Ecology requirements for discharges to storm, sanitary, and combined sewers; stormwater flow control, treatment and pollutant source control; and air pollution control.
- ~~Department of~~ Ecology requirements for dangerous or hazardous wastes, underground storage tanks, waste reduction, spill control and cleanup, and NPDES stormwater and wastewater discharge permit requirements.
- U. S. Environmental Protection Agency requirements for spill control and cleanup plans, and for NPDES permits on tribal lands.
- Washington State Department of Agriculture requirements for pesticide and fertilizer application control.
- Local Health Department requirements for the disposal of solid wastes to landfills or other facilities.
- U. S. Coast Guard requirements for transfer of petroleum products between marine vessels and onshore facilities and related spill control.
- Local and Washington State Fire Marshall requirements for storage and handling of flammable materials.

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Chapter 2 - Selection of Operational and Structural Source Control BMPs

Urban stormwater pollutant sources include manufacturing and commercial areas; high use vehicle parking lots; material (including wastes) storage and handling; vehicle/equipment fueling, washing, maintenance, and repair areas; erodible soil; streets/highways; and the handling/application of de-icers and lawn care products.

Operators can achieve reduction or the elimination of stormwater pollutants ~~can be achieved~~ by implementing ~~“operational source control BMPs”~~; Operational source control BMPs including formation of a pollution prevention team, good housekeeping, ~~employee training, practices, preventive maintenance procedures,~~ spill prevention and cleanup, ~~preventive maintenance, employee training,~~ regular inspections, and record keeping. These BMPs can be combined with impervious containments and covers, i.e., structural source control BMPs. If operational and structural source control BMPs are not feasible or adequate then stormwater treatment BMPs will be necessary. ~~Selecting~~Owners should select cost-effective source control BMPs ~~should be~~ based on ~~an assessment of the~~site specific pollutants and their sources.

Ecology’s Industrial Stormwater General Permit (ISGP), Boatyard General Permit, Sand and Gravel General Permit, and Phase I Municipal General Permit require the use of the BMPs described in this chapter in Stormwater Pollution Prevention Plans (SWPPPs). Local governments may also require the use of the BMPs described in this chapter. Refer to Section 1.6~~The applicable BMPs described in this chapter, or equivalent BMPs, will help businesses comply with Ecology’s Stormwater General Permit requirements which apply to new and existing facilities. For new developments or redevelopments, that are not covered under that Permit, implementation of those BMPs which are specified as applicable BMPs in this Manual, or equivalent BMPs, will also be required if incorporated into local government ordinances or equivalent documents. Facilities that are not required to apply the applicable and recommended BMPs described in this volume are encouraged to implement them.~~

The for more information regarding the applicable (mandatory) use of BMPs within SWPPPs.

Under the ISGP, if a facility’s sampling triggers Level 1 or Level 2 Corrective Action requirements, operators should consider the recommended operational (Level 1) and structural (Level 2) source control BMPs to fulfill permit requirements and reduce pollutant concentrations.

Base the initial selection of source control BMPs ~~described in this chapter should be based~~ on land use and the pollutant generating sources. Appendix IV-A~~Appendix IV-A~~ describes various land uses ~~and~~ activities

Note the different regulatory mechanisms in applying these BMPs for new development, redevelopment, and retrofits. Refer to Section 1.6 of this volume to

and the potential pollutant generating sources associated with those activities. The BMPs in this chapter may also be appropriate for land uses not listed in Appendix IV-A.

For example, if a commercial printing business conducts ~~vehicle maintenance~~, weed control with herbicides, loading and unloading of materials, and vehicle washing, it should refer to the following BMP sections for these activities: ~~Maintenance and Repair of Vehicles and Equipment; Landscaping and Lawn/Vegetation Management; Loading and Unloading Areas for Liquid or Solid Material; Washing and Steam Cleaning Vehicle/Equipment/Building Structures; and Commercial Printing Operations.~~

- Landscaping and Lawn/Vegetation Management.
- Loading and Unloading Areas for Liquid or Solid Material.
- Washing and Steam Cleaning Vehicle/Equipment/Building Structures.
- Commercial Printing Operations.

Operators under the ISGP or Boatyard permits should take special care to review this chapter in its entirety to ensure that all of the applicable (mandatory) source control BMPs are included within their industrial or boatyard SWPPP (regardless of the listings in Appendix IV-A). ~~The entire Operational BMP section of this chapter must be reviewed for applicability. The BMPs described herein may also be applicable for land uses not listed in Appendix IV-A.~~

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2.1 Applicable (Mandatory) Operational Source Control BMPs

Sites & facilities that require the implementation of source control BMPs

Formation of a Pollution Prevention Team

Formation of a Pollution Prevention Team
Good Housekeeping

The Where required by local code or by an Ecology NPDES Stormwater General Permit, implement the following operational source control BMPs must be implemented at the commercial and industrial establishments listed in Appendix IV-A, where required by Ecology's at:

- Commercial properties
- Industrial General Permit or by local government ordinances; properties
- -Multifamily properties
- Boatyards
- Sand and gravel mining operations
- Assign one or more individuals to be responsible for stormwater pollution control. Hold regular meetings to review the overall operation of the BMPs. Establish responsibilities for inspections, operation ~~and~~, maintenance, and ~~availability for emergency situations.~~

for emergencies. Train all team members in the operation, maintenance, and inspections of BMPs, and reporting procedures.

- Promptly contain and clean up solid and liquid pollutant leaks and spills including oils, solvents, fuels, and dust from manufacturing operations on any exposed soil, vegetation, or paved area.
- Sweep ~~paved material handling and storage areas regularly~~ all appropriate surfaces with vacuum sweepers quarterly or more frequently as needed, for the collection and disposal of dust and debris that could contaminate stormwater.
- Do not hose down pollutants from any area to the ground, storm ~~drain~~ drains, conveyance ~~ditch~~ ditches, or receiving water unless necessary for dust control purposes to meet air quality regulations ~~and unless the~~. Convey pollutants ~~are conveyed before discharge~~, to a treatment system approved by the local jurisdiction.
- Clean oils, debris, sludge, etc. from all ~~BMP systems~~ stormwater facilities regularly, including catch basins, settling/detention basins, oil/water separators, boomed areas, and conveyance systems; to prevent the contamination of stormwater. Refer to Appendix IV-D R.3 ~~Appendix IV-D R.3~~ for references to assist in ~~determining if a waste must be handled as hazardous~~ handling potentially dangerous waste.
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other drainage areas, ~~which are~~ subjected to pollutant material leaks or spills. Promptly repair or replace all leaking connections, pipes, hoses, valves, etc., which can contaminate stormwater.
- Do not connect floor drains in potential pollutant source areas to storm drains, surface water, or to the ground.
- ~~Promptly repair or replace all leaking connections, pipes, hoses, valves, etc. which can contaminate stormwater.~~

~~The following are recommended~~ Additional good housekeeping BMPs:

- Clean up pollutant liquid leaks and spills in impervious uncovered containment areas at the end of each working day.
- Use solid absorbents, e.g., clay and peat absorbents and rags for cleanup of liquid spills/leaks, where practicable.
- Promptly repair/replace/reseal damaged paved areas at industrial facilities
- Recycle materials, such as oils, solvents, and wood waste, to the maximum extent practicable.

Preventive
Maintenance

- Prevent the discharge of unpermitted liquid or solid wastes, process wastewater, and sewage to ground or surface water, or to storm drains ~~which that~~ discharge to surface water, or to the ground. ~~Do not connect floor drains in potential pollutant source areas to storm drains, surface water, or to the ground.~~
- Conduct all oily parts cleaning, steam cleaning, or pressure washing of equipment or containers inside a building, or on an impervious contained area, such as a concrete pad. Direct contaminated stormwater from such an area to a sanitary sewer where allowed by local sewer authority, or to other approved treatment.
- Pressure wash impervious surfaces contaminated with oils, metals, sediment, etc. Collect the resulting washwater for proper disposal (usually involves plugging storm drains, or otherwise preventing discharge and pumping or vactoring up washwater, for discharge to sanitary sewer or for vactor truck transport to a waste water treatment plant for disposal).
- Do not pave over contaminated soil unless it has been determined that ground water has not been and will not be contaminated by the soil. Call Ecology for assistance.
- Construct impervious areas that are compatible with the materials handled. Portland cement concrete, asphalt, or equivalent material may be considered.
- Use drip pans to collect leaks and spills from industrial/ commercial equipment such as cranes at ship/boat building and repair facilities, log stackers, industrial parts, trucks and other vehicles, ~~which are~~ stored outside.
- At industrial and commercial facilities, drain oil and fuel filters before disposal. Discard empty oil and fuel filters, oily rags, and other oily solid waste into appropriately closed and properly labeled containers, and in compliance with the Uniform Fire Code-or International Building Code.
- For the storage of liquids use containers, such as steel and plastic drums, that are rigid and durable, corrosion resistant to the weather and fluid content, non-absorbent, water tight, rodent-proof, and equipped with a close fitting cover.
- For the temporary storage of solid wastes contaminated with liquids or other potential ~~pollutant~~polluted materials use dumpsters, garbage cans, drums, and comparable containers, which are durable, corrosion resistant, non-absorbent, non-leaking, and equipped with either a solid cover or screen cover to prevent littering. If covered with a screen, the container must be stored under a ~~lean-to roof~~ or equivalent structure or other form of adequate cover.

- Where exposed to stormwater, use containers, piping, tubing, pumps, fittings, and valves that are appropriate for their intended use and for the contained liquid.

~~The following are recommended~~ Additional preventive maintenance BMPs:

- Where feasible, store potential stormwater pollutant materials inside a building or under a cover and/or containment.
- Minimize use of toxic cleaning solvents, such as chlorinated solvents, and other toxic chemicals.
- Use environmentally ~~safer~~ safe raw materials, products, additives, etc. such as substitutes for zinc used in rubber production.
- Recycle waste materials such as solvents, coolants, oils, degreasers, and batteries to the maximum extent feasible. Refer to [Appendix IV-C](#) ~~Appendix IV-C~~ for recommendations on recycling or disposal of vehicle waste liquids and other waste materials.
- Empty drip pans immediately after a spill or leak is collected in an uncovered area.
- Stencil warning signs at stormwater catch basins and drains, e.g., “Dump no waste – ~~Drains to waterbody.~~”

Note: Evidence of stormwater contamination ~~by oils and grease~~ can include the presence of visible sheen, color, or turbidity in the runoff, or present or historical operational problems at the facility. ~~Operators can use simple pH measurements~~ tests, for example with litmus or pH paper ~~can be used~~. These tests can screen for high or low pH levels (anything outside a 6.5-8.5 range) due to ~~test for stormwater~~ contamination in ~~areas subject to acid or alkaline contamination~~ stormwater.

Spill Prevention and Cleanup

- ~~Immediately upon discovery,~~ Stop, contain, and clean up all spills immediately upon discovery.
- If pollutant materials are stored on-site, have spill containment and cleanup kits readily accessible.
- If the spill has reached or may reach a sanitary or a storm sewer, ground water, or surface water notify ~~the local jurisdiction,~~ Ecology, and the local sewer authority immediately. Notification must comply with and federal spill reporting requirements. (See also [record keeping](#) ~~record keeping~~ at the end of this section and [S406 BMPs for Spills of Oil and Hazardous Substances](#) ~~BMPs for Spills of Oil and Hazardous Substances~~))
- Do not flush ~~or otherwise direct~~ absorbent materials or other spill cleanup materials to a storm drain. Collect the contaminated absorbent material as a solid and place in appropriate disposal containers.

~~The following is a~~ Recommended additional BMP:

Place and maintain emergency spill containment and cleanup kit(s) at outside areas where there is a potential for fluid spills. These kits should be appropriate for the materials ~~being handled~~ and the size of ~~the~~ potential spill. Locate spill kits within 25 feet of all fueling/fuel transfer areas, including on-board mobile fuel trucks.

Facilities covered under Industrial Stormwater General Permit must provide secondary containment for all chemical liquids, fluids, and petroleum products stored on-site.

Note: Ecology recommends that the kit(s) include salvage drums or containers, such as high density polyethylene, polypropylene or polyethylene sheet-lined steel; polyethylene or equivalent disposal bags; an emergency response guidebook; safety gloves/clothes/equipment; shovels or other soil removal equipment; and oil containment booms and absorbent pads; all stored in an impervious container.

Train all employees that work in pollutant source areas in:

- Identifying pollutant sources
- ~~and in~~ Understanding pollutant control measures, ~~spill response procedures, and~~
- Responding to spills
- Handling practices that are environmentally acceptable ~~material handling practices~~. Particularly those related to vehicle/equipment liquids such as fuels, and vehicle/equipment cleaning. ~~Use Ecology's "Guidance Manual for Preparing/Updating a Stormwater Pollution Prevention Plan for Industrial Facilities" (Publication Number 04-10-030) as a training reference.~~

Employee
Training

~~Conduct visual inspections quarterly during storm events to achieve following:~~

Inspections

Qualified personnel shall conduct visual inspections monthly. Make and maintain a record of each inspection on-site. Inspections shall:

Inspections

- Verify ~~that the descriptions accuracy~~ of the pollutant ~~sources identified source descriptions~~ in the ~~stormwater pollution control program are accurate~~ SWPPP.
- Verify ~~that the performance of the~~ stormwater ~~pollutant~~ operational and structural source controls ~~(and the treatment BMPs) being implemented are adequate.~~
- ~~Update the site map to~~ Reflect current conditions on the site.
- Include written observations of the presence of floating materials, suspended solids, oil and grease, discoloration, turbidity and odor in the stormwater discharges; in outside vehicle maintenance/repair; and

liquid handling, and storage areas. In areas where acid or alkaline materials are handled or stored use a simple litmus or pH paper to identify those types of stormwater contaminants where needed.

~~In addition, conduct at least one dry season inspection each year.~~

- ~~Determine whether there is/are~~ Eliminate or obtain a permit for unpermitted non-stormwater discharges to storm drains or receiving waters, such as process wastewater and vehicle/equipment washwater, ~~and either eliminate or obtain a permit for such a discharge.~~

Record keeping

Retain the following reports for ~~three~~ five years:

- Visual inspection reports which should include: ~~scope~~
 - Time and date of the inspection;
 - Locations inspected
 - Statement on status of compliance with the ~~personnel~~ permit
 - Summary report of any remediation activities required
 - Name, title, and signature of person conducting the inspection, ~~the date(s) of the inspection, major observations relating to the implementation of the SWPPP (performance of the BMPs, etc.) and actions taken to correct BMP inadequacies.~~
- Reports on spills of oil or hazardous substances in greater than Reportable Quantities (Code of Federal Regulations Title 40 Parts 302.4 and 117), ~~including the following: oil, gasoline, or diesel fuel, that causes a violation of the State of Washington's Water Quality Standards, or, that causes a film or sheen upon or discoloration of the waters of the State or adjoining shorelines or causes a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.-). Report spills of the following: antifreeze, oil, gasoline, or diesel fuel, that cause:~~
 - A violation of the State of Washington's Water Quality Standards.
 - A film or sheen upon or discoloration of the waters of the State or adjoining shorelines.
 - A sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shorelines.
- *To report a spill or to determine if a spill is a substance of a Reportable Quantity, call ~~your~~ the Ecology regional office and ask for an oil spill operations or a ~~hazardous~~ dangerous waste specialist:*

Northwest Region (425)649-7000

Southwest Region (360)407-6300

Eastern Region (509) ~~456-2926~~ 329-3400

Central Region (509) 575-2490

In addition, call the Washington Emergency Management Division at 1-800-258-5990 or 1-800-OILS-911 AND the National Response Center at 1-800-424-8802.

Also, refer to *Emergency Spill Response in Washington State*, Publication # 97-1165-CP.

The following is additional recommended record keeping:

Maintain records of all related pollutant control and pollutant generating activities such as training, materials purchased, material use and disposal, maintenance performed, etc.

2.2 Pollutant Source-Specific BMPs

Where required by local code or by an Ecology NPDES Stormwater General Permit, implement the applicable (mandatory) source control BMPs at:

- Commercial properties
- Industrial properties
- Multifamily properties
- Boatyards
- Sand and gravel mining operations

The Industrial Stormwater General Permit requires covered facilities to consider the recommended source control BMPs for Level 1 and 2 corrective actions.

Industrial sites covered by individual industrial stormwater permits must comply with the specific source control and treatment BMPs listed in their permits. Operators under individual industrial stormwater permits may include additional BMPs from this manual, if desired.

The source-specific BMPs described in this section, ~~or equivalent BMPs, can~~ may be applied to control the sources of pollutants identified in [Appendix IV-A](#). Ecology encourages all operators of facilities that implement pollutant-generating sources in [Appendix IV-A](#) to review their SWPPPs and use both the applicable (mandatory) and recommended BMPs where possible.

There are some emerging technologies that can be used as source controls. If these technologies

S401 BMPs for the Building, Repair, and Maintenance of Boats and Ships

Description of Pollutant Sources: Sources of pollutants for the building, repair, and maintenance of boats and ships at boatyards, shipyards, ports,

and marinas include pressure washing, surface preparation, paint removal, sanding, painting, engine maintenance and repairs, and material handling and storage, if conducted outdoors.

Potential pollutants include spent abrasive grits, solvents, oils, ethylene glycol, washwater, paint over-spray, cleaners/detergents, anti-corrosive compounds, paint chips, scrap metal, welding rods, resins, glass fibers, dust, and miscellaneous trash. Pollutant constituents include TSS, oil and grease, organics, copper, lead, tin, and zinc.

Pollutant Control Approach: Apply good housekeeping, preventive maintenance, and cover and contain BMPs in and around work areas.

Applicable Operational BMPs: Ecology's NPDES Boatyard General Permit requires coverage of all boatyards in Washington State with haul out facilities are required to be covered under the NPDES General Permit for Boatyard Activities. All shipyards in Washington State with haul out facilities such as drydocks, graving docks, marine railways or synchrolifts which engage in the construction, repair and maintenance of small vessels, 85% of which are required to be covered 65 feet or less in length, or revenues from which constitute more than 85% of gross receipts. Ecology may require coverage under an individual NPDES permit. Any facility conducting boatyard or shipyard activities strictly from dockside, with no vessel haul out, must be for large boatyards and shipyards in Washington State not covered by the NPDES Boatyard General Stormwater Permit for Industrial Activities. Stormwater General Permit (ISGP). The applicable operational BMPs are:

- Clean regularly all accessible work, service, and storage areas to remove debris, spent sandblasting material, and any other potential stormwater pollutants.
- Avoid the use of soaps, detergents and other chemicals that need to be rinsed or hosed off in the water. If necessary, consider applying sparingly so that a sponge, towel or rag can be used to remove residuals. Consider instead washing the boat in a suitable controlled area (see S431 BMPs for Washing and Steam Cleaning Vehicles/ Equipment/ Building Structures) while it is out of the water.
- Sweep rather than hose debris on the dock. ~~If Collect and convey hose water to treatment if~~ hosing is unavoidable ~~the hose water must be collected and conveyed to treatment.~~
- Collect spent abrasives regularly and store under cover to await proper disposal.
- Dispose of greasy rags, oil filters, air filters, batteries, spent coolant, and degreasers properly.
- Drain oil filters before disposal or recycling.

- Immediately repair or replace leaking connections, valves, pipes, hoses and equipment that causes the contamination of stormwater.
- Use drip pans, drop cloths, tarpaulins, or other protective devices in all paint mixing and solvent operations unless carried out in impervious contained and covered areas.
- Convey sanitary sewage to pump-out stations, portable on-site pump-outs, or commercial mobile pump-out facilities or other appropriate onshore facilities.
- Maintain automatic bilge pumps in a manner that will prevent automatic pumping of waste material ~~from being pumped automatically~~ into surface water.
- Prohibit uncontained spray painting, blasting or sanding activities over open water.
- Do not dump or pour waste materials down floor drains, sinks, or outdoor storm drain inlets that discharge to surface water. Plug floor drains ~~that are~~ connected to storm drains or to surface water. If necessary, install a ~~sump that is pumped~~ regularly operated sump pump.
- Prohibit outside spray painting, blasting, or sanding activities during windy conditions that render containment ineffective.
- Do not burn paint and/or use spray guns on topsides or above decks.
- Immediately clean up any spillage on ~~deck, pier, wharf~~, boat ~~or~~ ship deck, or adjacent surface areas and dispose of the wastes properly.
- In the event of an accidental discharge of oil or hazardous material into waters of the state or onto land with a potential for entry into state waters, immediately notify the yard, port, or marina owner or manager, local jurisdiction, the Department of Ecology, and the National Response Center (see Section 2.1 at 1-800-424-8802 (24 hour), of this volume). If the spill can reach or has reached marine water, call the U.S. Coast Guard at ~~(206) 217-6232~~ 1-800-424-8802.

Applicable Structural Source Control BMPs:

- Use fixed platforms with appropriate plastic or tarpaulin barriers as work surfaces and for containment when performing work ~~is performed~~ on a vessel in the water to prevent blast material or paint overspray from contacting stormwater or the receiving water. Keep use of such platforms ~~will be kept~~ to a minimum and ~~at no time be used~~ for do not perform extensive repair or construction in the water (anything in excess of 25 percent of the surface area of the vessel above the waterline).

- Use plastic or tarpaulin barriers beneath the hull and between the hull and dry dock walls to contain and collect waste and spent materials. Clean and sweep regularly to remove debris.
- Enclose, cover, or contain blasting and sanding activities to the maximum extent practicable to prevent abrasives, dust, and paint chips, from reaching storm sewers or receiving ~~water-~~waters. Use plywood and/or plastic sheeting to cover open areas between decks when sandblasting (scuppers, railings, freeing ports, ladders, and doorways).
- Direct deck drainage to a collection system sump for settling and/or additional treatment.
- Store cracked batteries in a covered secondary ~~container~~containers.
- Apply source control BMPs given in this chapter for other activities conducted at the marina, boat yard, shipyard, or port facility ([S409 BMPs for Fueling at Dedicated Stations](#), [S431 BMPs for Washing and Steam Cleaning Vehicle/Equipment/Building Structures](#), and [S406 BMPs for Spills of Oil and Hazardous Substances](#) ~~(BMPs for Fueling at Dedicated Stations, BMPs for Washing and Steam Cleaning Vehicle/Equipment/Building Structures, and BMPs for Spills of Oil and Hazardous Substances)~~).

Recommended Additional Operational BMPs: ~~The following BMPs are recommended unless they are required under a NPDES or Washington State waste discharge permit:~~

- Consider recycling paint, paint thinner, solvents, used oils, oil filters, pressure wash wastewater and any other recyclable materials.
- Perform paint and solvent mixing, fuel mixing, etc. on shore.

S402 BMPs for Commercial Animal Handling Areas

Description of Pollutant Sources: Animals at racetracks, kennels, fenced pens, veterinarians, and businesses that provide boarding services for horses, dogs, cats, etc., can generate pollutants from the following activities: manure deposits, animal washing, grazing, and any other animal handling activity that could contaminate stormwater. Pollutants can include coliform bacteria, nutrients, and total suspended solids. Individual Stormwater Permits covering commercial animal handling facilities include additional applicable source controls.

Pollutant Control Approach: To prevent, to the maximum extent practicable, the discharge of contaminated stormwater from animal handling and keeping areas.

Applicable Operational BMPs

- Regularly sweep and clean animal keeping areas to collect and properly dispose of droppings, uneaten food, and other potential stormwater contaminants.
- Do not hose down ~~to storm drains or to receiving water those~~ areas that contain potential stormwater contaminants where they drain to storm drains or to receiving waters.
- Do not ~~allow discharge~~ any ~~washwaters to be discharged~~ washwater to storm drains or to receiving ~~water waters~~ without proper treatment.
- If the operator keeps animals ~~are kept~~ in unpaved and uncovered areas, the ground must have either ~~have~~ vegetative cover or some other type of ground cover such as mulch.
- ~~If animals are not leashed or in cages, Surround~~ the area where animals are kept ~~must be surrounded by~~ with a fence or other means ~~that prevents to prevent~~ animals from moving away from the controlled area where BMPs are used.

S403 BMPs for Commercial Composting

Description of Pollutant Sources: Commercial composting facilities, operating outside without cover, require large areas to decompose wastes and other feedstocks. Design these facilities to separate stormwater from leachate (i.e., industrial wastewater) to the greatest extent possible. When stormwater contacts any active composting areas, including waste receiving and processing areas, it becomes leachate. Pollutants in leachate include nutrients, biochemical oxygen demand (BOD), organics, coliform bacteria, acidic pH, color, and suspended solids. Stormwater at composting facilities include runoff from areas not associated with active processing and curing, such as product storage areas, vehicle maintenance areas, and access roads.

NPDES and State Solid Waste Permit Requirements: ~~Discharge of leachate from a compost facility will~~ Solid Waste Regulations require a ~~State or NPDES permit from Ecology, depending on the disposal method chosen for managing leachate at~~ collection and containment of all leachate produced from activities at commercial composting facilities. Composting facilities that propose to discharge to surface water, municipal sewer system, or ground water must obtain the facility. (See Chapter 2 in "Compost Facility Resource Handbook, Guidance for Washington State", November 1998, Publication # 97-502.) An additional alternative, zero discharge, appropriate permits. Zero discharge is possible by containing all leachate from the facility (in tanks or ponds) for use early in the composting process or preventing production of leachate (by composting under a roof or in an enclosed building).

Pollutant Control Approach: Consider ~~the leachate control specified in publication #97-502 or~~ zero leachate discharge.

Applicable Operational BMPs:

Applicable Operational BMPs:

- Ensure that the compost feedstocks do not contain dangerous wastes, regulated under [Chapter 173-303 WAC](#) ~~Chapter 173-303 WAC~~ or hazardous products of a similar nature, or solid wastes that are not beneficial to the composting process. ~~Employees must be trained~~ [Train employees](#) to screen these materials ~~in/out of~~ incoming ~~waste/feedstocks~~.
- ~~Contact other federal, state, and local agencies with environmental or zoning permits. Contact your local permitting authority for applicable permit and regulatory local health department for more information. Local health departments are responsible for issuing solid waste handling permits for commercial compost facilities.~~
- ~~Apply for coverage under the Industrial Stormwater General Permit to Discharge Stormwater Associated with Industrial Activities,~~ if the facility discharges stormwater to surface water or a municipal stormwater system. If all stormwater from the facility [properly infiltrates into the surrounding area to ground water](#), the [Industrial Stormwater](#) General Permit is not required.
- ~~Develop a plan of operations as outlined in the Compost Facility Resource Handbook, Publication #97-502. There are some cases where an Individual State Waste Discharge permit is required. Check with your local Ecology office and health department to discuss your permitting options..~~
- Store finished compost in a manner to prevent contamination of stormwater.

Applicable Structural Source Control BMPs:

- Compost pads are required ~~for all uncovered facilities~~ in areas of the state with wet climates ~~(per water quality regulations)~~.
- Provide curbing for all compost pads to prevent stormwater run-on and leachate run-off.
- Slope all compost pads sufficiently to direct leachate to the collection device.
- Provide one or more sumps or catch basins capable of collecting all leachate generated by the design storm and conveying it to the leachate holding structure for all compost pads.

Applicable Treatment BMPs:

- Convey all leachate from composting operations to a sanitary sewer, holding tank, or on-site treatment systems designed to treat the leachate and TSS.

Refer to "Compost Facility Resource Handbook, Guidance for Washington State," November 1998, Publication #97-502, for additional design criteria and information.

- Line ponds used to collect, store, or treat leachate and other contaminated waters associated with the composting process. Ponds shall meet the design standards of WAC 173-350-220 must be lined to prevent ground water contamination. Apply "AKART" or, including All Known Available and Reasonable Methods of Prevention and Treatment ~~to~~(AKART). Maintain all pond liners, regardless of the construction materials.

Recommended Additional BMPs:

- Clean up debris from yard areas regularly.
- Locate stored residues in areas designed to collect leachate.
- Limit storage times of residues to prevent degradation and generation of leachate.
- Consider using leachate as make-up water in early stages of the composting process. Do not use leachate for moisture or dust control, on finished products or nearly finished compost since leachate can contain pathogenic bacteria. ~~care should be taken to avoid contaminating finished product or nearly finished product. This recommended practice will limit the potential re-inoculation of these materials with leachate pathogens.~~
- In areas of the state with dry climates, consider using evaporation as a means of reducing the quantity of leachate.

S404 BMPs for Commercial Printing Operations

Description of Pollutant Sources: Materials used in the printing process include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. With indoor printing operations, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials and offloading of chemicals at external unloading bays. Pollutants can include TSS, pH, heavy metals, oil and grease, and COD.

Pollutant Control Approach: Ensure appropriate disposal and NPDES permitting of process wastes. Cover and contain stored raw and waste materials.

Applicable Operational BMPs:

- Discharge process wastewaters to a sanitary sewer, if approved by the local sewer authority, or to an approved process wastewater treatment system.

- Do not discharge process wastes or wastewaters into storm ~~drains~~sewers or surface water.
- Determine whether any of these wastes qualify for regulation as dangerous wastes and dispose of them accordingly.

Applicable Structural Source Control BMP: Store raw materials or waste materials that could contaminate stormwater in covered and contained areas.

Recommended Additional BMPs:

- Train all employees in pollution prevention, spill response, and environmentally acceptable materials handling procedures.
- Store materials in proper, appropriately labeled containers. Identify and label all chemical substances.
- Regularly inspect all stormwater management devices ~~should be inspected regularly~~ and ~~maintained~~maintain as necessary.
- Try to use press washes without listed solvents, and with the lowest VOC content possible. Don't evaporate ink cleanup trays to the outside atmosphere.
- Place cleanup sludges into a container with a tight lid and dispose of as ~~hazardous~~dangerous waste. Do not dispose of cleanup sludges in the garbage or in containers of soiled towels.

For additional information on pollution prevention, Ecology recommends the following Washington Department of Ecology publications: [A Guide for Screen Printers](#) ~~are recommended: A Guide for Screen Printers,~~ Publication #94-137 and [A Guide for Lithographic Printers](#) ~~A Guide for Lithographic Printers,~~ Publication #94-139.

S405 BMPs for Deicing and Anti-Icing Operations - Airports and Streets

Refer to 40 CFR Part 449 for EPA effluent limitations guidelines and new source performance standards to control discharges of pollutants from airport deicing operations

Description of Pollutant Sources: Operators use deicing and/or apply anti-icing compounds on highways, streets, airport runways, and on aircraft to control ice and snow. Typically, ethylene glycol and propylene glycol are deicers used on aircraft. Deicers commonly used on highways and streets include calcium magnesium acetate (CMA), calcium chloride, magnesium chloride, sodium chloride, urea, and potassium acetate. The deicing and anti-icing compounds become pollutants when conveyed to storm drains or to surface water after application. Leaks and spills of these chemicals can also occur during their handling and storage.

BMPs for Airport De/anti-icing Operations

Pollutant Control Approach for Aircraft: Spent glycol discharges in aircraft application areas are regulated process wastewaters ~~that are regulated~~ under Ecology's Industrial Stormwater General Permit. ~~(Contact the Ecology Regional Office for details.)~~ BMPs for aircraft de/anti-icers

must be consistent with aviation safety and the operational needs of the aircraft operator.

Note ~~that this~~
applicable
containment BMP
of aircraft de/anti-
icing applications,
and applicable
treatment BMPs for
de/anti-icer spent
chemicals such as
glycols.

Applicable BMPs for Aircraft:

Conduct aircraft deicing or anti-icing applications in impervious containment areas. Collect aircraft deicer or anti-icer spent chemicals, such as glycol, draining from aircraft in deicing or anti-icing application areas and convey to a sanitary sewer, treatment, or other approved disposal or recovery method. Divert deicing runoff from paved gate areas to appropriate collection areas or conveyances for proper treatment or disposal.

Do not ~~allow discharge~~ spent deicer or anti-icer chemicals or stormwater contaminated with aircraft deicer or anti-icer chemicals ~~to be discharged~~ from application areas, including gate areas, ~~into storm drains. No discharge~~ to surface water, or ground water, directly or indirectly ~~should occur.~~

Transfer deicing and anti-icing chemicals on an impervious containment pad, or equivalent spill/leak containment area, and store in secondary containment areas. (See Storage of Liquids in ~~Above-Ground~~ Aboveground Tanks)

Recommended Additional BMPs for Aircraft:

Establish a centralized aircraft de/anti-icing facility, if ~~feasible and~~ practicable, or in designated areas of the tarmac equipped with separate collection drains for the spent deicer liquids.

Consider installing an aircraft de/anti-icing chemical recovery system, or contract with a chemical recycler, ~~if practicable.~~

Applicable BMPs for Airport Runways/Taxiways:

Avoid excessive application of all de/anti-icing chemicals, which could contaminate stormwater.

Store and transfer de/anti-icing materials on an impervious containment pad or an equivalent containment area and/or under cover in accordance with BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products ~~BMP Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products in this volume.~~ Consider other material storage and transfer approaches ~~may be considered only~~ if ~~it can be demonstrated that stormwater will not be contaminated with or that~~ the de/anti-icer material ~~cannot reach surface or ground waters~~ will not contaminate stormwater.

Recommended Additional BMPs for Airport Runways/Taxiways:

Include limits on toxic materials and phosphorous in the specifications for de/anti-icers, where applicable.

Consider using anti-icing materials rather than deicers if it will result in less adverse environmental impact.

Select cost-effective de/anti-icers that cause the least adverse environmental impact.

S406 BMPs for Streets/ Highways

Applicable BMPs:

- Select de and anti-icers that cause the least adverse environmental impact. Apply only as needed using minimum quantities.
- Where ~~feasible and~~ practicable use roadway deicers, such as calcium magnesium acetate, potassium acetate, or similar materials, that cause less adverse environmental impact than urea, and sodium chloride.
- Store and transfer de/ ~~and~~ anti-icing materials on an impervious containment pad in accordance with [BMP Storage or Transfer \(Outside\) of Solid Raw Materials, By-Products, or Finished Products](#)~~BMP Storage or Transfer (Outside) of Solid Raw Materials, By Products, or Finished Products~~ in this volume.
- Sweep/clean up accumulated de/ ~~and~~ anti-icing materials and grit from roads as soon as possible after the road surface clears.

Recommended Additional BMPs

- Intensify roadway cleaning in early spring to help remove particulates from road surfaces.
- Include limits on toxic metals in the specifications for de/anti-icers.

S407 BMPs for Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots

Description of Pollutant Sources: Dust can cause air and water pollution problems particularly at demolition sites and in arid areas where reduced rainfall exposes soil particles to transport by air.

Pollutant Control Approach: Minimize dust generation and apply environmentally friendly and government approved dust suppressant chemicals, if necessary.

Applicable Operational BMPs:

Applicable Operational BMPs:

- Sprinkle or wet down soil or dust with water as long as it does not result in a wastewater discharge.
- Use only local and/or state government approved dust suppressant chemicals such as those listed in Ecology Publication #96-433, [Techniques for Dust Prevention and Suppression](#)~~“Techniques for Dust Prevention and Suppression.”~~
- Avoid excessive and repeated applications of dust suppressant chemicals. Time the application of dust suppressants to avoid or minimize their wash-off by rainfall or human activity such as irrigation.

- Apply stormwater containment to prevent the conveyance of ~~stormwater TSSsediment~~ into storm drains or receiving waters.
- ~~Ecology prohibits~~ the use of motor oil for dust control ~~is prohibited. Care should be taken. Take care~~ when using lignin derivatives and other high BOD chemicals in ~~excavations or~~ areas ~~easily accessible~~ ~~susceptible~~ to ~~contaminating~~ surface water or ground water.
- Consult with ~~the~~ Ecology ~~Regional Office in your area~~ ~~and the local permitting authority~~ on discharge permit requirements if the dust suppression process results in a wastewater discharge to the ground, ground water, storm drain, or surface water.

Recommended Additional Operational BMPs for Roadways and Other Trafficked Areas:

- Consider limiting use of off-road recreational vehicles on dust generating land.
- Consider ~~graveling or~~ paving unpaved permanent roads and other trafficked areas at municipal, commercial, and industrial areas.
- Consider paving or stabilizing shoulders of paved roads with gravel, vegetation, or local government approved chemicals.
- Encourage use of alternate paved routes, if available.
- Vacuum ~~or wet~~ sweep fine dirt and skid control materials from paved roads soon after winter weather ends or when needed.
- Consider using ~~pre-washed~~ traction sand ~~that is pre-washed~~ to reduce dust emissions.

Additional Recommended Operational BMPs for Dust Generating Areas:

- Prepare a dust control plan. Helpful references include: Control of Open Fugitive Dust Sources (EPA-450/3-88-088), and Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures (EPA-450/2-92-004).
- Limit exposure of soil (dust source) as much as feasible.
- Stabilize dust-generating soil by growing and maintaining vegetation, mulching, topsoiling, and/or applying stone, sand, or gravel.
- Apply windbreaks in the soil such as trees, board fences, tarp curtains, bales of hay, etc.
- ~~Cover dust-generating piles with wind impervious fabric, or equivalent material.~~

S408 BMPs for Dust Control at Manufacturing Areas

Description of Pollutant Sources: Industrial material handling activities can generate considerable amounts of dust that is typically removed using exhaust systems. Mixing cement and concrete products and handling powdered materials can also generate dust. Particulate materials that can cause air pollution include grain dust, sawdust, coal, gravel, crushed rock, cement, and boiler fly ash. Air emissions can contaminate stormwater. The objective of this BMP is to reduce the stormwater pollutants caused by dust generation and control.

Pollutant Control Approach: Prevent dust generation and emissions where feasible, regularly clean-up dust that can contaminate stormwater, and convey dust contaminated stormwater to proper treatment.

Applicable BMPs:

- Clean, as needed, powder material handling equipment and vehicles ~~that can be sources of stormwater pollutants, to remove accumulated dust and residue.~~
- Regularly sweep dust accumulation areas that can contaminate stormwater. ~~Sweeping should be conducted~~ Conduct sweeping using vacuum filter equipment to minimize dust generation and to ensure optimal dust removal.

Recommended BMPs:

- In manufacturing operations, train employees to ~~carefully~~-handle powders carefully to prevent generation of dust.
- Use dust filtration/collection systems such as bag house filters, cyclone separators, etc. to control vented dust emissions that could contaminate stormwater. Control of zinc dusts in rubber production is one example.
- Use water spray to flush dust accumulations to sanitary sewers where allowed by the local sewer authority or to other appropriate treatment system.
- Use approved dust suppressants such as those listed in Ecology Publication Techniques for Dust Prevention and Suppression ~~Techniques for Dust Prevention and Suppression,~~ #96-433- (Ecology, 1996). Application of some products may not be appropriate in close proximity to receiving waters or conveyances close to receiving waters. For more information check with ~~the~~ Ecology ~~Regional Office~~ or the local jurisdiction.

Recommended Treatment BMPs: ~~For removal of TSS in stormwater use~~Install sedimentation basins, wet ponds, wet vaults, catch basin filters, vegetated filter strips, or equivalent sediment removal BMPs ~~(Volume V).~~

S409 BMPs for Fueling At Dedicated Stations

Description of Pollutant Sources: A fueling station is a facility dedicated to the transfer of fuels from a stationary pumping station to mobile vehicles or equipment. It includes above or under-ground fuel storage facilities. In addition to general service gas stations, fueling may also occur at 24-hour convenience stores, construction sites, warehouses, car washes, manufacturing establishments, port facilities, and businesses with fleet vehicles. Typical causes of stormwater contamination at fueling stations include leaks/spills of fuels, lube oils, radiator coolants, and vehicle washwater.

Pollutant Control Approach: New or substantially remodeled* fueling stations must be constructed on an impervious concrete pad under a roof to keep out rainfall and stormwater run-on. The facility must use a treatment BMP ~~must be used~~ for contaminated stormwater and wastewaters in the fueling containment area.

** Substantial remodeling includes replacing the canopy, or relocating or adding one or more fuel dispensers in such a way that modify the Portland cement concrete (or equivalent) paving in the fueling area ~~is modified~~.*

For new or substantially remodeled Fueling Stations:

Applicable Operational BMPs:

- Prepare an emergency spill response and cleanup plan (per [S426 BMPs for Spills of Oil and Hazardous Substances](#) ~~BMPs for Spills of Oil and Hazardous Substances~~) and have designated trained person(s) available either on site or on call at all times to promptly and properly implement that plan and immediately cleanup all spills. Keep suitable cleanup materials, such as dry adsorbent materials, on site to allow prompt cleanup of a spill.
- Train employees on the proper use of fuel dispensers. Post signs in accordance with the Uniform Fire Code (UFC) ~~or~~ International Fire Code (IFC). Post “No Topping Off” signs (topping off gas tanks causes spillage and vents gas fumes to the air). Make sure that the automatic shutoff on the fuel nozzle is functioning properly.
- The person conducting the fuel transfer must be present at the fueling pump during fuel transfer, particularly at unattended or self-serve stations.
- Keep drained oil filters in a suitable container or drum.

Applicable Structural Source Control BMPs:

- Design the fueling island to control spills (dead-end sump or spill control separator in compliance with the UFC or IFC), and to treat collected stormwater and/or wastewater to required levels. Slope the concrete containment pad around the fueling island toward drains;

either trench drains, catch basins and/or a dead-end sump. The slope of the drains shall not be less than 1 percent (Section 7901.8 of the UFC). ~~Drains to, Section 5703.6.8 of the IFC).~~

- Drains to treatment facilities must have a normally closed shutoff valve, ~~which must be closed in the event of a spill.~~ The spill control sump must be sized in compliance with Section 7901.8 of the UFC; or
- Design the fueling island as a spill containment pad with a sill or berm raised to a minimum of four inches (Section 7901.8 of the UFC) to prevent the runoff of spilled liquids and to prevent run-on of stormwater from the surrounding area. Raised sills are not required at the open-grate trenches that connect to an approved drainage-control system.
- The fueling pad must be paved with Portland cement concrete, or equivalent. ~~Asphalt is~~ Ecology does not consider ~~consider asphalt~~ an equivalent material.
- The fueling island must have a roof or canopy to prevent the direct entry of precipitation onto the spill containment pad (see [Figure 2.2.1](#) ~~Figure 2.1~~). The roof or canopy should, at a minimum, cover the spill containment pad (within the grade break or fuel dispensing area) and preferably extend several additional feet to reduce the introduction of windblown rain. Convey all roof drains to storm drains outside the fueling containment area.

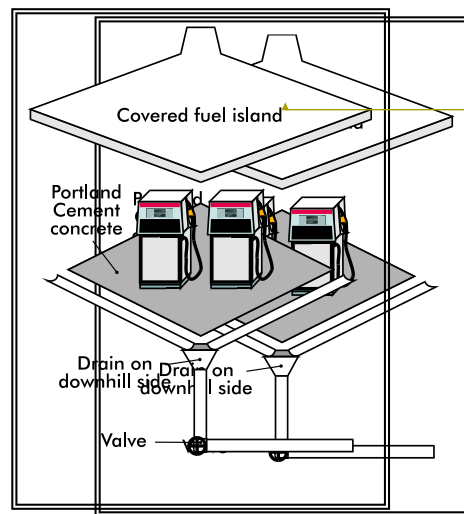


Figure 2.2.1 – Covered Fuel Island

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- Convey stormwater collected on the fuel island containment pad ~~must be conveyed~~ to a sanitary sewer system, if approved by the sanitary authority; ~~or to an approved treatment system such as an oil/water separator and a basic treatment BMP. (Basic treatment BMPs are listed in Volume V and include media filters and biofilters)-).~~ Discharges from treatment systems to storm drains or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain ~~greater than a significant amount of~~ oil and grease.
- Alternatively, collect stormwater ~~collected on from~~ the fuel island containment pad ~~may be collected and held hold~~ for proper off-site disposal.
- Approval from the local sewer authority is required for conveyance of any fuel-contaminated stormwater to a sanitary sewer ~~must be approved by the local sewer authority and~~. The discharged stormwater must comply with pretreatment regulations (WAC 173-216-060 (WAC 173-216-060)-). These regulations prohibit discharges that could "cause fire or explosion. ~~An explosive or flammable mixture is defined under.~~" State and federal pretreatment regulations define an explosive or flammable mixture, based on a flash point determination of the mixture. ~~If contaminated stormwater is determined not to be explosive, then it~~ Stormwater could be conveyed to a sanitary sewer system if it is determined not to be explosive.
- Transfer the fuel from the delivery tank trucks to the fuel storage tank in impervious contained areas and ensure that appropriate overflow protection is used. Alternatively, cover nearby storm drains during the filling process and use drip pans under all hose connections.

Additional BMP for Vehicles 10 feet in height or greater

A roof or canopy may not be ~~practicable~~ feasible at fueling stations that regularly fuel vehicles that are 10 feet in height or greater, particularly at industrial or WSDOT sites. At those types of fueling facilities, the following BMPs apply, as well as the applicable BMPs and fire prevention (UFC requirements) of this BMP for fueling stations:

- If a roof or canopy is impractical, the concrete fueling pad must be equipped with emergency spill control, ~~which includes including~~ a shutoff valve for ~~the~~ drainage from the fueling area. Maintain the valve ~~must be in the~~ closed position in the event of a spill. An electronically actuated valve is preferred to minimize the time lapse between spill and containment. ~~Spills must be cleaned~~ Clean up spills and disposed dispose of materials off-site in accordance with S406 BMPs for Spills of Oil and Hazardous Substances ~~BMPs for Spills of Oil and Hazardous Substances.~~
- The valve may be opened to convey contaminated stormwater to a sanitary sewer, if approved by the sewer authority, or to oil removal

treatment such as an API or CP oil/water separator, catchbasin insert, or equivalent treatment, and then to a basic treatment BMP.

Discharges from treatment systems to storm ~~drains~~sewer or surface water or to the ground must not display ongoing or recurring visible sheen and must not contain greater than a significant amount of oil and grease.

~~An explosive or flammable mixture is defined under state and federal pretreatment regulations, based on a flash point determination of the mixture. If contaminated stormwater is determined not to be explosive or) then it could be conveyed to a sanitary sewer system.~~

S410 BMPs for Illicit Connections to Storm Drains

Description of Pollutant Sources: Illicit connections are unpermitted sanitary or process wastewater discharges to a storm sewer or to surface water, rather than to a sanitary sewer, industrial process wastewater, or other appropriate treatment. They can also include swimming pool water, filter backwash, cleaning solutions/washwaters, cooling water, etc. Experience has shown that illicit connections are common, particularly in older buildings.

Pollutant Control Approach: Identify and eliminate unpermitted discharges or obtain an NPDES permit, where necessary, particularly at industrial and commercial facilities.

Applicable Operational BMPs:

- Eliminate unpermitted wastewater discharges to storm ~~drains~~sewer, ground water, or surface water; ~~and,~~
- Convey unpermitted discharges to a sanitary sewer if allowed by the local sewer authority, or to other approved treatment; ~~and,~~
- Obtain appropriate state and local permits for these discharges.

Recommended Additional Operational BMPs: At commercial and industrial facilities, conduct a survey of wastewater discharge connections to storm drains and to surface water as follows:

- Conduct a field survey of buildings, particularly older buildings, and other industrial areas to locate storm drains from buildings and paved surfaces. Note where these join the public storm drain(s).
- During non-stormwater conditions inspect each storm drain for non-stormwater discharges. Record the locations of all non-stormwater discharges. Include all permitted discharges.
- If useful, prepare a map of each area ~~as it is to be surveyed.~~ Show on the map the known location of storm ~~drains~~sewers, sanitary sewers, and permitted and unpermitted discharges. Aerial photos may be

useful. Check records such as piping schematics to identify known side sewer connections and show these on the map. Consider using smoke, dye, or chemical analysis tests to detect connections between two conveyance systems (e.g., process water and stormwater). If desirable, conduct TV inspections of the storm drains and record the footage on videotape.

- Compare the observed locations of connections with the information on the map and revise the map accordingly. Note suspect connections that are inconsistent with the field survey.
- Identify all connections to storm ~~drains~~sewers or to surface water and take the actions specified above as applicable BMPs.

S411 BMPs for Landscaping and Lawn/ Vegetation Management

Description of Pollutant Sources: Landscaping can include grading, soil transfer, vegetation removal, pesticide and fertilizer applications, and watering. Stormwater contaminants include toxic organic compounds, heavy metals, oils, total suspended solids, coliform bacteria, fertilizers, and pesticides.

Lawn and vegetation management can include control of objectionable weeds, insects, mold, bacteria, and other pests with ~~chemical~~ pesticides and is conducted commercially at commercial, industrial, and residential sites. Examples include weed control on golf course lawns, access roads, and utility corridors and during landscaping; sap stain and insect control on lumber and logs; rooftop moss removal; killing nuisance rodents; fungicide application to patio decks, and residential lawn/plant care. It is possible to release toxic pesticides such as pentachlorophenol, carbamates, and organometallics ~~can be released~~ to the environment by leaching and dripping from treated parts, container leaks, product misuse, and outside storage of pesticide contaminated materials and equipment. Poor management of the vegetation and poor application of pesticides or fertilizers can cause appreciable stormwater contamination.

Pollutant Control Approach: Control of fertilizer and pesticide applications, soil erosion, and site debris to prevent contamination of stormwater.

Develop and implement an Integrated Pest Management Plan (IPM) and use pesticides only as a last resort. ~~If~~Carefully apply pesticides/ herbicides ~~are used they must be carefully applied,~~ in accordance with label instructions ~~on U.S. Environmental Protection Agency (EPA) registered materials.~~ Maintain appropriate vegetation, with proper fertilizer application where practicable, to control erosion and the discharge of stormwater pollutants. Where practicable grow plant species appropriate for the site, or adjust the soil properties of the subject site to grow desired plant species.

Applicable Operational BMPs for Landscaping:

- Install engineered soil/landscape systems to improve the infiltration and regulation of stormwater in landscaped areas.
- Do not dispose of collected vegetation into waterways or storm ~~drainage~~sewer systems.

Recommended Additional Operational BMPs for Landscaping:

- Conduct mulch-mowing whenever practicable
- Dispose of grass clippings, leaves, sticks, or other collected vegetation, by composting, if feasible.
- Use mulch or other erosion control measures ~~when~~on soils ~~are~~ exposed for more than one week during the dry season or two days during the rainy season.
- ~~If oil or other chemicals are handled,~~ Store and maintain appropriate oil and chemical spill cleanup materials in readily accessible locations: when using oil or other chemicals. Ensure that employees are familiar with proper spill cleanup procedures.
- Till fertilizers into the soil rather than dumping or broadcasting onto the surface. Determine the proper fertilizer application rate for the types of soil and vegetation encountered.
- Till a topsoil mix or composted organic material into the soil to create a well-mixed transition layer that encourages deeper root systems and drought-resistant plants.
- Use manual and/or mechanical methods of vegetation removal rather than applying herbicides, where practical.

Applicable Operational BMPs for the Use of Pesticides:

- Develop and implement an IPM (See section on IPM in [Applicable Operational BMPs for Vegetation Management](#) ~~at end of BMP~~) and use pesticides only as a last resort.
- Implement a pesticide-use plan and include at a minimum: a list of selected pesticides and their specific uses; brands, formulations, application methods and quantities to be used; equipment use and maintenance procedures; safety, storage, and disposal methods; and monitoring, record keeping, and public notice procedures. All procedures shall conform to the requirements of [Chapter 17.21 RCW](#) ~~Chapter 17.21 RCW~~ and [Chapter 16-228 WAC](#) ~~(Appendix IV-D R.7 Chapter 16-228 WAC (Appendix IV-D R.7))~~.
- Choose the least toxic pesticide available that is capable of reducing the infestation to acceptable levels. The pesticide should readily degrade in the environment and/or have properties that strongly bind it to the soil. ~~Conduct~~ any pest control ~~used should be conducted~~ activity at the life stage when the pest is most vulnerable. For example, if it is necessary to use a *Bacillus thuringiensis* ~~is~~ application to control tent caterpillars, ~~apply it must be applied to the material~~ before the caterpillars cocoon or it will be ineffective. Any method used should be site-specific and not used wholesale over a wide area.
- Apply the pesticide according to label directions. ~~Under no conditions shall~~ ~~Do not apply~~ pesticides ~~be applied~~ in quantities that exceed manufacturer's instructions.
- Mix the pesticides and clean the application equipment in an area where accidental spills will not enter surface or ground waters, and will not contaminate the soil.
- Store pesticides in enclosed areas or in covered impervious containment. ~~Ensure that~~ ~~Do not discharge~~ pesticide contaminated stormwater or spills/leaks of pesticides ~~are not discharged~~ to storm ~~drains, sewers~~. Do not hose down the paved areas to a storm ~~drainsewer~~ or conveyance ditch. Store and maintain appropriate spill cleanup materials in a location known to all near the storage area.
- Clean up any spilled pesticides ~~and ensure that the~~. ~~Keep~~ pesticide contaminated waste materials ~~are kept~~ in designated covered and contained areas.
- The pesticide application equipment must be capable of immediate shutoff in the event of an emergency.
- Do not spray pesticides within 100 feet of open waters including wetlands, ponds, and streams, sloughs and any drainage ditch or channel that leads to open water except when ~~approved by following~~ ~~approval of~~ Ecology or the local jurisdiction. ~~Flag~~ all sensitive areas

including wells, creeks, and wetlands ~~must be flagged~~ prior to spraying.

- Post notices and delineate the spray area prior to the application, as required by the local government jurisdiction or by Ecology, ~~complete public posting of the area to be sprayed prior to the application~~.
- Conduct spray applications ~~should only be conducted~~ during weather conditions as specified in the label direction and applicable local and state regulations. Do not apply during rain or immediately before expected rain.

Recommended Additional Operational BMPs for the use of pesticides:

- Consider alternatives to the use of pesticides such as covering or harvesting weeds, substitute vegetative growth, and manual weed control/moss removal.
- Consider the use of soil amendments, such as compost, that are known to control some common diseases in plants, such as Pythium root rot, ash stem blight, and parasitic nematodes. The following are three possible mechanisms for disease control by compost addition (USEPA Publication 530-F-9-044):
 1. Successful competition for nutrients by antibiotic production;
 2. Successful predation against pathogens by beneficial microorganism; and
 3. Activation of disease-resistant genes in plants by composts.

Installing an amended soil/landscape system can preserve both the plant system and the soil system more effectively. This type of approach provides a soil/landscape system with adequate depth, permeability, and organic matter to sustain itself and continue working as an effective stormwater infiltration system and a sustainable nutrient cycle.

- Once a pesticide is applied, evaluate its effectiveness ~~should be evaluated~~ for possible improvement. Records should be kept showing the ~~applicability and inapplicability~~ effectiveness of the pesticides considered.
- Develop an annual evaluation procedure ~~should be developed~~ including a review of the effectiveness of pesticide applications, impact on buffers and sensitive areas (including potable wells), public concerns, and recent toxicological information on pesticides used/proposed for use. If individual or public potable wells are located in the proximity of commercial pesticide applications, contact the regional Ecology hydrogeologist to determine if additional pesticide application control measures are necessary.
- Rinseate from equipment cleaning and/or triple-rinsing of pesticide containers should be used as product or recycled into product.

- ~~The application equipment used should be capable of immediate shutoff in the event of an emergency.~~

For more information, contact the Washington State University (WSU) Extension Home-Assist Program, (253) 445-4556, or Bio-Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA.94707, or ~~the Washington Department of Ecology to obtain “Hazardous Waste Pesticides” (Publication #89-41); and/or~~ EPA to obtain a publication entitled “Suspended, Canceled, and Restricted Pesticides” which lists all restricted pesticides and the specific uses that are allowed. ~~Valuable information from these sources may also be available on the internet.~~

Applicable Operational BMPs for Vegetation Management:

- Use at least an eight-inch "topsoil" layer with at least 8 percent organic matter to provide a sufficient vegetation-growing medium. Amending existing landscapes and turf systems by increasing the percent organic matter and depth of topsoil can substantially improve the permeability of the soil, the disease and drought resistance of the vegetation, and reduce fertilizer demand. This reduces the demand for fertilizers, herbicides, and pesticides. Organic matter is the least water-soluble form of nutrients that can be added to the soil. Composted organic matter generally releases only between 2 and 10 percent of its total nitrogen annually, and this release corresponds closely to the plant growth cycle. ~~If Return~~ natural plant debris and mulch ~~are returned to~~ the soil, ~~this system can to~~ continue recycling nutrients indefinitely.
- Select the appropriate turfgrass mixture for ~~you~~the climate and soil type. Certain tall fescues and rye grasses resist insect attack because the symbiotic endophytic fungi found naturally in their tissues repel or kill common leaf and stem-eating lawn insects. ~~However,~~ they do not, ~~however,~~ repel root-feeding lawn pests such as Crane Fly larvae, and are toxic to ruminants such as cattle and sheep. The fungus causes no known adverse effects to the host plant or to humans. Endophytic grasses are commercially available ~~and can be used; use them~~ in areas such as parks or golf courses where grazing does not occur. ~~The local Cooperative~~ Local agricultural or gardening resources such as Washington State University Extension office can offer advice on which types of grass are best suited to the area and soil type.
- Use the following seeding and planting BMPs, or equivalent BMPs to obtain information on grass mixtures, temporary and permanent seeding procedures, maintenance of a recently planted area, and fertilizer application rates: *Temporary* ~~and Permanent~~ Seeding, Mulching and Matting, Clear, Plastic Covering, Permanent Seeding and Planting, and *Sodding* as described in Volume II.
- ~~Selection of desired plant species can be made by~~ Adjusting the soil properties of the subject site ~~can assist in selection of desired plant species.~~ For example, design a constructed wetland ~~can be designed~~ to resist the invasion of reed canary grass by layering specific strata of organic matters (e.g., ~~compost~~composted forest product residuals) and creating a mildly acidic pH and carbon-rich soil medium. Consult a soil restoration specialist for site-specific conditions.
- Aerate lawns regularly in areas of heavy use where the soil tends to become compacted. ~~Aeration should be conducted~~ Conduct aeration while the grasses in the lawn are growing most vigorously. Remove layers of thatch greater than ¾-inch deep.
- Mowing is a stress-creating activity for turfgrass. ~~When grass is mowed too short~~ Grass decreases its productivity ~~is decreased when~~

mown too short and there is less growth of roots and rhizomes. The turf becomes less tolerant of environmental stresses, more disease prone and more reliant on outside means such as pesticides, fertilizers, and irrigation to remain healthy. Set the mowing height at the highest acceptable level and mow at times and intervals designed to minimize stress on the turf. Generally mowing only 1/3 of the grass blade height will prevent stressing the turf.

Irrigation:

- The depth from which a plant normally extracts water depends on the rooting depth of the plant. Appropriately irrigated lawn grasses normally root in the top 6 to 12 inches of soil; lawns irrigated on a daily basis often root only in the top 1 inch of soil. Improper irrigation can encourage pest problems, leach nutrients, and make a lawn completely dependent on artificial watering. The amount of water applied depends on the normal rooting depth of the turfgrass species used, the available water holding capacity of the soil, and the efficiency of the irrigation system. Consult with the local water utility, Conservation District, or Cooperative Extension office to help determine optimum irrigation practices.

Fertilizer Management:

- Turfgrass is most responsive to nitrogen fertilization, followed by potassium and phosphorus. Fertilization needs vary by site depending on plant, soil, and climatic conditions. Evaluation of soil nutrient levels through regular testing ensures the best possible efficiency and economy of fertilization. For details on soils testing, contact the local Conservation District, a soils testing professional, or Cooperative Washington State University Extension Service office.
- ~~Fertilizers should be applied~~ Apply fertilizers in amounts appropriate for the target vegetation and at the time of year that minimizes losses to surface and ground waters. Do not fertilize ~~during a drought or~~ when the soil is dry. Alternatively, do not apply fertilizers within three days prior to predicted rainfall. The longer the period between fertilizer application and either rainfall or irrigation, the less fertilizer runoff occurs.
- Use slow release fertilizers such as methylene urea, IDBU, or resin coated fertilizers when appropriate, generally in the spring. Use of slow release fertilizers is especially important in areas with sandy or gravelly soils.
- Time the fertilizer application to periods of maximum plant uptake. Generally Ecology generally recommends application in the fall and spring ~~applications are recommended~~, although WSU Washington State University turf specialists recommend four fertilizer applications per year.

- Properly trained persons should apply all fertilizers. Apply no fertilizer at commercial and industrial facilities ~~fertilizers should not be applied,~~ to grass swales, filter strips, or buffer areas that drain to sensitive water bodies unless approved by the local jurisdiction.

Integrated Pest Management

An IPM program might consist of the following steps:

Step 1: Correctly identify problem pests and understand their life cycle

Step 2: Establish tolerance thresholds for pests.

Step 3: Monitor to detect and prevent pest problems.

Step 4: Modify the maintenance program to promote healthy plants and discourage pests.

Step 5: Use cultural, physical, mechanical, or biological controls first if pests exceed the tolerance thresholds.

Step 6: Evaluate and record the effectiveness of the control and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

For an elaboration of these steps, refer to [Appendix IV-F](#).

S412 BMPs for Loading and Unloading Areas for Liquid or Solid Material

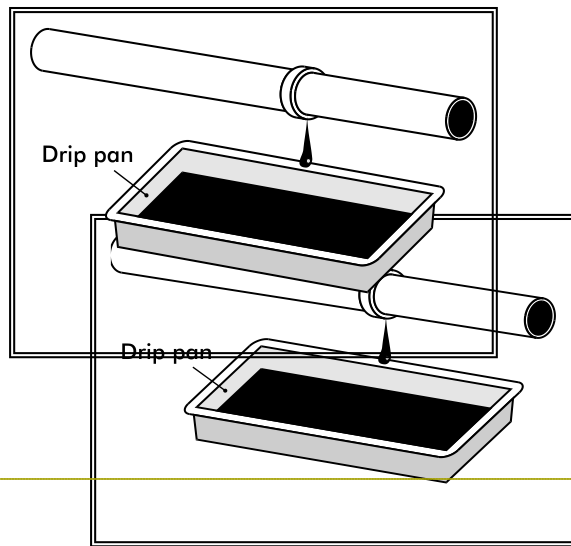
Description of Pollutant Sources: Operators typically conduct loading/unloading of liquid and solid materials at industrial and commercial facilities at shipping and receiving, outside storage, fueling areas, etc. Materials transferred can include products, raw materials, intermediate products, waste materials, fuels, scrap metals, etc. Leaks and spills of fuels, oils, powders, organics, heavy metals, salts, acids, alkalis, etc. during transfer may cause stormwater contamination. Spills from hydraulic line breaks are a common problem at loading docks.

Pollutant Control Approach: Cover and contain the loading/unloading area where necessary to prevent run-on of stormwater and runoff of contaminated stormwater.

Applicable Operational BMPs:

At All Loading/ Unloading Areas:

- A significant amount of debris can accumulate at outside, uncovered loading/unloading areas. Sweep these surfaces frequently to remove loose material that could otherwise be washed off by stormwater. Sweep outside areas that are temporarily covered for a period after removal of time by the containers, logs, or other material after covering the areas are cleared ground.
- Place drip pans, or other appropriate temporary containment device, at locations where leaks or spills may occur such as hose connections, hose reels and filler nozzles. Always use drip pans shall always be used when making and breaking connections (see [Figure 2.2.2](#)). Check loading/ unloading equipment such as valves, pumps, flanges, and connections regularly for leaks and repair as needed.



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Figure 2.2.2 – Drip Pan

At Tanker Truck and Rail Transfer Areas to Above/Below-ground Storage Tanks:

- To minimize the risk of accidental spillage, prepare an "Operations Plan" that describes procedures for loading/unloading. Train the employees, especially fork lift operators, in its execution and post it or otherwise have it readily available to all employees.
- Report spills of reportable quantities to Ecology (~~refer to Section 2.1 for telephone numbers of Ecology Regional Offices).~~
- Prepare and implement an Emergency Spill Cleanup Plan for the facility (See S406 BMPs for Spills of Oil and Hazardous Substances~~BMP Spills of Oil and Hazardous Substances~~) which includes the following BMPs:
 - Ensure the ~~clean-up~~cleanup of liquid/solid spills in the loading/unloading area immediately, if a significant spill occurs, and, upon completion of the loading/unloading activity, or, at the end of the working day.
 - Retain and maintain an appropriate oil spill cleanup kit on-site for rapid cleanup of material spills. (See S406 BMPs for Spills of Oil and Hazardous Substances~~(See BMP Spills of Oil and Hazardous Substances).~~

- Ensure that an employee trained in spill containment and cleanup is present during loading/unloading.

At Rail Transfer Areas to Above/below-ground Storage Tanks: Install a drip pan system as illustrated (see [Figure 2.2.3](#)) within the rails to collect spills/leaks from tank cars and hose connections, hose reels, and filler nozzles.

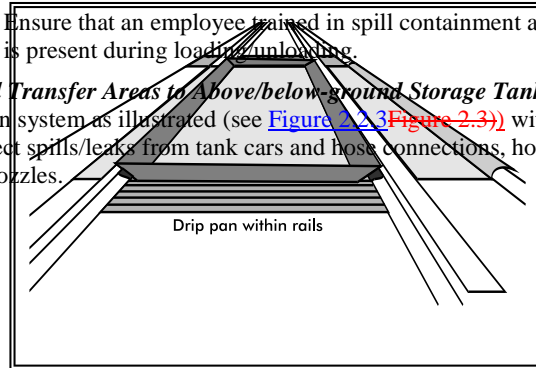
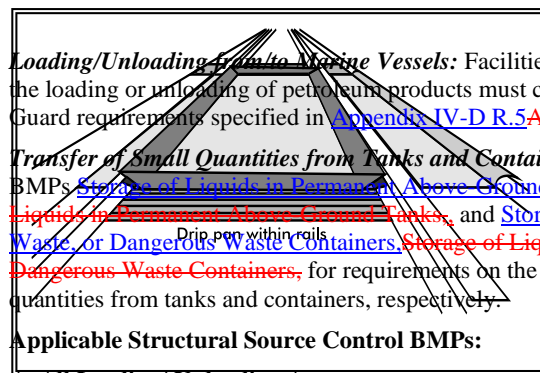


Figure 2.2.3 – Drip Pan Within Rails



Loading/Unloading from/to Marine Vessels: Facilities and procedures for the loading or unloading of petroleum products must comply with Coast Guard requirements specified in [Appendix IV-D R.5](#).

Transfer of Small Quantities from Tanks and Containers: Refer to BMPs [Storage of Liquids in Permanent Above-Ground Tanks](#), [Storage of Liquids in Permanent Above-Ground Tanks](#), and [Storage of Liquid, Food Waste, or Dangerous Waste Containers](#), for requirements on the transfer of small quantities from tanks and containers, respectively.

Applicable Structural Source Control BMPs:

At All Loading/ Unloading Areas:

- Consistent with Uniform Fire Code requirements ([Appendix IV-D R.2](#)) and to the extent practicable, conduct unloading or loading of solids and liquids in a manufacturing building, under a roof, or lean-to, or other appropriate cover.

- Berm, dike, and/or slope the loading/unloading area to prevent run-on of stormwater and to prevent the runoff or loss of any spilled material from the area.
- ~~Large loading areas frequently are not curbed along the shoreline. As a result, stormwater passes directly off the paved surface into surface water.~~ Place curbs along the edge of the shoreline, or slope the edge such that the stormwater can flow to an internal storm ~~drain~~sewer system that leads to an approved treatment BMP. Avoid draining directly to the surface water from loading areas.
- Pave and slope loading/unloading areas to prevent the pooling of water. Minimize the use of catch basins and drain lines within the interior of the paved area ~~must be minimized as they will frequently be covered by material, or they should be placed or place catch basins~~ in designated “alleyways” that are not covered by material, containers, or equipment.
- Retain on-site the necessary materials for rapid cleanup of spills.

Recommended Structural Source Control BMP: For the transfer of pollutant liquids in areas that cannot contain a catastrophic spill, install an automatic shutoff system in case of unanticipated off-loading interruption (e.g. coupling break, hose rupture, overfill, etc.).

At Loading and Unloading Docks:

- Install/maintain overhangs, or door skirts that enclose the trailer end (see Figures 2.2.4~~Figures 2.4 and 2.2.5(2-5))~~ to prevent contact with rainwater.
- Design the loading/unloading area with berms, sloping, etc. to prevent the run-on of stormwater.
- ~~Retain on-site the necessary materials for rapid cleanup of spills.~~

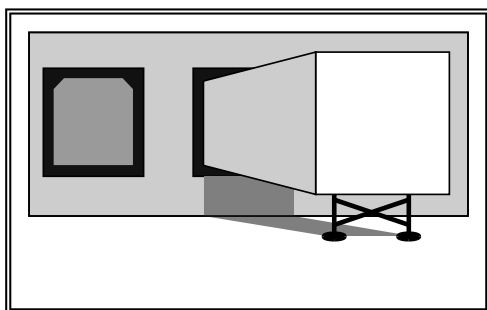


Figure 2.2.4 – Loading Dock with Door Skirt

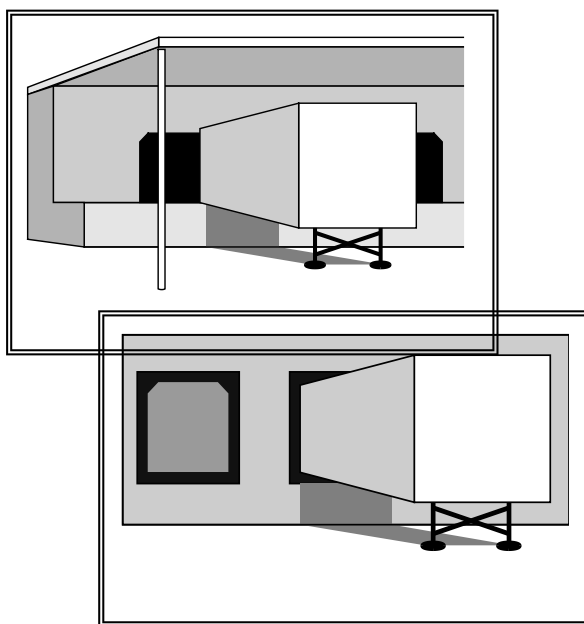


Figure 2.2.5 – Loading Dock with Overhang

At Tanker Truck Transfer Areas to Above/Below-Ground Storage Tanks:

- Pave the area on which the transfer takes place. If any transferred liquid, such as gasoline, is reactive with asphalt, pave the area with Portland cement concrete.

- Slope, berm, or dike the transfer area to a dead-end sump, spill containment sump, a spill control ~~(SC)~~ oil/water separator, or other spill control device. The minimum spill retention time should be 15 minutes at the greater flow rate of the highest fuel dispenser nozzle through-put rate, or the peak flow rate of the 6-month, 24-hour storm event over the surface of the containment pad, whichever is greater. The ~~volume~~capacity of the spill containment sump should be a minimum of 50 gallons with ~~an~~adequate additional volume provided for grit sedimentation~~-volume~~.

S413 BMPs for Log Sorting and Handling

Description of Pollutant Sources: Log yards are paved or unpaved areas where logs are transferred, sorted, debarked, cut, and stored to prepare them for shipment or for the production of dimensional lumber, plywood, chips, poles, or other products. Log yards are generally maintained at sawmills, shipping ports, and pulp mills. Typical pollutants include oil and grease, BOD, settleable solids, total suspended solids (including soil), high and low pH, heavy metals, pesticides, wood-based debris, and leachate

The following are pollutant sources:

- Log storage, rollout, sorting, scaling, and cutting areas
- Log and liquid loading areas
- Log sprinkling
- Debarking, bark bin and conveyor areas
- Bark, ash, sawdust and wood debris piles, and ~~other~~ solid wastes
- Metal salvage areas
- Truck, rail, ship, stacker, and loader access areas
- Log trucks, stackers, loaders, forklifts, and other heavy equipment
- Maintenance shops and parking areas
- Cleaning areas for vehicles, parts, and equipment
- Storage and handling areas for hydraulic oils, lubricants, fuels, paints, liquid wastes, and other liquid materials
- Pesticide usage for log preservation and surface protection
- Application of herbicides for weed control
- Contaminated soil resulting from leaks or spills of fluids

Ecology's Baseline General Permit Requirements:

Industries with log yards are required to obtain coverage under the ~~baseline~~Industrial Stormwater General Permit for discharges of stormwater associated with industrial activities~~-to surface water-~~. The

permit requires preparation and on-site retention of an Industrial Stormwater Pollution Prevention ~~Plans~~Plan (SWPPP). ~~The SWPPP must identify operational, source control, erosion and sediment control and, if necessary, treatment BMPs.~~ Required and recommended operational, structural source control, and treatment BMPs are presented in detail in Ecology's Guidance Document: Industrial Stormwater General Permit Implementation Manual for Log Yards~~"Industrial Stormwater General Permit Implementation Manual for Log Yards,"~~ Publication # 04-10-031. ~~It is recommended~~Ecology recommends that all log yard facilities obtain a copy of this document.

S414 BMPs for Maintenance and Repair of Vehicles and Equipment

Description of Pollutant Sources: Pollutant sources include parts/vehicle cleaning, spills/leaks of fuel and other liquids, replacement of liquids, outdoor storage of batteries/liquids/parts, and vehicle parking.

Pollutant Control Approach: Control of leaks and spills of fluids using good housekeeping and cover and containment BMPs.

Applicable Operational BMPs:

- Inspect ~~for leaks~~ all incoming vehicles, parts, and equipment stored temporarily outside for leaks.
- Use drip pans or containers under parts or vehicles that drip or that are likely to drip liquids, such as during dismantling of liquid containing parts or removal or transfer of liquids.
- Remove batteries and liquids from vehicles and equipment in designated areas designed to prevent stormwater contamination. Store cracked batteries in a covered non-leaking secondary containment system.
- Remove liquids from vehicles retired for scrap.
- Empty oil and fuel filters before disposal. Provide for proper disposal of waste oil and fuel.
- Do not pour/convey washwater, liquid waste, or other ~~pollutant~~pollutants into storm drains or to surface water. Check with the local sanitary sewer authority for approval to convey water to a sanitary sewer.
- Do not connect maintenance and repair shop floor drains to storm drains or to surface water.
- To allow for snowmelt during the winter, install a drainage trench with a sump for particulate collection ~~can be installed and used only~~. Use the drainage trench for draining the snowmelt only and not for discharging any vehicular or shop pollutants.

Applicable Structural Source Control BMPs:

Applicable Structural Source Control BMPs:

- Conduct all maintenance and repair of vehicles and equipment in a building, or other covered impervious containment area that is sloped to prevent run-on of uncontaminated stormwater and runoff of contaminated ~~stormwater.~~ water.
- ~~The Operators may conduct~~ maintenance of refrigeration engines in refrigerated trailers ~~may be conducted~~ in the parking area ~~with.~~ Exercise due caution to avoid the release of engine or refrigeration fluids to storm drains or surface water.
- Park large mobile equipment, such as log stackers, in a designated contained area.

~~For additional applicable BMPs refer to the following BMPs: Fueling at Dedicated Stations; Washing and Steam Cleaning Vehicle/Equipment/Building Structures; Loading and Unloading Areas for Liquid or Solid Material; Storage of Liquids in Permanent Above Ground Tanks; Storage of Liquid, Food Waste, or Dangerous Waste Containers; Storage or Transfer (Outside) of Solid Raw Materials, By-Products, or Finished Products; Spills of Oil and Hazardous Substances; Illicit Connections to Storm Drains; and other BMPs provided in this chapter.~~

Additional applicable BMPs:

- [S409 BMPs for Fueling at Dedicated Stations](#)
- [S410 BMPs for Illicit Connections to Storm Drains](#)
- [S412 BMPs for Loading and Unloading Areas for Liquid or Solid Material](#)
- [S426 BMPs for Spills of Oil and Hazardous Substances](#)
- [S427 BMPs Storage of Liquid, Food Waste, or Dangerous Waste Containers](#)
- [S428 BMPs for Storage of Liquids in Permanent Aboveground Tanks](#)
- [S429 BMPs for Storage or Transfer \(Outside\) of Solid Raw Materials, By-Products, or Finished Products](#)
- [S431 BMPs for Washing and Steam Cleaning Vehicle/Equipment/Building Structures](#)

Applicable Treatment BMPs: Convey contaminated stormwater runoff from vehicle staging and maintenance areas ~~must be conveyed~~ to a sanitary sewer, if allowed by the local sewer authority, or to an API or CP oil and water separator followed by a basic treatment BMP (See Volume V), applicable filter, or other equivalent oil treatment system.

Recommended Additional Operational BMPs:

Note ~~that a this~~ applicable treatment BMP ~~is applicable~~ for contaminated stormwater.

- ~~Consider storing~~Store damaged vehicles inside a building or other covered containment, until successfully removing all liquids ~~are removed. Remove liquids from vehicles retired for scrap.~~
- Clean parts with aqueous detergent based solutions or non-chlorinated solvents such as kerosene or high flash mineral spirits, and/or use wire brushing or sand blasting whenever practicable. Avoid using toxic liquid cleaners such as methylene chloride, 1,1,1-trichloroethane, trichloroethylene or similar chlorinated solvents. Choose cleaning agents that can be recycled.
- Inspect all BMPs regularly, particularly after a significant storm. Identify and correct deficiencies to ensure that the BMPs are functioning as intended.
- Avoid hosing down work areas. Use dry methods for cleaning leaked fluids.
- Recycle greases, used oil, oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic fluids, transmission fluids, and engine oils (see [Appendix IV-C](#)~~Appendix IV-C~~).
- Do not mix dissimilar or incompatible waste liquids stored for recycling.

S415 BMPs for Maintenance of Public and Private Utility Corridors and Facilities

Description of Pollutant Sources: Passageways and equipment at petroleum product, natural gas, and water pipelines, and electrical power transmission corridors and rights-of-way can be sources of pollutants such as herbicides used for vegetation management, and eroded soil particles from unpaved access roads. At pump stations, waste materials generated during maintenance activities may be temporarily stored outside. Additional potential pollutant sources include the leaching of preservatives from wood utility poles, PCBs in older transformers, water removed from underground transformer vaults, and leaks/spills from petroleum pipelines. The following are potential pollutants: oil and grease, TSS, BOD, organics, PCBs, pesticides, and heavy metals.

Pollutant Control Approach: Control of fertilizer and pesticide applications, soil erosion, and site debris that can contaminate stormwater.

Applicable Operational BMPs:

Applicable Operational BMPs:

- Implement BMPs for “Landscaping and Lawn/Vegetation Management” and R.7 in Appendix IV-D on Pesticide Regulations.
- When removing water or sediments ~~are removed~~ from electric transformer vaults, determine ~~whether~~the presence of contaminants

~~might be present~~ before disposing of the water and sediments. This includes inspecting for the presence of oil or sheen, and determining from records or testing if the transformers contain PCBs. If records or tests indicate that the ~~sediments~~sediments or water are contaminated above applicable levels, manage these media in accordance with applicable federal and state regulations, including the federal PCB rules (40 CFR 761) and the state MTCA cleanup regulations ([Chapter 173-340 WAC](#)~~(Chapter 173-340 WAC)~~). Water removed from the vaults can be discharged in accordance with the federal 40 CFR 761.79, and state regulations ([Chapter 173-201A WAC and Chapter 173-200 WAC](#)~~(Chapter 173-201A WAC and Chapter 173-200 WAC)~~), or via the sanitary sewer if the requirements, including applicable permits, for such a discharge are met. (See also [Appendix IV-D R.1](#)~~Appendix IV-D R.1 and R.3 R.3~~).

- Within utility corridors, ~~consider preparing~~prepare maintenance procedures ~~and to minimize the erosion of soil~~. An implementation schedule ~~that provides~~may provide for a vegetative, gravel, or equivalent cover that minimizes bare or thinly vegetated ground surfaces within the corridor, ~~to prevent the erosion of soil~~.
- Provide maintenance practices to prevent stormwater from accumulating and draining across and/or onto roadways. ~~Stormwater should be conveyed~~Convey stormwater through roadside ditches and culverts. The road should be crowned, outsloped, water barred, or otherwise left in a condition not conducive to erosion. Appropriately maintaining grassy roadside ditches discharging to surface waters is an effective way of removing some pollutants associated with sediments carried by stormwater.
- Maintain ditches and culverts at an appropriate frequency to ensure that plugging and flooding across the roadbed, with resulting overflow erosion, does not occur.
- Apply the appropriate BMPs in this Volume for the storage of waste materials that can contaminate stormwater.

Recommended Operational BMPs

- When selecting utility poles for a specific location, ~~consideration should be given to~~consider the potential environmental effects of the pole or poles during storage, handling, and end-use, as well as its cost, safety, efficacy, and expected life. ~~If a~~Use wood ~~product~~products treated with chemical preservatives ~~is used, it should be~~ made in accordance with generally accepted industry standards such as the American Wood Preservers Association Standards. ~~If the pole~~Consider alternative materials or technologies if placing poles ~~will be placed~~ in or near an environmentally sensitive area, such as a wetland or a drinking water well, ~~alternative materials or~~ Alternative technologies ~~should be considered~~. These include poles constructed

with material(s) other than wood such as fiberglass composites, metal, or concrete. Consider other technologies and materials, such as sleeves or caissons for wood poles, ~~may also be considered~~ when they are determined to be practicable and available.

- As soon as practicable remove all litter from wire cutting/replacing operations. ~~etc.~~
- Implement temporary erosion and sediment control in areas ~~where clear cuts are conducted~~ cleared of trees and vegetation and during the construction of new roads ~~are constructed~~.

S416 BMPs for Maintenance of Roadside Ditches

Description of Pollutant Sources: Common road debris including eroded soil, oils, vegetative particles, and heavy metals can be sources of stormwater pollutants.

Pollutant Control Approach: Maintain roadside ditches ~~should be maintained~~ to preserve the condition and capacity for which they were originally constructed, and to minimize bare or thinly vegetated ground surfaces. Maintenance practices should provide for erosion and sediment control (Refer to BMP [Landscaping and Lawn/Vegetation Management](#) ~~Landscaping and Lawn/Vegetation Management~~).

Applicable Operational BMPs:

- Inspect roadside ditches regularly ~~as needed~~, to identify sediment accumulations and localized erosion.
- Clean ditches on a regular basis, as needed. ~~Ditches should be kept~~Keep ditches free of rubbish and debris.
- Vegetation in ditches often prevents erosion and cleanses runoff waters. Remove vegetation only when flow is blocked or excess sediments have accumulated. Conduct ditch maintenance (seeding, fertilizer application, harvesting) in late spring and/or early fall, where possible. This allows re-establishment of vegetative cover ~~to be re-established~~ by the next wet season thereby minimizing erosion of the ditch as well as making the ditch effective as a biofilter.
- In the area between the edge of the pavement and the bottom of the ditch, commonly known as the “bare earth zone,” use grass vegetation, wherever possible. ~~Vegetation should be established~~Establish vegetation from the edge of the pavement, if possible, or at least from the top of the slope of the ditch.
- Maintain diversion ditches on top of cut slopes ~~that are~~ constructed to prevent slope erosion by intercepting surface drainage ~~must be maintained~~ to retain their diversion shape and capability.
- Do not leave ditch cleanings ~~are not to be left~~ on the roadway surfaces. Sweep, collect, and dispose of dirt and debris remaining on the pavement at the completion of ditch cleaning operations.
- Consider screening roadside ditch cleanings, not contaminated by spills or other releases and not associated with a stormwater treatment system such as a bioswale, ~~may be screened~~ to remove litter ~~and separated~~. Separate screenings into soil and vegetative matter (leaves, grass, needles, branches, etc.). ~~The soil fraction may be handled as ‘clean soils’ and .) categories. Compost or dispose of~~ the vegetative matter ~~can be composted or disposed of~~ in a municipal waste landfill. Consult with the jurisdictional health department to discuss use or disposal options for the soil portion. For more information, please see *“Recommendations for Management of Street Wastes,”* in Appendix IV-G ~~Appendix IV-G~~ of this volume.
- Roadside ditch cleanings contaminated by spills or other releases known or suspected to contain dangerous waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC) ~~Dangerous Waste Regulations (Chapter 173-303 WAC) unless~~. If testing determines it is materials are not dangerous waste, but ~~but~~ contaminants are present, consult with the jurisdictional health department for disposal options.
- Examine culverts on a regular basis for scour or sedimentation at the inlet and outlet, and repair as necessary. Give priority to those culverts

conveying perennial and/or salmon-bearing streams and culverts near streams in areas of high sediment load, such as those near subdivisions during construction.

Recommended Treatment BMPs:

Install biofiltration swales and filter strips – (See Chapter 9, Volume V) to treat roadside runoff wherever practicable and use engineered topsoils wherever necessary to maintain adequate vegetation ~~(CH2M Hill, 2000)~~. These systems can improve infiltration and stormwater pollutant control upstream of roadside ditches.

S417 BMPs for Maintenance of Stormwater Drainage and Treatment Systems

Description of Pollutant Sources: Facilities include roadside catch basins on arterials and within residential areas, conveyance systems, detention facilities such as ponds and vaults, oil/water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems presented in Volume V. Oil and grease, hydrocarbons, debris, heavy metals, sediments and contaminated water are found in catch basins, oil and water separators, settling basins, etc.

Pollutant Control Approach: Provide maintenance and cleaning of debris, sediments, and oil from stormwater collection, conveyance, and treatment systems to obtain proper operation.

~~**Applicable Operational BMPs:**~~

Applicable Operational BMPs:

Maintain stormwater treatment facilities ~~according to per~~ the operations and maintenance (O & M) procedures presented in Section 4.6 of Volume V in addition to the following BMPs:

- Inspect and clean treatment BMPs, conveyance systems, and catch basins as needed, and determine ~~whether necessary O&M improvements in O & M are needed.~~
- Promptly repair any deterioration threatening the structural integrity of ~~the stormwater~~ facilities. These include replacement of clean-out gates, catch basin lids, and rock in emergency spillways.
- Ensure ~~that adequacy of~~ storm sewer capacities ~~are not exceeded~~ and ~~that prevent~~ heavy sediment discharges to the sewer system ~~are prevented.~~
- Regularly remove debris and sludge from BMPs used for peak-rate control, treatment, etc. and discharge to a sanitary sewer if approved by the sewer authority, or truck to ~~a~~ an appropriate local or state government approved disposal site.
- Clean catch basins when the depth of deposits reaches 60 percent of the sump depth as measured from the bottom of basin to the invert of

the lowest pipe into or out of the basin. However, in no case should there be less than six inches clearance from the debris surface to the invert of the lowest pipe. Some catch basins (for example, WSDOT Type 1L basins) may have as little as 12 inches sediment storage below the invert. These catch basins ~~will need more~~ frequent inspection and cleaning to prevent scouring. Where these catch basins are part of a stormwater collection and treatment system, the system owner/operator may choose to concentrate maintenance efforts on downstream control devices as part of a systems approach.

- Clean woody debris in a catch basin as frequently as needed to ensure proper operation of the catchbasin.
- Post warning signs; “Dump No Waste - Drains to Ground Water,” “Streams,” “Lakes,” or emboss on or adjacent to all storm drain inlets *where ~~practical~~ possible*.
- Disposal of sediments and liquids from the catch basins must comply with “Recommendations for Management of Street Wastes” described in ~~Appendix IV-G~~ [Appendix IV-G](#) of this volume.

Additional Applicable BMPs: Select additional applicable BMPs from this chapter depending on the pollutant sources and activities conducted at the facility. Those BMPs include:

- [S425 BMPs for Soil Erosion and Sediment Control at Industrial Sites](#)
- [S427 BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers](#)
- [S406 BMPs for Spills of Oil and Hazardous Substances](#)
- [S410 BMPs for Illicit Connections to Storm Drains](#)
- ~~[S430 BMPs for Urban Streets](#)~~ ~~BMPs for Soil Erosion and Sediment Control at Industrial Sites~~
- ~~BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers~~
- ~~BMPs for Spills of Oil and Hazardous Substances~~
- ~~BMPs for Illicit Connections to Storm Drains~~
- ~~BMPs for Urban Streets.~~

•

S418 BMPs for Manufacturing Activities - Outside

Description of Pollutant Sources: Manufacturing pollutant sources include outside process areas, stack emissions, and areas where

manufacturing activity has taken place in the past and significant exposed pollutant materials remain.

Pollution Control Approach: Cover and contain outside manufacturing and prevent stormwater run-on and contamination, where feasible.

Applicable Operational BMP:

- Sweep paved areas regularly, as needed, to prevent contamination of stormwater.

Applicable Structural Source Control BMPs:

- Alter the activity by eliminating or minimizing the contamination of stormwater.
- **Applicable Structural Source Control BMPs:** Enclose the activity (see [Figure 2.2.6](#)). If possible, enclose the manufacturing activity in a building.
- Cover the activity and connect floor drains to a sanitary sewer, if approved by the local sewer authority. Berm or slope the floor as needed to prevent drainage of pollutants to outside areas. ([Figure 2.2.7](#))
- Isolate and segregate pollutants as feasible. Convey the segregated pollutants to a sanitary sewer, process treatment, or a dead-end sump depending on available methods and applicable permit requirements.

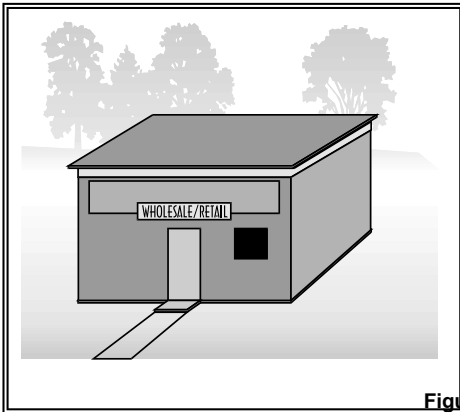
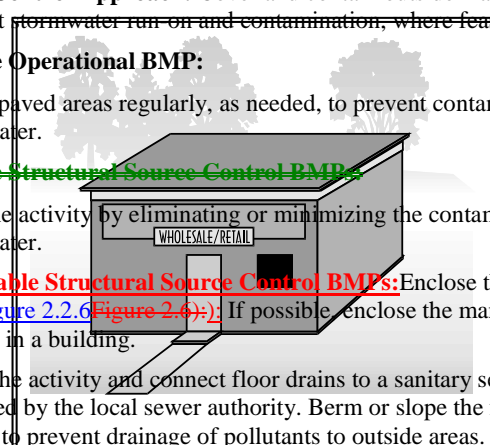
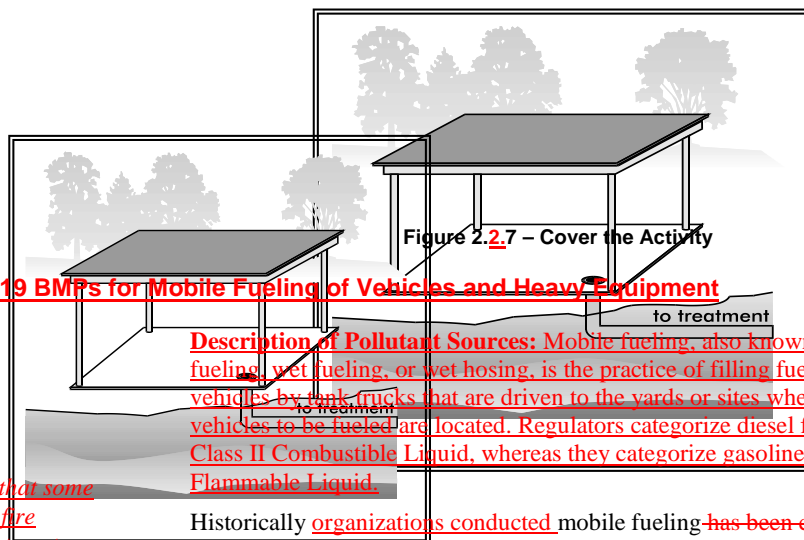


Figure 2.2.6 – Enclose the Activity



S419 BMPs for Mobile Fueling of Vehicles and Heavy Equipment

Description of Pollutant Sources: Mobile fueling, also known as fleet fueling, wet fueling, or wet hosing, is the practice of filling fuel tanks of vehicles by tank trucks that are driven to the yards or sites where the vehicles to be fueled are located. Regulators categorize diesel fuel as a Class II Combustible Liquid, whereas they categorize gasoline as a Flammable Liquid.

Note that some local fire departments may have restrictions on mobile fueling practices.

Historically organizations conducted mobile fueling ~~has been conducted~~ for off-road vehicles ~~that are~~ operated for extended periods ~~of time~~ in remote areas. This includes construction sites, logging operations, and farms. Some organizations conduct mobile fueling of on-road vehicles ~~is also conducted~~ commercially in the State of Washington.

Pollutant Control Approach: Operators typically need proper training of the fueling ~~operator/operators~~, and the use of spill/drip control and reliable fuel transfer equipment with backup shutoff valving ~~are typically needed~~.

Applicable Operational BMPs:

Organizations and individuals conducting mobile fueling operations must implement the ~~following~~bulleted BMPs ~~below~~. The operating procedures for the driver/operator should be simple, clear, effective, and their implementation verified by the organization ~~that will potentially be~~ liable for environmental and third party damage.

- Ensure that the local fire department approves all mobile fueling operations ~~are approved by the local fire department and~~. Comply with local and Washington State fire codes.
- In fueling locations that are in close proximity to sensitive aquifers, designated wetlands, wetland buffers, or other waters of the State, approval by local jurisdictions is necessary to ensure compliance with additional local requirements.
- Ensure ~~the~~ compliance with all 49 CFR 178 requirements for DOT 406 cargo tanker. Documentation from a Department of Transportation (DOT) Registered Inspector ~~shall be~~provides proof of compliance.
- Ensure the presence and the constant observation/monitoring of the driver/operator at the fuel transfer location at all times during fuel transfer and ensure ~~that~~implementation of the following procedures ~~are implemented~~ at the fuel transfer locations:
 - ~~Locating~~Locate the point of fueling at least 25 feet from the nearest storm ~~drain~~sewer or inside an impervious containment with a volumetric holding capacity equal to or greater than 110 percent of the fueling tank volume, or covering the storm ~~drain~~sewer to ensure no inflow of spilled or leaked fuel. ~~Storm drains~~ Covers are not required for storm sewers that convey the inflow to a spill control separator approved by the local jurisdiction and the fire department ~~need not be covered~~. Potential spill/leak conveyance surfaces must be impervious and in good repair.
 - ~~Placement of~~Place a drip pan, or an absorbent pad under each fueling location prior to and during all dispensing operations. The pan (must be liquid tight) and the absorbent pad must have a capacity of at least 5 gallons. There is no need to report spills retained in the drip pan or the pad ~~need not be reported~~.
 - Manage the handling and operation of fuel transfer hoses and nozzle, drip pan(s), and absorbent pads as needed to prevent spills/leaks of fuel from reaching the ground, storm ~~drains~~sewer, and receiving waters.

- ~~Not~~Avoid extending the fueling hoses across a traffic lane without fluorescent traffic cones, or equivalent devices, conspicuously placed ~~so that to block~~ all traffic is blocked from crossing the fuel hose.
- ~~Removing~~Remove the fill nozzle and ~~cessation of~~cease filling ~~the~~ tank when the automatic shut-off valve engages. Do not ~~allow~~lock automatic shutoff fueling nozzles ~~to be locked~~ in the open position.
- ~~Not “topping~~Do not “top off” the fuel receiving equipment.
- Provide the driver/operator of the fueling vehicle with:
 - Adequate flashlights or other mobile lighting to view fuel fill openings with poor accessibility. Consult with local fire department for additional lighting requirements.
 - Two-way communication with his/her home base.
- Train the driver/operator annually in spill prevention and cleanup measures and emergency procedures. Make all employees aware of the significant liability associated with fuel spills.
- ~~The~~The responsible manager shall properly sign and date the fueling operating procedures ~~should be properly signed and dated by the responsible manager, distributed.~~ Distribute procedures to the operators, ~~retain~~retain them in the organization files, and ~~make~~make them available in the event an authorized government agency requests a review.
- ~~Ensure that~~Immediately notify the local fire department (911) and the appropriate regional office of the Department of Ecology ~~are immediately notified~~ in the event of any spill entering ~~the~~ surface or ground waters. Establish a “call down list” to ensure the rapid and proper notification of management and government officials should any significant amount of product be lost off-site. Keep the list in a protected but readily accessible location in the mobile fueling truck. The “call down list” should also pre-identify spill response contractors available in the area to ensure the rapid removal of significant product spillage into the environment.
- Maintain a minimum of the following spill clean-up materials in all fueling vehicles, that are readily available for use:
 - Non-water absorbents capable of absorbing ~~45~~at least 15 gallons of diesel fuel.
 - A storm drain plug or cover kit.
 - A non-water absorbent containment boom of a minimum 10 feet in length with a 12-gallon minimum absorbent capacity.
 - ~~A non-metallic shovel; and,~~

- A non-spark generating shovel (a steel shovels could generate a spark and cause an explosion in the right environment around a spill).
- Two, five-gallon buckets with lids.
- Use automatic shutoff nozzles for dispensing the fuel. Replace automatic shut-off nozzles as recommended by the manufacturer.
- Maintain and replace equipment on fueling vehicles, particularly hoses and nozzles, at established intervals to prevent failures.

Applicable Structural Source Control BMPs: Include the following fuel transfer site components:

- Automatic fuel transfer shut-off nozzles; ~~and,~~
- An adequate lighting system at the filling point.

S420 BMPs for Painting/ Finishing /Coating of Vehicles/Boats/ Buildings/ Equipment

Description of Pollutant Sources: Surface preparation and the application of paints, finishes, and/or coatings to vehicles, boats, buildings, and/or equipment outdoors can be sources of pollutants. Potential pollutants include organic compounds, oils and greases, heavy metals, and suspended solids.

Pollutant Control Approach: Cover and contain painting and sanding operations and apply good housekeeping and preventive maintenance practices to prevent the contamination of stormwater with painting ~~oversprays~~ over sprays and grit from sanding.

Applicable Operational BMPs:

- Train employees in the careful application of paints, finishes, and coatings to reduce misuse and over spray. Use ~~ground or~~ drop cloths underneath outdoor painting, scraping, sandblasting work, and properly clean and temporarily store collected debris daily.
- Do not conduct spraying, blasting, or sanding activities over open water or where wind may blow paint into water.
- Wipe up spills with rags and other absorbent materials immediately. Do not hose down the area to a storm ~~drain or sewer,~~ receiving water, or conveyance ditch ~~to receiving water.~~
- On marine dock areas sweep rather than hose down debris. Collect any hose water generated and convey to appropriate treatment and disposal.
- ~~Use a storm drain cover, filter fabric, or similarly~~ Use an effective runoff control device if dust, grit, washwater, or other pollutants may escape the work area and enter a catch basin. The containment

device(s) must be in place at the beginning of the workday. Collect contaminated runoff and solids and properly dispose of such wastes before removing the containment device(s) at the end of the workday.

- Use a ground cloth, pail, drum, drip pan, tarpaulin, or other protective device for activities such as outdoor paint mixing and tool cleaning outside, or where spills can contaminate stormwater.
- Properly dispose of all wastes and prevent all uncontrolled releases to the air, ground, or water.
- Clean brushes and tools covered with non-water-based paints, finishes, or other materials in a manner that allows collection of used solvents (e.g., paint thinner, turpentine, xylol, etc.) for recycling or proper disposal.
- Store toxic materials under cover (tarp, etc.) during precipitation events and when not in use to prevent contact with stormwater.

Applicable Structural Source Control BMPs: Enclose and/or contain all work while using a spray gun or conducting sand blasting and in compliance with applicable air pollution control, OSHA, and WISHA requirements. Do not conduct outside spraying, grit blasting, or sanding activities during windy conditions ~~which~~that render containment ineffective.

Recommended Additional Operational BMPs:

- Clean paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers ~~or~~. Dump pollutants collected in portable containers ~~that can be dumped~~ into a sanitary sewer drain, NOT a stormwater drain.
- Recycle paint, paint thinner, solvents, pressure washwater, and any other recyclable materials.
- Use efficient spray equipment such as electrostatic, air-atomized, high volume/low pressure, or gravity feed spray equipment.
- Purchase recycled paints, paint thinner, solvents, and other products, if feasible.

S421 BMPs for Parking and Storage of Vehicles and Equipment

Description of Pollutant Sources: Public and commercial parking lots such as retail store, fleet vehicle (including rent-a-car lots and car dealerships), equipment sale and rental parking lots, and parking lot driveways, can be sources of toxic hydrocarbons and other organic compounds, including oils and greases, metals, and suspended solids.

Pollutant Control Approach: If the parking lot is a **high-use site** as defined below, provide appropriate oil removal equipment for the contaminated stormwater runoff.

Applicable Operational BMPs:

- If washing ~~of~~ a parking lot ~~is conducted~~, discharge the washwater to a sanitary sewer, if allowed by the local sewer authority, or other approved wastewater treatment system, or collect ~~the washwater~~ for off-site disposal.
- Do not hose down the area to a storm ~~drain~~sewer or ~~to a~~ receiving water. Vacuum sweep parking lots, storage areas, and driveways; regularly to collect dirt, waste, and debris.

Applicable Treatment BMPs: An oil removal system such as an API or CP oil and water separator, catch basin filter, or equivalent BMP, approved by the local jurisdiction, is ~~applicable~~necessary for parking lots meeting the threshold vehicle traffic intensity level of a *high-use site*.

Vehicle High-Use Sites

Establishments subject to ~~a~~ vehicle high-use intensity ~~have been determined to be~~are significant sources of oil contamination of stormwater. Examples of potential high use areas include customer parking lots at fast food stores, grocery stores, taverns, restaurants, large shopping malls, discount warehouse stores, quick-lube shops, and banks. If the PGIS for a high-use site exceeds 5,000 square feet in a threshold discharge area, ~~and an~~ oil control BMP from the Oil Control Menu (in Volume V) is necessary. A high-use site at a commercial or industrial establishment has one of the following characteristics: (Gaus/King County, 1994)

- Is subject to an expected average daily vehicle traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area: or
- Is subject to storage of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.).

S422 BMPs for Railroad Yards

Description of Pollutant Sources: Pollutant sources can include:

- Drips/leaks of vehicle fluids onto the railroad bed
- Human waste disposal
- Litter
- Locomotive/railcar/equipment cleaning areas
- Fueling areas
- Outside material storage areas
- Erosion and loss of soil particles from the railroad bed
- Maintenance and repair activities at railroad terminals
- Switching and maintenance yards

- Herbicides used for vegetation management.

Waste materials can include waste oil, solvents, degreasers, antifreeze solutions, radiator flush, acids, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludges, and machine chips with residual machining oil and toxic fluids/solids lost during transit. Potential pollutants include oil and grease, TSS, BOD, organics, pesticides, and metals.

Pollutant Control Approach: Apply good housekeeping and preventive maintenance practices to control leaks and spills of liquids in railroad yard areas.

Applicable Operational and Structural Source Control BMPs:

- Implement the applicable BMPs in this chapter depending on the pollutant generating activities/sources at a railroad yard facility.
- Do not allow discharge to outside areas from toilets while a train is in transit. Use pumpout facilities ~~should be used~~ to service these units.
- Use drip pans at hose/pipe connections during liquid transfer and other leak-prone areas.
- During maintenance, do not discard debris or waste liquids along the tracks or in railroad yards.

Applicable Treatment BMPs: In areas subjected to leaks/spills of oils or other chemicals, convey ~~the contaminated~~ stormwater to appropriate treatment such as a sanitary sewer, if approved by the appropriate sewer authority, or, to a CP or API oil/water separator for floating oils, or other treatment, as approved by the local jurisdiction.

S423 BMPs for Recyclers and Scrap Yards

Description of Pollutant Sources: Includes businesses that reclaim various materials for resale or for scrap, such as vehicles and vehicle/equipment parts, construction materials, metals, beverage containers, and papers.

Potential sources of pollutants include paper, plastic, metal scrap debris, engines, transmissions, radiators, batteries, and other materials contaminated or that contain fluids ~~or are contaminated with fluids.~~ Other pollutant sources include leachate from metal components, contaminated soil, and the erosion of soil. Activities that can generate pollutants include the transfer, dismantling, and crushing of vehicles and scrap metal; the transfer and removal of fluids; maintenance and cleaning of vehicles, parts, and equipment; and storage of fluids, parts for resale, solid wastes, scrap parts, and materials, equipment and vehicles that contain fluids; generally in uncovered areas.

Potential pollutants typically found at vehicle recycle and scrap yards include oil and grease, ethylene and propylene glycol, PCBs, total suspended solids, BOD, heavy metals, and acidic pH.

Applicable Best Management Practices:

For facilities subject to Ecology's Industrial Stormwater General Permit refer to BMP Guidance Document #94-146, *Vehicle Recyclers: A Guide for Implementing the Industrial Stormwater General National Pollutant Discharge Elimination System (NPDES) Permit Requirements* ~~"Best Management Practices to Prevent Stormwater Pollution at Vehicle Recycler Facilities."~~, Washington Department of Ecology, March 2011, website: <http://www.ecy.wa.gov/biblio/94146.html> ~~September 1994 for selection of BMPs.~~ Apply the BMPs in that guidance document ~~can also be applied~~ to scrap material recycling facilities depending on the pollutant sources existing at those facilities ~~and to non-permitted facilities.~~

S424 BMPs for Roof/ Building Drains at Manufacturing and Commercial Buildings

Description of Pollutant Sources: Stormwater runoff from roofs and sides of manufacturing and commercial buildings can be sources of pollutants caused by leaching of roofing materials, building vents, and other air emission sources. Research has identified vapors and entrained liquid and solid droplets/particles as potential pollutants in roof/building runoff. Metals, solvents, acidic/alkaline pH, BOD, and organics, are some of the pollutant constituents identified.

Ecology has performed a study on zinc in industrial stormwater. The study is presented in Ecology Publication 08-10-025 *Suggested Practices to reduce Zinc Concentrations in Industrial Stormwater Discharges*, website: <http://www.ecy.wa.gov/biblio/0810025.html> ~~NOTE: At the time of publication, an updated guidance document for Vehicle Recycler Facilities was almost completed. When completed, it will be posted at the Dept. of Ecology's stormwater web page: <http://www.ecy.wa.gov/programs/wq/stormwater/index.html>~~

. The user should refer to this document for more details on addressing zinc in stormwater.

Pollutant Control Approach: Evaluate the potential sources of stormwater pollutants and apply source control BMPs where feasible.

Applicable Operational Source Control BMPs:

- If leachates and/or emissions from buildings are suspected sources of stormwater pollutants, then sample and analyze the stormwater draining from the building.
- Sweep the area routinely to remove any zinc residuals.

- If a roof/building stormwater pollutant source is identified, implement appropriate source control measures such as air pollution control equipment, selection of materials, operational changes, material recycle, process changes, etc.

Applicable Structural Source Control BMPs:

- Paint/coat the galvanized surfaces as described in Ecology Publication # 08-10-025.

Applicable Treatment BMPs:

Treat runoff from roofs to the appropriate level. The facility may use enhanced treatment BMPs as described in Volume V of the SWMMWW. Some facilities regulated by the Industrial Stormwater General Permit, or local jurisdiction, may have requirements that cannot be achieved with enhanced treatment BMPs. In these cases, additional treatment measures may be required. A treatment method for meeting stringent requirements such as Chitosan-Enhanced Sand Filtration may be appropriate.

S425 BMPs for Soil Erosion and Sediment Control at Industrial Sites

Description of Pollutant Sources: Industrial activities on soil areas; exposed and disturbed soils; steep grading; etc. can be sources of sediments that can contaminate stormwater runoff.

Pollutant Control Approach: Limit the exposure of erodible soil, stabilize, or cover erodible soil where necessary to prevent erosion, and/or provide treatment for stormwater contaminated with TSS caused by eroded soil.

Applicable BMPs:

Cover Practice Options:

- Vegetative cover such as grass, trees, shrubs, on erodible soil areas; ~~or,~~
- Covering with mats such as clear plastic, jute, synthetic fiber; ~~and/or,~~
- Preservation of natural vegetation including grass, trees, shrubs, and vines; ~~or,~~

Structural Practice Options:

- Vegetated swale; ~~dike,~~
- Dike
- Silt fence
- ~~Check dam~~
- ~~Gravel filter berm~~
- ~~Sedimentation basin~~

- ~~and~~ Proper grading.

(For design information refer to Volume II, “Standards and Specifications for BMPs”).

S426 BMPs for Spills of Oil and Hazardous Substances

Description of Pollutant Sources: Federal law requires owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, transferring, distributing, refining, or consuming oil and/or oil products to have a Spill Prevention and Emergency Cleanup Plan (SPECP). The SPECP is required if the above ground storage capacity of the facility, is 1,320 gallons or more of oil. Additionally, the SPECP is required if any single container with a capacity in excess of 660 gallons and which, due to their location, could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines (40 CFR 112.1 (b)). Onshore and offshore facilities, which, due to their location, could not reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines are exempt from these regulations (40 CFR 112.1(1)(i)). State Law requires owners of businesses that produce dangerous wastes to have a SPECP. These businesses should refer to [Appendix IV-D R.6](#). The federal definition of oil is oil of any kind or any form, including, but not limited to petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Pollutant Control Approach: Maintain, update, and implement ~~an oil spill prevention~~ a Spill Prevention and Emergency Cleanup Plan.

Applicable Operational BMPs: The businesses and public agencies identified in [Appendix IV-A](#) ~~Appendix IV-A that are~~ required to prepare and implement ~~ana Spill Prevention and~~ Emergency ~~Spill~~ Cleanup Plan shall implement the following:

- Prepare ~~ana Spill Prevention and~~ Emergency ~~Spill Control~~ Cleanup Plan (~~SCPSPECP~~), which includes:
 - A description of the facility including the owner's name and address;
 - The nature of the activity at the facility;
 - The general types of chemicals used or stored at the facility;
 - A site plan showing the location of storage areas for chemicals, the locations of storm drains, the areas draining to them, and the location and ~~description~~ of any devices to stop spills from leaving the site such as positive control valves;
 - Cleanup procedures;

- Notification procedures ~~to be~~ used in the event of a spill, such as notifying key personnel. Agencies such as Ecology, local fire department, Washington State Patrol, and the local Sewer Authority, shall be notified.
- The name of the designated person with overall spill cleanup and notification responsibility.
- Train key personnel in the implementation of the ~~Emergency SCP~~ SPECP. Prepare a summary of the plan and post it at appropriate points in the building, identifying the spill cleanup coordinators, location of cleanup kits, and phone numbers of regulatory agencies to ~~be contacted~~ contact in the event of a spill.
- Update the ~~SCP~~ SPECP regularly.
- Immediately notify Ecology, the local jurisdiction, and the local Sewer Authority if a spill may reach sanitary or storm sewers, ground water, or surface water, in accordance with federal and Ecology spill reporting requirements.

- Immediately clean up spills. Do not use emulsifiers for cleanup unless there is an appropriate disposal method for the resulting oily wastewater ~~is implemented.~~ Do not wash absorbent material ~~shall not be washed~~ down a floor drain or into a storm sewer; ~~and,~~
- Locate emergency spill containment and cleanup kit(s) in high-potential spill areas. The contents of the kit shall be appropriate for the type and quantities of chemical liquids stored at the facility.

Recommended Additional Operational BMP: Spill kits should include appropriately lined drums, absorbent pads, and granular or powdered materials for neutralizing acids or alkaline liquids where applicable. In fueling areas: Package absorbent ~~should be packaged~~ material in small bags for easy use and make available small drums ~~should be available~~ for storage of absorbent and/or used absorbent. Deploy spill kits ~~should be deployed~~ in a manner that allows rapid access and use by employees.

S427 BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers

Description of Pollutant Sources: Steel and plastic drums with volumetric capacities of 55 gallons or less are typically used at industrial facilities for container storage of liquids and powders. The BMPs specified below apply to container(s) located outside a building. Use these BMPs when temporarily storing accumulated food wastes, vegetable or animal grease, used oil, liquid feedstock, cleaning chemicals, or Dangerous Wastes (liquid or solid). ~~These BMPs do not apply when Ecology has permitted the business to store the wastes (Appendix IV-D R.4). Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, BOD, COD are potential pollutant constituents.~~

Pollutant Control Approach: Store containers in impervious containment under a roof, or other appropriate cover, or in a building. ~~For~~ When collection trucks directly pick up roll-containers ~~(for example, dumpsters) that are picked up directly by the collection truck,~~ ensure a file ~~can be placed~~ is on both sides of the curb to facilitate moving the dumpster. ~~If a~~ For storage ~~area is to be used~~ areas on-site for less than 30 days, consider using a portable temporary secondary system like that shown in Figure 2.2.8 ~~Figure 2.8 can be used~~ in lieu of a permanent system as described above.

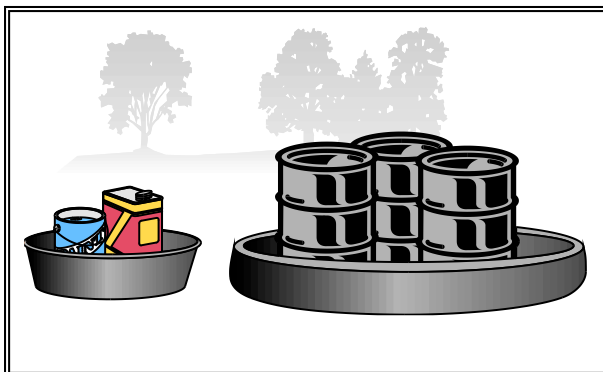
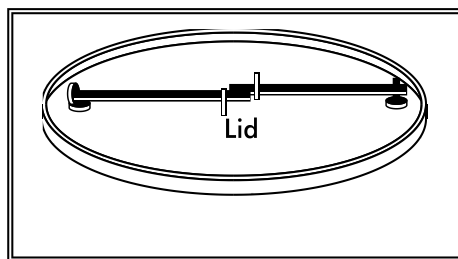


Figure 2.2.8 – Secondary Containment System

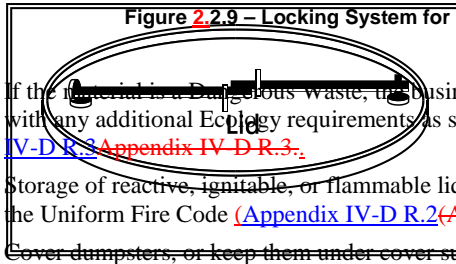
Applicable Operational BMPs:

- Place tight-fitting lids on all containers.
- Place drip pans beneath all mounted container taps and at all potential drip and spill locations during filling and unloading of containers.
- Inspect container storage areas regularly for corrosion, structural failure, spills, leaks, overfills, and failure of piping systems. Check containers daily for leaks/spills. Replace containers, and replace and tighten bungs in drums as needed.
- Businesses accumulating Dangerous Wastes that do not contain free liquids need only to store these wastes in a sloped designated area with the containers elevated or otherwise protected from storm water run-on.
- ~~Drums~~Secure drums when stored in an area where unauthorized persons may gain access ~~must be secured~~ in a manner that prevents accidental spillage, pilferage, or any unauthorized use (see [Figure 2.2.9](#)).



[Figure 2.2.9](#)

Figure 2.2.9 – Locking System for Drum Lid



- If the material is a Dangerous waste, the business owner must comply with any additional Ecology requirements as specified in [Appendix IV-D R.2](#) ~~Appendix IV-D R.3.~~
- Storage of reactive, ignitable, or flammable liquids must comply with the Uniform Fire Code ([Appendix IV-D R.2](#)) ~~(Appendix IV-D R.2).~~
- ~~Cover dumpsters, or keep them under cover~~ such as a lean-to, to prevent the entry of stormwater. Replace or repair leaking garbage dumpsters.
- Drain dumpsters and/or dumpster pads to sanitary sewer. Keep dumpster lids closed. Install waterproof liners.

Applicable Structural Source Control BMPs:

- Keep containers with Dangerous Waste, food waste, or other potential pollutant liquids inside a building unless this is ~~impracticable~~ not feasible due to site constraints or Uniform ~~International~~ Fire Code requirements.
- Store containers in a designated area, which is covered, bermed or diked, paved and impervious in order to contain leaks and spills (see [Figure 2.2.10](#) ~~Figure 2.10~~). Slope the secondary containment ~~shall be sloped~~ to drain into a dead-end sump for the collection of leaks and small spills.
- For liquid wastes, surround the containers with a dike as illustrated in [Figure 2.2.10](#) ~~Figure 2.10~~. The dike must be of sufficient height to provide a volume of either 10 percent of the total enclosed container volume or 110 percent of the volume contained in the largest container, whichever is greater, ~~or, if a single container, 110 percent of the volume of that container.~~

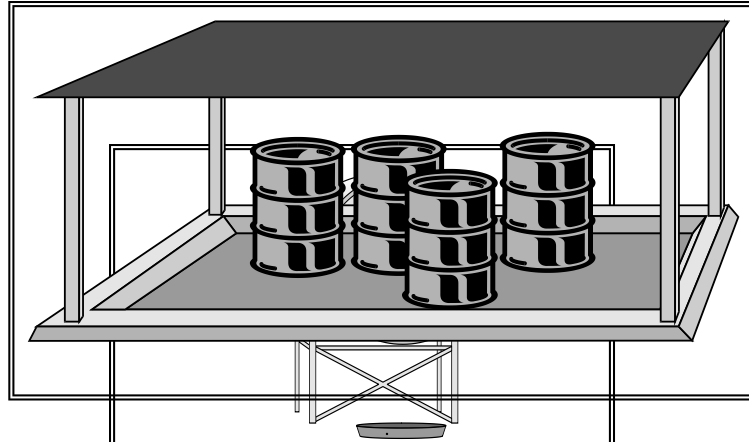


Figure 2.2.10 – Covered and Bermed Containment Area

- Where material is temporarily stored in drums, use a containment system ~~can be used~~ as illustrated, in lieu of the above system (see [Figure 2.2.8](#) ~~Figure 2.8~~).
- Place containers mounted for direct removal of a liquid chemical for use by employees inside a containment area as described above. Use a drip pan during liquid transfer (see [Figure 2.2.11](#) ~~Figure 2.11~~).

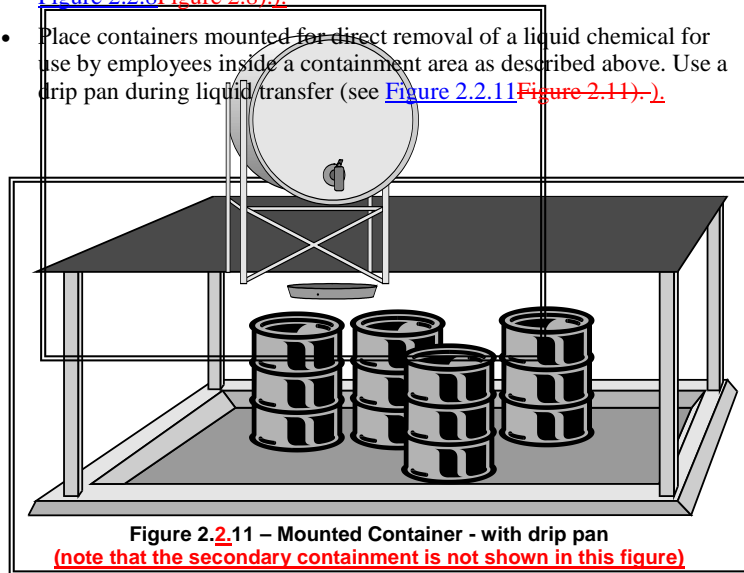


Figure 2.2.11 – Mounted Container - with drip pan
(note that the secondary containment is not shown in this figure)

Applicable Treatment BMP:

- For contaminated stormwater in the containment area, connect the sump outlet to a sanitary sewer, if approved by the local Sewer Authority, or to appropriate treatment such as an API or CP oil/water separator, catch basin filter or other appropriate system (see Volume V). Equip the sump outlet with a normally closed valve to prevent the

Note ~~that at this~~ treatment BMP is applicable for contaminated stormwater from drum storage areas.

release of spilled or leaked liquids, especially flammables (compliance with Fire Codes), and dangerous liquids. Open this valve ~~may be opened~~ only for the conveyance of contaminated stormwater to treatment.

- Another option for discharge of contaminated stormwater is to pump it from a dead-end sump or catchment to a tank truck or other appropriate vehicle for off-site treatment and/or disposal.

S428 BMPs for Storage of Liquids in Permanent Aboveground Tanks

Description of Pollutant Sources: Aboveground tanks containing liquids (excluding uncontaminated water) may be equipped with a valved drain, vent, pump, and bottom hose connection. Aboveground tanks may be heated with steam heat exchangers equipped with steam traps, if required. Leaks and spills can occur at connections and during liquid transfer. Oil and grease, organics, acids, alkalis, and heavy metals in tank water and condensate drainage can also cause stormwater contamination at storage tanks.

Pollutant Control Approach: Install secondary containment or a double-walled tank. Slope the containment area to a drain with a sump. Operators may need to discharge stormwater collected in the containment area ~~may need to be discharged~~ to treatment such as an API or CP oil/water separator, or equivalent BMP. Add safeguards against accidental releases including protective guards around tanks to protect against vehicle or forklift damage, and tagging valves to reduce human error. *Tank water and condensate discharges are process wastewater that may need an NPDES Permit.*

Applicable Operational BMPs:

- Inspect the tank containment areas regularly for leaks/spills, cracks, corrosion, etc. to identify problem components such as fittings, pipe connections, and valves, ~~for leaks/spills, cracks, corrosion, etc.~~
- Place adequately sized drip pans beneath all mounted taps and drip/spill locations during filling/unloading of tanks. Operators may need valved drain tubing ~~may be needed~~ in mounted drip pans.
- Vacuum sweep and clean the tank storage area regularly, if paved.
- Replace or repair tanks that are leaking, corroded, or otherwise deteriorating.
- All installations shall comply with the Uniform Fire Code (Appendix IV-D R.2 ~~(Appendix IV-D R.2)~~) and the National Electric Code.

Applicable Structural Source Control BMPs:

- Locate permanent tanks in impervious (Portland cement concrete or equivalent) secondary containment surrounded by dikes as illustrated in Figure 2.2.12 ~~Figure 2.12,~~ or use UL Approved double-walled-

tanks. The dike must be of sufficient height to provide a containment volume of either 10 percent of the total enclosed tank volume or 110 percent of the volume contained in the largest tank, whichever is greater, ~~or, if a single tank, 110 percent of the volume of that tank.~~

- Slope the secondary containment to drain to a dead-end sump ~~(optional)~~ or equivalent, for the collection of small spills.
- Include a tank overfill protection system to minimize the risk of spillage during loading.

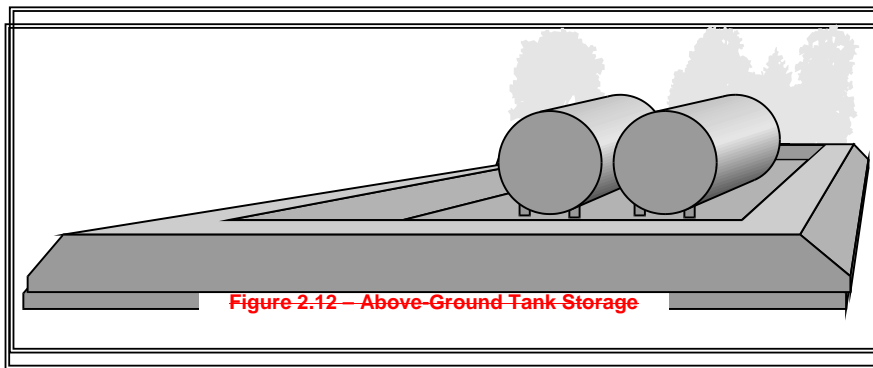


Figure 2.12 – Above-ground Tank Storage

Applicable Treatment BMPs:

- ~~If the~~For an uncovered tank containment area ~~is uncovered~~, equip the outlet from the spill-containment sump with a ~~shutoff valve, which is normally closed and~~shutoff valve. Operators may ~~be opened, open this valve~~ manually or automatically, only to convey contaminated stormwater to approved treatment or disposal, or to convey uncontaminated stormwater to a storm ~~drain, sewer~~. Evidence of contamination can include the presence of visible sheen, color, or turbidity in the runoff, or existing or historical operational problems at the facility. Use simple pH ~~measurements~~tests with litmus or pH paper ~~can be used~~ for areas subject to acid or alkaline contamination.
- At petroleum tank farms, convey stormwater contaminated with floating oil or debris in the contained area through an API or CP-type oil/water separator (Volume V, Treatment BMPs), or other approved treatment prior to discharge to storm drain or surface water.

Note ~~that~~this treatment BMP for stormwater from petroleum tank farms.

S429 BMPs for Storage or Transfer (Outside) of Solid Raw Materials, Byproducts, or Finished Products

Description of Pollutant Sources: Some pollutant sources stored outside in large piles, stacks, etc. at commercial or industrial establishments include:

- Solid raw materials
- Byproducts
- Gravel
- Sand
- Salts
- Topsoil
- Compost
- Logs
- Sawdust
- Wood chips
- Lumber
- Concrete
- Metal products

Contact between outside bulk materials and stormwater can cause leachate, and erosion of the stored materials. Contaminants may include TSS, BOD, organics, and dissolved salts (sodium, calcium, and magnesium chloride, etc.).

Pollutant Control Approach: Provide impervious containment with berms, dikes, etc. and/or cover to prevent run-on and discharge of leachate pollutant(s) and TSS.

Applicable Operational BMP: Do not hose down the contained stockpile area to a storm drain or a conveyance to a storm drain, or to a receiving water.

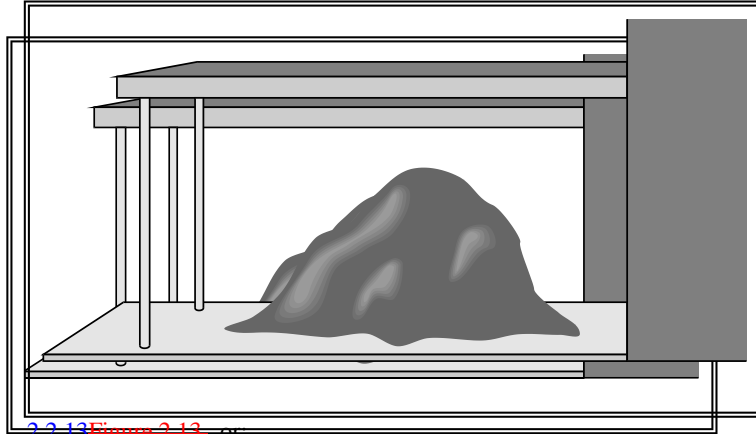
Applicable Structural Source Control BMP Options: ~~Choose one or more of~~ The source control BMP options listed below ~~for~~ are applicable to:

- Stockpiles greater than 5 cubic yards of erodible or water soluble materials such as ~~soil~~:
- Soil

- Road deicing salts, ~~compost,~~
- Compost
- Unwashed sand and gravel, ~~sawdust, etc. Also included are~~
- Sawdust
- Outside storage areas for solid materials such as ~~logs, bark, lumber,;~~
- Logs
- Bark
- Lumber
- Metal products, ~~etc.~~

Choose one or more of the following Source Controls:

- Store in a building or paved and bermed covered area as shown in [Figure](#)



[2.2.13](#) [Figure 2.13.1](#) or,

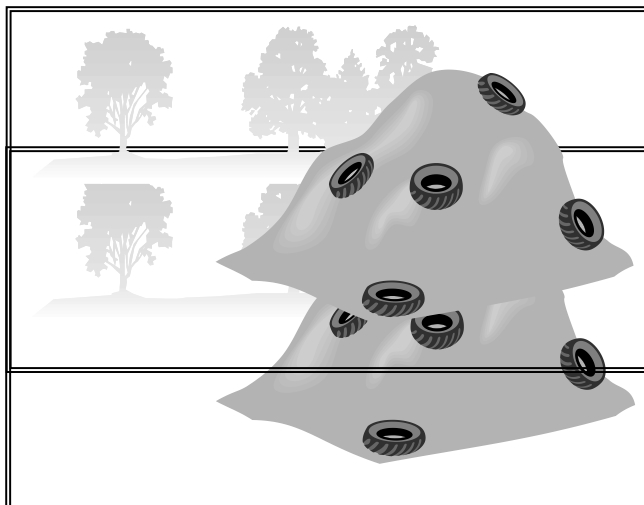


Figure 2.2.13 – Covered Storage Area for Bulk Solids (include berm if needed)

- Place temporary plastic sheeting (polyethylene, polypropylene, hypalon, or equivalent) over the material as illustrated (see [Figure 2.2.14](#) ~~Figure 2.14~~), or;

Figure 2.2.14 – Material Covered with Plastic Sheeting

- Pave the area and install a stormwater drainage system. Place curbs or berms along the perimeter of the area to prevent the run-on of uncontaminated stormwater and to collect and convey runoff to treatment. Slope the paved area in a manner that minimizes the contact between stormwater (e.g., pooling) and leachable materials in compost, logs, bark, wood chips, etc.
- For large uncovered stockpiles ~~that cannot be covered~~, implement containment practices at the perimeter of the site and at any catch basins as needed to prevent erosion and discharge of the stockpiled material ~~offsite~~ off-site or to a storm drain. Ensure that no direct discharge of contaminated stormwater ~~is not discharged directly~~ to catch basins exists without conveying runoff through an appropriate treatment BMP.

Applicable Treatment BMP: Convey contaminated stormwater from the stockpile area to a wet pond, wet vault, settling basin, media filter, or other appropriate treatment system depending on the contamination.

Recommended Additional Operational BMPs:

- Maintain drainage areas in and around storage of solid materials with a minimum slope of 1.5 percent to prevent pooling and minimize leachate formation. Areas should be sloped to drain stormwater to the

perimeter ~~where it can be collected for collection~~ or to internal drainage “alleyways” where ~~material is not~~ stockpiled material exists.

- Sweep paved storage areas regularly for collection and disposal of loose solid materials.
- If and when feasible, collect and recycle water-soluble materials (leachates) ~~to the stockpile~~.
- Stock cleanup materials, such as brooms, dustpans, and vacuum sweepers near the storage area.

S430 BMPs for Urban Streets

Description of Pollutant Sources: Urban streets can be the source of vegetative debris, paper, fine dust, vehicle liquids, tire and brake wear residues, heavy metals (lead and zinc), soil particles, ice control salts, domestic wastes, lawn chemicals, and vehicle combustion products. Street surface contaminants contain significant concentrations of particle sizes less than 250 microns (Sartor and Boyd, 1972).

Pollutant Control Approach: Conduct efficient street sweeping where and when appropriate to minimize the contamination of stormwater. Do not wash street debris into storm drains.

Facilities not covered under the Industrial Stormwater General Permit may consider a minimum amount of water washing of streets. All facilities must comply with their local stormwater requirements for discharging to storm sewers. Municipal NPDES permittees are required to limit street wash water discharges and may have special conditions or treatment requirements.

Recommended BMPs:

- For maximum stormwater pollutant reductions on curbed streets and high volume parking lots, use efficient vacuum sweepers (refer to Volume V, Ch. 12, for information about ~~an emerging~~ high-efficiency vacuum sweeper technology).

Note: High-efficiency street sweepers utilize strong vacuums and the mechanical action of main and gutter brooms combined with an air filtration system that only returns clean air to the atmosphere (i.e., filters very fine particulates). They sweep dry and use no water since they do not emit any dust.

~~It has been reported that~~ High-efficiency vacuum sweepers have the capability of removing ~~from pavements under good condition~~, 80 percent or more of the accumulated street dirt particles whose diameters are less than 250 microns ~~(Sutherland, 1998)~~. This assumes pavements under good condition and reasonably expected accumulation conditions.

- For moderate stormwater pollutant reductions on curbed streets use regenerative air sweepers or tandem sweeping operations.

Note: A tandem sweeping operation involves a single pass of a mechanical sweeper followed immediately by a single pass of a vacuum sweeper or regenerative air sweeper.

- *A regenerative air sweeper blows air down on the pavement to entrain particles and uses a return vacuum to transport the material to the hopper.*
- *These operations usually use water to control dust. This reduces their ability to pick up fine particulates.*

~~*It has been reported that*~~ *These types of sweepers have the capability of removing approximately 25 to 50 percent of the accumulated street dirt particles whose diameters are less than 250 microns. (Sutherland, 1998).* *This assumes pavements under good conditions and typical accumulation conditions.*

- For minimal stormwater pollutant reductions on curbed streets ~~us~~-use mechanical sweepers.

- *Note: The industry refers to mechanical sweepers ~~are referred to~~ as broom sweepers and ~~use~~uses the mechanical action of main and gutter brooms to throw material on a conveyor belt that transports it to the hopper.*
- *These sweepers usually use water to control dust. This reduces their ability to pick up fine particulates.*

~~*It has been reported that*~~ *Mechanical sweepers have the capability of removing only 10 to 20 percent of the accumulated street dirt particles whose diameters are less than 250 microns. (Sutherland, 1998).* *This assumes pavements under good condition and the most favorable accumulation conditions.*

- Conduct vacuum sweeping at optimal frequencies. Optimal frequencies are those scheduled sweeping intervals that produce the most cost-effective annual reduction of pollutants normally found in stormwater and can vary depending on land use, traffic volume and rainfall patterns.
- Train operators in those factors that result in optimal pollutant removal. These factors include sweeper speed, brush adjustment and rotation rate, sweeping pattern, maneuvering around parked vehicles, and interim storage and disposal methods.
- Consider the use of periodic parking restrictions in low to medium density single-family residential areas to ensure the sweeper's ability to sweep along the curb.

- Establish programs for prompt vacuum sweeping, removal, and disposal of debris from special events that will generate higher than normal loadings.
- Disposal of street sweeping solids must comply with “Recommendations for Management of Street Wastes” described in Appendix IV-G ~~Appendix IV-G~~ of this volume.
- Inform citizens about eliminating yard debris, oil and other wastes in street gutters to reduce street pollutant sources.

S431 BMPs for Washing and Steam Cleaning Vehicles/ Equipment/ Building Structures

Description of Pollutant Sources: Pollutant sources include the commercial cleaning of vehicles, aircraft, vessels, and other transportation, restaurant kitchens, carpets, and industrial equipment, and large buildings with low- or high-pressure water or steam. This includes “charity” car washes at gas stations and commercial parking lots. The cleaning can include hand washing, scrubbing, sanding, etc. Washwater from cleaning activities can contain oil and grease, suspended solids, heavy metals, soluble organics, soaps, and detergents that can contaminate stormwater.

Pollutant Control Approach: The preferred approach is to cover and/or contain the cleaning activity, or conduct the activity inside a building, to separate the uncontaminated stormwater from the ~~pollutant~~ washwater sources. ~~Washwater must be conveyed~~ Convey washwater to a sanitary sewer after approval by the local sewer authority, ~~temporarily stored,~~ Provide temporary storage before proper disposal, or ~~recycled,~~ with recycling. Under this preferred approach, no discharge to the ground, to a storm drain, or to surface water. ~~Washwater should occur.~~

The Industrial Stormwater General Permit prohibits the discharge of process wastewater (e.g., vehicle washing wastewater) to ground water or surface water. Stormwater that commingles with process wastewater is considered process wastewater.

Facilities not covered under the Industrial Stormwater General Permit that are unable to follow one of the preferred approaches listed above may be discharged ~~discharge washwater~~ to the ground only after proper treatment in accordance with Ecology guidance WQ-95-056, Vehicle and Equipment Washwater Discharges/Best Management Practices Manual, September 2007 or most recent update. Note that the Vehicle and Equipment Washwater Discharges/Best Management Practices Manual “Vehicle and Equipment Washwater Discharges,” June 1995, is scheduled to be updated in 2012. Please check for the most recent version of Ecology guidance.

The quality of any discharge to the ground after proper treatment must comply with Ecology’s Ground Water Quality Standards, Chapter 173-

[200 WAC Chapter 173-200 WAC.](#) ~~Contact the local Ecology Regional Office for an NPDES Permit application for discharge of wastewater to surface water or to a storm drain after on-site treatment.~~

~~Facilities not covered under the Industrial Stormwater General Permit that are unable to comply with one of the preferred approaches and want to discharge to storm sewer, must meet their local stormwater requirements. Local authorities may require treatment prior to discharge.~~

~~Contact the local Ecology Regional Office to discuss permitting options for discharge of wastewater to surface water or to a storm drain after on-site treatment.~~

Applicable Structural Source Control BMPs: Conduct vehicle/equipment washing in one of the following locations:

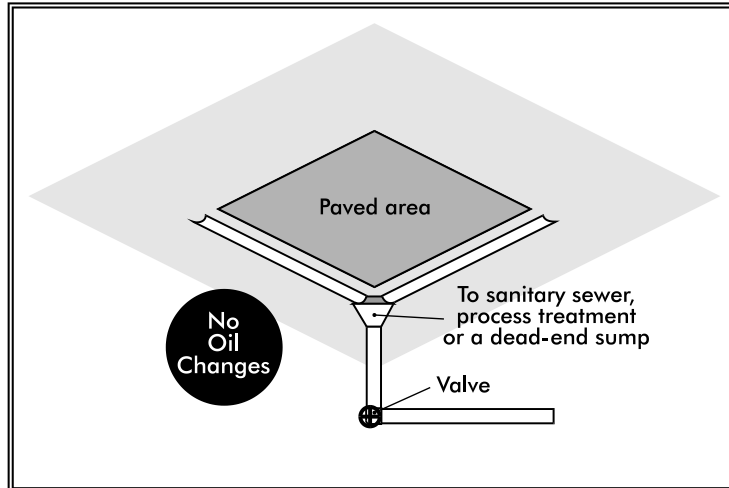
- At a commercial washing facility in which the washing occurs in an enclosure and drains to the sanitary sewer, or
- In a building constructed specifically for washing of vehicles and equipment, which drains to a sanitary sewer.

Conduct outside washing operation in a designated wash area with the following features:

- In a paved area, ~~constructed as~~construct a spill containment pad to prevent the run-on of stormwater from adjacent areas. Slope the spill containment area ~~so that to collect~~ washwater ~~is collected~~ in a containment pad drain system with perimeter drains, trench drains or catchment drains. Size the containment pad to extend out a minimum of four feet on all sides of the washed vehicles and/or equipment ~~being washed~~.
- ~~Convey the washwater to a sump (like a grit separator) and then to a sanitary sewer (if allowed by the local Sewer Authority), or other appropriate wastewater treatment or recycle system. An NPDES permit may be required for any washwater discharge to a storm drain or receiving water after treatment. Contact the Ecology regional office for NPDES Permit requirements.~~
- The containment sump must have a positive control outlet valve for spill control with live containment volume, and oil/water separation. Size the minimum live storage volume to contain the maximum expected daily washwater flow plus the sludge storage volume below the outlet pipe. Shut the outlet valve ~~will be shut~~ during the washing cycle to collect the washwater in the sump. The valve should remain shut for at least two hours following the washing operation to allow the oil and solids to separate before discharge to a sanitary sewer. ~~(See Ecology Publication WQ-95-056)~~
- Close the inlet valve in the discharge pipe ~~should be closed~~ when washing is not occurring, thereby preventing the entry of uncontaminated stormwater into the pretreatment/ treatment system. The stormwater can then drain into the conveyance/discharge system outside of the wash pad (essentially ~~bypasses~~bypassing the ~~washwater treatment/conveyance~~sanitary sewer or recycle system). Post signs to inform people of the operation and purpose of the valve. Clean the concrete pad thoroughly until there is no foam or visible sheen in the washwater prior to closing the inlet valve and allowing uncontaminated stormwater to overflow and drain off the pad. ~~(See Figure 2-15)~~
- Collect the washwater from building structures and convey it to appropriate treatment such as a sanitary sewer system if it contains

Note that the purpose of the valve is to convey only washwater and contaminated stormwater to a treatment system.

oils, soaps, or detergents, ~~where feasible.~~ If the washwater does not contain oils, soaps, or detergents (in this case only a low pressure, clean, cold water rinse is allowed) then it could drain to soils that have sufficient natural attenuation capacity for dust and sediment.



Recommended Additional BMPs:

- Mark the wash area ~~should be well marked~~ at gas stations, multi-family residences and any other business where non-employees wash vehicles.
- Operators may use a manually operated positive control valve for uncovered wash pads, ~~the positive control outlet valve may be manually operated,~~ but a pneumatic or electric valve system is preferable. The valve may be on a timer circuit ~~where it is~~ and opened upon completion of a wash cycle. After draining the sump or separator, the timer would then close the valve ~~after the sump or separator is drained (Figure 2-15).~~
- Use phosphate-free biodegradable detergents when practicable.
- Consider recycling the washwater.

Figure 2.15 – Uncovered Wash Area

~~Because Operators may use~~ soluble/emulsifiable detergents ~~can be used~~ in the wash medium, ~~and should use it with care and the appropriate treatment. Carefully consider~~ the selection of soaps and detergents and treatment BMPs ~~should be considered carefully.~~ Oil/water separators are ineffective in removing emulsified or water soluble detergents. Another treatment appropriate for emulsified and water soluble detergents may be required.

Exceptions

- At gas stations (for charity car washes) or commercial parking lots, where it is not possible to discharge the washwater to a sanitary sewer, a temporary plug or a temporary sump pump can be used at the storm drain to collect the washwater for off-site disposal such as to a nearby sanitary sewer.
- New and used car dealerships may wash vehicles in the parking stalls as long as employees use a temporary plug system ~~is used~~ to collect the washwater for disposal as stated above, or an approved treatment system for the washwater is in place.

At industrial sites, contact ~~the local~~ Ecology ~~Regional Office~~ for NPDES Permit requirements even ~~if when not using~~ soaps, detergents, and/or other chemical cleaners ~~are not used~~ in washing trucks.

S432 BMPs for Wood Treatment Areas

Description of Pollutant Sources: Wood treatment includes both anti-staining and wood preserving using pressure processes or by dipping or spraying. Wood preservatives include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate, arsenic trioxide, malathion, or inorganic arsenicals such as chromated copper arsenate, acid copper chromate, chromate zinc chloride, and fluor-chrome-arsenate-phenol. Anti-staining chemical additives include iodo-prophenyl-butyl carbamate, dimethyl sulfoxide, didecyl dimethyl ammonium chloride, sodium azide, 8-quinolinol; copper (II) chelate, sodium ortho-phenylphenate, 2-(thiocyanomethylthio)-benzothiazole (TCMTB) and methylene bis-(thiocyanate), and zinc naphthenate.

Pollutant sources include drips of condensate or preservative after pressurized treatment; product washwater (in the treatment or storage areas), spills and leaks from process equipment and preservative tanks, fugitive emissions from vapors in the process, blowouts and emergency pressure releases, and kick-back from lumber (phenomenon where preservative leaks as it returns to normal pressure). Potential pollutants typically include the wood treating chemicals, BOD, suspended solids, oil and grease, benzene, toluene, ethylbenzene, phenol, chlorophenols, nitrophenols, heavy metals, and PAH depending on the chemical additive used.

Pollutant Control Approach: Cover and contain all wood treating areas and prevent all leaching of and stormwater contamination by wood treating chemicals. ~~All wood treating facilities in Washington State are required to be covered under an Individual NPDES Permit.~~ Wood treating facilities may be covered by the Industrial Stormwater General Permit or by an individual permit. Individual permits covering wood treatment areas include applicable source control BMPs or require the development of BMPs or a SWPPP. Facilities covered under the Industrial Stormwater General Permit must prepare and implement a SWPPP. When developing a SWPPP or BMPs, wood treating facilities should include the applicable operational and structural source control BMPs listed below.

Applicable Operational BMPs: ~~The individual NPDES Permit will require at a minimum the following Operational BMPs:~~

- ~~Dedicate~~ Use dedicated equipment ~~that is used~~ for treatment activities to prevent the tracking of treatment chemicals to other areas on the site.
- Eliminate non-process traffic on the drip pad. Scrub down non-dedicated lift trucks on the drip pad.
- Immediately remove and properly dispose of soils with visible surface contamination (green soil) to prevent the spread of chemicals to ground water and/or surface water via stormwater runoff.
- ~~If any wood is observed to be contributing chemicals to the environment in the treated wood storage area, relocate it on~~ Relocate the wood to a concrete chemical containment structure until the surface is clean and until it is drip free and surface dry. if the wood contributes chemicals to the environment in the treated wood storage area.

Recommended Operational BMP:

Consider using preservative chemicals that do not adversely ~~impact~~ effect receiving surface water and ground water.

Applicable Structural Source Control BMPs: ~~The individual NPDES Permit will require at a minimum the following Structural Source Control BMPs:.~~

- Cover and/or enclose, and contain ~~with~~ impervious surfaces, all wood treatment areas. Slope and drain areas around dip tanks, spray booths, retorts, and any other process equipment in a manner that allows return of treatment chemicals to the wood treatment process.
- Cover storage areas for freshly treated wood to prevent contact of treated wood products with stormwater. Segregate clean stormwater from process water. ~~Ensure that~~ Convey all process water ~~is conveyed~~ to an approved treatment system.

- Seal any holes or cracks in the asphalt areas that are subject to wood treatment chemical contamination.
- Elevate stored, treated wood products to prevent contact with stormwater run-on and runoff
- Place dipped lumber over the dip tank, or on an inclined ramp for a minimum of 30 minutes to allow excess chemical to drip back to the dip tank.
- Place treated lumber ~~either~~ from dip tanks or retorts in a covered paved storage area for at least 24 hours before placement in outside storage. Use a longer storage period during cold weather unless the temporary storage building is heated. ~~The~~Prior to moving wood ~~shall be outside,~~ ensure that the wood is drip free and surface dry ~~before it is moved outside.~~

S433 BMPs for Pools, Spas, Hot Tubs, and Fountains

Description of Pollutant Sources: This section includes BMPs for pools, spas, hot tubs, and fountains used for recreational / decorative purposes that use chemicals and/or that are heated. Permittees that use pools, spas, hot tubs, and fountains as part of an industrial process should refer to their Industrial Stormwater Permit.

Discharge from pools, spas, hot tubs, and fountains can degrade ambient water quality. The waters from these sources typically contain bacteria that contaminate the receiving waters. Chemicals lethal to aquatic life such as chlorine, bromine and algaecides can be found in pools, spas, hot tubs, and fountains. These waters may be at an elevated temperature and can have negative effects on receiving waters and to aquatic life. Diatomaceous earth backwash from swimming pool filters can clog gills and suffocate fish.

Routine maintenance activities generate a variety of wastes. Chlorinated water, backwash residues, algaecides, and acid washes are a few examples. Direct disposal of these waters to storm drain systems and waters of the State is not permitted without prior treatment and approval.

The quality of any discharge to the ground after proper treatment must comply with Ecology's Ground Water Quality Standards, Chapter 173-200 WAC.

The Washington State Department of Health and local health authorities regulate Water Recreation facilities which include pools, spas, and hot tubs. Owners and operators of those facilities must comply with those regulations, policies and procedures. Following the guidelines here does not exempt or supersede any requirements of the regulatory authorities.

Pollutant Control Approach: Many manufacturers do not recommend draining pools, spas, hot tubs or fountains; refer to the facility's operation

and maintenance manual. If the water feature must be drained, convey discharges (within hoses or pipes) to a sanitary sewer if approved by the local sewer authority or to a storm sewer following the conditions outlined below. Do not discharge to a septic system, since it may cause the system to fail. No discharge to the ground, or to surface water should occur, unless permitted by the proper regulatory authority.

Applicable Operational BMPs:

- Clean the pool, spa, hot tub, or fountain regularly, maintain proper chlorine levels and maintain water filtration and circulation. Doing so will limit the need to drain the facility.
- Manage pH and water hardness to reduce copper pipe corrosion that can stain the facility and pollute receiving waters.
- Before using copper algaecides, try less toxic alternatives. Only use copper algaecides if the others alternative do not work. Ask a pool/spa/hot tub/fountain maintenance service or store for help resolving persistent algae problems without using copper algaecides.
- Develop and regularly update a facility maintenance plan that follows all discharge requirements.
- Dispose of unwanted chemicals properly. Many of them are hazardous wastes when discarded.
- Discharge waters originating from a pool/spa/hot tub/fountain to a sanitary sewer, if approved by the local sewer authority, local health authority or both. Do not discharge waters containing copper-based algaecides may to storm sewer systems.
- Do not discharge water directly from a pool, spa, hot tub, fountain, process wastes or wastewaters into storm drains except if the discharge water is:
 - Dechlorinated/debrominated to 0.1 ppm or less. (Some guidance on dechlorination is provided in the Department of Health's Water System Design Manual, Revised 12/09, DOH Publication 331-123. The Department of Health manual further references AWWA, 1999b, C651 - AWWA Standard for Disinfecting Water Mains, American Water Works Association, Denver, CO. and AWWA, 2002, C652 - AWWA Standard for Disinfecting Water Storage Facilities, American Water Works Association, Denver, CO. for more details.) Contact a pool chemical supplier to obtain the neutralizing chemicals needed.
 - pH-adjusted.
 - Reoxygenated if necessary
 - Free of any coloration, dirt, suds, or algae.
 - Free of any filter media.

- Free of acid cleaning wastes.
- At a temperature that will prevent an increase in temperature in the receiving water. Cool heated water prior to discharge.
- Released at a rate that can be accommodated by the receiving body (i.e. can infiltrate or be safely conveyed).
- Swimming pool cleaning wastewater and filter backwash shall not be discharged to the storm sewer.
- Bag diatomaceous earth (pool filtering agent) and dispose at a landfill.

Applicable Structural Source Control BMPs:

- Ensure that the pool/spa/hot tub/fountain system is free of leaks and operates within the design parameters.
- Do not provide any permanent links to storm drain systems. All connections should be visible and carefully controlled.
- If the dechlorination or cooling process selected requires the water to be stored for a time, it should be contained within the pool or appropriate temporary storage container.

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Appendix IV-A Urban Land Uses and Pollutant Generating Sources

Use this appendix to identify pollutant-generating sources at various land uses (manufacturing, transportation, communication, wholesale, retail, service - based on the 1987 Standard Industrial Classification codes (OMB, 1987), and public agencies). Applicable operational and structural source control and treatment BMPs for each pollutant source can then be selected by referring to [Chapter 2](#) of this Volume. Other land uses not included in this appendix should also consider implementing applicable [\(mandatory\)](#) BMPs for their pollutant sources.

A.1 Manufacturing Businesses

Cement **SIC: 3241**

Description: These businesses produce Portland cement, the binder used in concrete for paving, buildings, pipe, and other structural products. The three basic steps in cement manufacturing are: 1) proportioning, grinding, and blending raw materials; 2) heating raw materials to produce a hard, stony substance known as clinker; and 3) combining the clinker with other materials and grinding the mixture into a fine powdery form. The raw materials include limestone, silica, alumina, iron, chalk, oyster shell marl, or shale. Waste materials from other industries are often used such as slag, fly ash and spent blasting sand. Raw materials are crushed, mixed and heated in a kiln to produce the correct chemical composition. Kilns typically are coal, gas, or oil fired. The output of the kiln is a clinker that is ground to produce the final product.

The basic process may be wet or dry. In the wet process water is mixed with the raw ingredients in the initial crushing operation and in some cases is used to wash the material prior to use. Water may also be used in the air pollution control scrubber. The most significant waste material from cement production is the kiln dust. Concrete products may also be produced at ready-mix concrete facilities. Refer to "Concrete Products" for a description of the BMPs appropriate to these activities.

Potential Pollutant Generating Sources: Stormwater may be contaminated during the crushing, grinding, storage, and handling of kiln dust, limestone, shale, clay, coal, clinker, gypsum, anhydrite, slag, sand, and product and at the vehicle and equipment maintenance, fueling, and cleaning areas. Total suspended solids, aluminum, iron and other heavy metals, pH, COD, potassium, sulfate, and oil and grease are some of the potential pollutants. The following mean concentrations in stormwater discharges have been reported Environmental Protection Agency (EPA's) multi-sector permit fact sheet (EPA, 1995): TSS=1067, COD=107.5,

aluminum=72.6, iron=7.5, all in mg/L, and pH=2-12. These values may be useful in characterizing stormwater contaminants at cement manufacturing facilities.

Chemicals Manufacturing

SIC: 2800, 3861

Description: This group is engaged in the manufacture of chemicals, or products based on chemicals such as acids, alkalis, inks, chlorine, industrial gases, pigments, chemicals used in the production of synthetic resins, fibers and plastics, synthetic rubber, soaps and cleaners, pharmaceuticals, cosmetics, paints, varnishes, resins, photographic materials, chemicals, organic chemicals, agricultural chemicals, adhesives, sealants, and ink.

Potential Pollutant Generating Sources: Activities that can contaminate stormwater include bagging, blending, packaging, crushing, milling, shredding, granulation, grinding, storage, distribution, loading/unloading, and processing of materials; equipment storage; application of fertilizers; foundries; lime application; use of machinery; material handling and warehousing; cooling towers; fueling; boilers; ~~hazardous~~ dangerous waste treatment, storage and disposal; wastewater treatment; plant yard areas of past industrial activity; access roads and tracks; drum washing, and maintenance and repair.

Chemical businesses in the Seattle area surveyed for dangerous wastes have been found to produce waste caustic solutions, soaps, heavy metal solutions, inorganic and organic chemicals, solvents, acids, alkalis, paints, varnishes, pharmaceuticals, and inks. The potential pollutants include BOD, TSS, COD, oil and grease, pH, total phosphorus, nitrates, nitrites, total Kjeldahl nitrogen, ammonia, specific organics, and heavy metals. EPA stormwater multi-sector permit fact sheet data ⁽⁷⁾ includes the following mean values in mg/L except pH: BOD, 4.4-143.2; TSS, 35-493; COD, 42.36-245.3; Oil and Grease, 0.3-6.0; NO₂+NO₃, 0.3-35.9; TKN, 1.3-108.9; tot. P, 0.1-65.7; ammonia, 40.45-73.22; Al, 1.20-1.78; Cu, .12-19; Mn, .56-. 71; Zn, 1.74-2.11; Fe, 2.24-3.52 and pH, 3.5-10.4. This data could be helpful in characterizing stormwater pollutants at the facility.

Concrete Products

SIC: 3270

Description: Businesses that manufacture ready-mix concrete, gypsum products, concrete blocks and bricks, concrete sewer or drainage pipe, septic tanks, and prestressed concrete building components. Concrete is prepared on-site and poured into molds or forms to produce the desired product. The basic ingredients of concrete are sand, gravel, Portland cement, crushed stone, clay, and reinforcing steel for some products. Admixtures including fly ash, calcium chloride, triethanolamine, lignosulfonic acid, sulfonated hydrocarbon, fatty acid glyceride, or vinyl

acetate, which may be added to obtain desired characteristics such as slower or more rapid curing times.

The first stage in the manufacturing process is proportioning cement, aggregate, admixtures and water, and then transporting the product to a rotary drum, or pan mixer. The mixture is then fed into an automatic block-molding machine that rams, presses, or vibrates the mixture into its final form. The final product is then stacked on iron framework cars where it cures in four hours. After being mixed in a central mixer, concrete is molded in the same manner as concrete block. The concrete cures in the forms for a number of hours. Forms are washed for reuse, and the concrete products are stored until they can be shipped.

Potential Pollutant Generating Sources: Pollutant generating activities/sources include stockpiles; washing of waste concrete from trucks, forms, equipment, and the general work area; and water from the curing of concrete products. Besides the basic ingredients for making concrete products, chemicals used in the curing of concrete and the removal of forms may end up in stormwater. These chemicals can include latex sealants, bitumastic coatings and release agents. Trucks and equipment maintained on-site may generate waste oil and solvents, and other waste materials. Potential pollutants include TSS, COD, BOD, pH, lead, iron, zinc, and oil and grease.

Electrical Products

SIC: 3600, 3800

Description: A variety of products are produced including electrical transformers and switchgear, motors, generators, relays, and industrial controls; communications equipment for radio and TV stations and systems; electronic components and accessories including semiconductors; printed board circuits; electromedical and electrotherapeutic apparatus; and electrical instrumentation. Manufacturing processes include electroplating, machining, fabricating, etching, sawing, grinding, welding, and parts cleaning. Materials used include metals, ceramics, quartz, silicon, inorganic oxides, acids, alkaline solutions, arsenides, phosphides, cyanides, oils, fuels, solvents, and other chemicals.

Potential Pollutant Generating Sources: Pollutant generating activities/sources include bulk storage of raw materials, by-products or finished products; loading and unloading of liquid materials from truck or rail; temporary storage of waste oil and solvents from cleaning manufacturing equipment; used equipment temporarily stored on site that could drip oil and residual process materials; maintenance and repair of vehicles and equipment; and temporary storage of Dangerous Wastes.

Waste liquids which are sometimes stored outside include spent acetone and solvents, ferric chloride solutions, soldering fluxes mixed with thinner or alcohol, spent acids, and oily waste. Several of these liquid wastes contain chlorinated hydrocarbons, ammonium salts, and metals such as

chromium, copper, lead, silver, zinc, nickel, and tin. Waste solids include soiled rags and sanding materials.

Wastewater consists of solutions and rinses from electroplating operations, and the wastewaters from cleaning operations. Water may also be used to cool saws and grinding machines. Sludges are produced by the wastewater treatment process. Potential pollutants include TSS, oil and grease, organics, pH, BOD, COD, Total Kjeldahl Nitrogen, Nitrate and Nitrite Nitrogen, copper, zinc, lead, and silver.

Food Products

SIC: 2000

Description: Businesses in this category include meat packing plants, poultry slaughtering and processing, sausage and prepared meats, dairy products, preserved fruits and vegetables, flour, bakery products, sugar and confectioneries, vegetable and animal oils, beverages, canned, frozen or fresh fish, pasta products, snack foods, and manufactured ice. Food processing typically occurs inside buildings. Exceptions are meat packing plants where live animals may be kept outside, and fruit and vegetable plants where the raw material may be temporarily stored outside. Meat production facilities include stockyards, slaughtering, cutting and deboning, meat processing, rendering, and materials recovery. Dairy production facilities include receiving stations, clarification, separation, and pasteurization followed by culturing, churning, pressing, curing, blending, condensing, sweetening, drying, milling, and packaging. Canned frozen and preserved fruits and vegetables are typically produced by washing, cutting, blanching, and cooking followed by drying, dehydrating, and freezing.

Grain mill products are processed during washing, milling, debranning, heat treatment, screening, shaping, and vitamin and mineral supplementing. Bakery products processing includes mixing, shaping, of dough, cooling, and decorating. Operations at an edible oil manufacturer include refining, bleaching, hydrogenation, fractionation, emulsification, deodorization, filtration, and blending. Beverage production includes brewing, distilling, fermentation, blending, and packaging. Wine processors often crush grapes outside the process building and/or store equipment outside when not in use. Some wine producers use juice from grapes crushed elsewhere. Some vegetable and fruit processing plants use caustic solutions.

Potential Pollutant Generating Sources: The following are potential stormwater pollutant causing activities/sources: loading/unloading of materials, equipment/vehicle maintenance, liquid storage in tanks and drums, air emissions (ovens, vents), solid wastes handling and storage, wastewater treatment, pest control, animal containment and transit, and vegetable storage. Materials exposed to stormwater include acids, ammonia, activated carbon, bleach, blood, bone meal, brewing residuals, caustic soda, chlorine, coke oven tar, detergents, eggs, feathers, feed,

ferric chloride, fruits, vegetables, coffee beans, gel bone, grain, hides, lard, manure, milk, salts, skim powder, starch, sugar, tallow, ethyl alcohol, oils, fats, whey, yeast, and wastes. The following are the pollutants typically expected from this industry segment: BOD, TSS, Oil and Grease, pH, Kjeldahl Nitrogen, copper, manganese, fecal coliform, and pesticides.

Glass Products

SIC: 3210, 3220, 3230

Description: The glass form produced may be flat or window glass, safety glass, or container glass, tubing, glass wool, or fibers. The raw materials are sand mixed with a variety of oxides such as aluminum, antimony, arsenic, lead, copper, cobalt oxide, and barium. The raw materials are mixed and heated in a furnace. Processes that vary with the intended product shape the resulting molten material. The cooled glass may be edged, ground, polished, annealed and/or heat-treated to produce the final product. Air emissions from the manufacturing buildings are scrubbed to remove particulates.

Potential Pollutant Generating Sources: Raw materials are generally stored in silos except for crushed recycled glass and materials washed off recycled glass. Contamination of stormwater and/or ground water can be caused by raw materials lost during unloading operations, errant flue dust, equipment/vehicle maintenance and engine fluids from mobile lifting equipment that is stored outside. The maintenance of the manufacturing equipment will produce waste lubricants and cleaning solvents. The flue dust is likely to contain heavy metals such as arsenic, cadmium, chromium, mercury, and lead. Potential pollutants include suspended solids, oil and grease, high/low pH, and heavy metals such as arsenic, cadmium, chromium, mercury, and lead.

Industrial Machinery and Equipment, Trucks and Trailers, Aircraft, Aerospace, and Railroad

SIC: 3500, 3713/14, 3720, 3740, 3760, 3800

Description: This category includes the manufacture of a variety of equipment including engines and turbines, farm and garden equipment, construction and mining machinery, metal working machinery, pumps, computers and office equipment, automatic vending machines, refrigeration and heating equipment, and equipment for the manufacturing industries. This group also includes many small machine shops, and the manufacturing of trucks, trailers and parts, airplanes and parts, missiles, spacecraft, and railroad equipment and instruments.

Manufacturing processes include various forms of metal working and finishing, such as electroplating, anodizing, chemical conversion coating, etching, chemical milling, cleaning, machining, grinding, polishing, sand blasting, laminating, hot dip coating, descaling, degreasing, paint stripping, painting, and the production of plastic and fiberglass parts. Raw materials include ferrous and non-ferrous metals, such as aluminum,

copper, iron, steel, and their alloys, paints, solvents, acids, alkalis, fuels, lubricating and cutting oils, and plastics.

Potential Pollutant Generating Sources: Potential pollutant sources include fuel islands, maintenance shops, loading/unloading of materials, and outside storage of gasoline, diesel, cleaning fluids, equipment, solvents, paints, wastes, detergents, acids, other chemicals, oils, metals, and scrap materials. Air emissions from stacks and ventilation systems are potential areas for exposure of materials to rain water.

Metal Products

SIC: 2514, 2522, 2542, 3312, 3314-17, 3320, 3350, 3360, 3400, 3590

Description: This group includes mills that produce basic metals and primary products, as well as foundries, electroplaters, and fabricators of final metal products. Basic metal production includes steel, copper, and aluminum. Mills that transform metal billets, either ferrous or nonferrous such as aluminum, to primary metal products are included. Primary metal forms include sheets, flat bar, building components such as columns, beams and concrete reinforcing bar, and large pipe.

Steel mills in the Pacific Northwest use recycled metal and electric furnaces. The molten steel is cast into billets or ingots that may be reformed on site or taken to rolling mills that produce primary products. As iron and steel billets may sit outside before reforming, surface treatment to remove scale may occur prior to reforming. Foundries pour or inject molten metal into a mold to produce a shape that cannot be readily formed by other processes. The metal is first melted in a furnace. The mold is made of sand or metal die blocks that are locked together to make a complete cavity. The molten metal is ladled in and the mold is cooled. The rough product is finished by quenching, cleaning and chemical treatment. Quenching involves immersion in a plain water bath or water with an additive.

Businesses that fabricate metal products from metal stock provide a wide range of products. The raw stock is manipulated in a variety of ways including machining of various types, grinding, heating, shearing, deformation, cutting and welding, soldering, sand blasting, brazing, and laminating. Fabricators may first clean the metal by sand blasting, descaling, or solvent degreasing. Final finishing may involve electroplating, painting, or direct plating by fusing or vacuum metalizing. Raw materials, in particular recycled metal, are stored outside prior to use, as are billets before reforming. The descaling process may use salt baths, sodium hydroxide, or acid (pickling).

Primary products often receive a surface coating treatment. Prior to the coating the product surface may be prepared by acid pickling to remove scale or alkaline cleaning to remove oils and greases. The two major classes of metallic coating operations are hot and cold coating. Zinc, tin

and aluminum coatings are applied in molten metal baths. Tin and chromium are usually applied electrolytically from plating solutions.

Potential Pollutant Generating Sources: Potential pollutant generating sources include outside storage of chemicals, metal feedstock, byproducts (fluxes), finished products, fuels, lubricants, waste oil, sludge, waste solvents, Dangerous Wastes, piles of coal, coke, dusts, fly ash, baghouse waste, slag, dross, sludges, sand refractory rubble, and machining waste; unloading of chemical feedstock and loading of waste liquids such as spent pickle liquor by truck or rail; material handling equipment such as cranes, conveyors, trucks, and forklifts; particulate emissions from scrubbers, baghouses or electrostatic precipitators; fugitive emissions; maintenance shops; erosion of soil from plant yards; and floor, sink, and process wastewater drains.

Based on EPA's multi-sector industrial stormwater permit/fact sheet the following are ranges of mean composite/grab pollutant concentrations from this industrial group (values are in mg/L except pH): BOD at 34.1/32.2; COD at 109.8/221.3; NO₂+NO₃ N at 1.38/1.17; TKN at 3.05/3.56; Oil and grease at 8.88 (grab); pH at 2.6-10.3 (range-grab); total phosphorus at .52/1.25; TSS at 162/368; copper at 2.28/3.53; lead at .19/.79; zinc at 6.60/8.90; aluminum at 2.6/4.8; iron at 32.30/45.97; cadmium at 0.015/0.074; chromium at 2.2/5.053; nickel at 0.75/0.7; manganese at .59/.68; ammonia at .55/.85; and pyrene at .01/.06.

Paper and Pulp

SIC: 2610, 2620, 2630

Description: Large industrial complexes in which pulp and/or paper, and/or paperboard are produced. Products also include newsprint, bleached paper, glassine, tissue paper, vegetable parchment, and industrial papers. Raw materials include: wood logs, chips, wastepaper, jute, hemp, rags, cotton linters, bagasse, and esparto. The chips for pulping may be produced on-site from logs, and/or imported.

The following manufacturing processes are typically used: raw material preparation, pulping, bleaching, and papermaking. All of these operations use a wide variety of chemicals including caustic soda, sodium and ammonium sulfites, chlorine, titanium oxide, starches, solvents, adhesives, biocides, hydraulic oils, lubricants, dyes, and many chemical additives.

Potential Pollutant Generating Sources: The large process equipment used for pulping is not enclosed. Thus, precipitation falling over these areas may become contaminated. Maintenance of the process equipment produces waste products similar to that produced from vehicle and mobile equipment maintenance. Logs may be stored, debarked and chipped on site. Large quantities of chips are stored outside. Although this can be a source of pollution, the volume of stormwater flow is relatively small because the chip pile retains the majority of the precipitation. Mobile equipment such as forklifts, log stackers, and chip dozers are sources of

leaks/spills of hydraulic fluids. Vehicles and equipment are fueled and maintained on-site.

Paper Products

SIC: 2650, 2670

Description: Included are businesses that take paper stock and produce basic paper products such as cardboard boxes and other containers, and stationery products such as envelopes and bond paper. Wood chips, pulp, and paper can be used as feedstock.

Potential Pollutant Generating Sources: The following are potential pollutant sources:

1. ~~1.~~ Outside loading/unloading of solid and liquid materials.
2. ~~2.~~ Outside storage and handling of dangerous wastes, and other liquid and solid materials.
3. ~~3.~~ Maintenance and fueling activities.
4. ~~4.~~ Outside processing activities comparable to Pulp and Paper processing in preceding section.

Petroleum Products

SIC: 2911, 2950

Description: The petroleum refining industry manufactures gasoline, kerosene, distillate and residual oils, lubricants and related products from crude petroleum, and asphalt paving and roofing materials. Although petroleum is the primary raw material, petroleum refineries also use other materials such as natural gas, benzene, toluene, chemical catalysts, caustic soda, and sulfuric acid. Wastes may include filter clays, spent catalysts, sludges, and oily water.

Asphalt paving products consist of sand, gravel and petroleum-based asphalt that serves as the binder. Raw materials include stockpiles of sand and gravel and asphalt emulsions stored in aboveground tanks.

Potential Pollutant Generating Sources:

- Outside processing such as distillation, fractionation, catalytic cracking, solvent extraction, coking, desulfuring, reforming, and desalting.
- Petrochemical and fuel storage and handling.
- Outside liquid chemical piping and tankage.
- Mobile liquid handling equipment such as tank trucks, forklifts, etc.
- Maintenance and parking of trucks and other equipment.
- Waste Piles, and handling and storage of asphalt emulsions, cleaning chemicals, and solvents.
- Waste treatment and conveyance systems.

The following are potential pollutants at oil refineries: oil and grease, BOD5, COD, TOC, phenolic compounds, PAH, ammonia nitrogen, TKN, sulfides, TSS, low and high pH, and chromium (total and hexavalent).

Printing
SIC: 2700

Description: This industrial category includes the production of newspapers, periodicals, commercial printing materials and businesses that do their own printing and those that perform services for the printing industry, for example bookbinding. Processes include typesetting, engraving, photoengraving, and electrotyping.

Potential Pollutant Generating Sources: Various materials used in modifying the paper stock include inorganic and organic acids, resins, solvents, polyester film, developers, alcohol, vinyl lacquer, dyes, acetates, and polymers. Waste products may include waste inks and ink sludge, resins, photographic chemicals, solvents, acid and alkaline solutions, chlorides, chromium, zinc, lead, spent formaldehyde, silver, plasticizers, and used lubricating oils. As the printing operations occur indoors, the only likely points of potential contact with stormwater are the outside temporary storage of waste materials, offloading of chemicals at external unloading bays, and vehicle/equipment repair and maintenance. Pollutants of concern include TSS, pH, heavy metals, oil and grease, and COD.

Rubber and Plastic Products
SIC: 3000

Description: Although different in basic feedstock and processes used, businesses that produce rubber, fiberglass and plastic products belong to the same SIC group. Products in this category include rubber tires, hoses, belts, gaskets, seals; and plastic sheet, film, tubes, pipes, bottles, cups, ice chests, packaging materials, and plumbing fixtures. The rubber and plastics industries use a variety of processes ranging from polymerization to extrusion using natural or synthetic raw materials. These industries use natural or synthetic rubber, plastics components, pigments, adhesives, resins, acids, caustic soda, zinc, paints, fillers, and curing agents.

Potential Pollutant Generating Sources: Pollutant generating sources/activities include storage of liquids, other raw materials or by-products, scrap materials, oils, solvents, inks and paints; unloading of liquid materials from trucks or rail cars; washing of equipment; waste oil and solvents produced by cleaning manufacturing equipment; used equipment that could drip oil and residual process materials; and maintenance shops.

Based on data in EPA's multi-sector permit fact sheet the following are mean pollutant concentrations in mg/L, except for pH (unitless) and 1,1,1 trichloroethane, methylene chloride, toluene, zinc, oil/grease which are min.-max. grab sample values: BOD at 11.21-13.92, COD at 72.08-100.0,

NO₃ + NO₂ Nitrogen at 86-1.26, TKN at 1.55-2.34, total phosphorus at .34-.41, TSS at 119.32-188.55, pH range of 2.56-10.1, trichloroethane at 0.00-0.38, methylene chloride at 0.00-13.0, toluene at 0.00-3.8, zinc at .011-7.60 and oil and grease at 0.0-91.0. These data may be helpful in characterizing potential stormwater pollutants.

Ship and Boat Building and Repair Yards

SIC: 3730

Description: Businesses that build or repair ships and boats. Typical activities include hull scraping, sandblasting, finishing, metal fabrication, electrical repairs, engine overhaul, and welding, fiberglass repairs, hydroblasting and steam cleaning.

Potential Pollutant Generating Sources: Outside boatyard activities that can be sources of stormwater pollution include pressure washing, surface preparation, paint removal, sanding, painting, engine/vessel maintenance and repairs, and material handling and storage.

Secondary sources of stormwater contaminants are cooling water, pump testing, gray water, sanitary waste, washing down the work area, and engine bilge water. Engine room bilge water and oily wastes are typically collected and disposed of through a licensed contracted disposal company. Two prime sources of copper are leaching of copper from anti-fouling paint and wastes from hull maintenance. Wastes generated by boatyard activities include spent abrasive grits, spent solvent, spent oils, fuel, ethylene glycol, washwater, paint overspray, various cleaners/detergents and anti-corrosive compounds, paint chips, scrap metal, welding rods, wood, plastic, resins, glass fibers, dust, and miscellaneous trash such as paper and glass.

Ecology, local shipyards, and METRO have sampled pressure wash wastewater. The effluent quality has been variable and frequently exceeds water quality criteria for copper, lead, tin, and zinc. From monitoring results received to date, metal concentrations typically range from 5 to 10 mg/L, but have gone as high as 190 mg/L copper with an average 55 mg/L copper.

Wood

SIC 2420, 2450, 2434, 2490, 2511/12, 2517, 2519, 2521, 2541

Description: This group includes sawmills, and all businesses that make wood products using cut wood, with the exception of wood treatment businesses. Wood treatment as well as log storage and sorting yards are covered in other sections of this chapter. Included in this group are planing mills, millworks, and businesses that make wooden containers and prefab building components, mobile homes, and glued-wood products like laminated beams, as well as office and home furniture, partitions, and cabinets. All businesses employ cutting equipment whose by-products are chips and sawdust. Finishing is conducted in many operations.

Potential Pollutant Generating Sources: Businesses may have operations that use paints, solvents, wax emulsions, melamine formaldehyde and other thermosetting resins, and produce waste paints and paint thinners, turpentine, shellac, varnishes and other waste liquids. Outside storage, trucking, and handling of these materials can also be pollutant sources.

Potential pollutants reported in EPA's draft multi-sector permit/fact sheet (U.S. EPA, 1995) include the following (all are grab/composite mean values, in mg/L, except for oil and grease and pH): BOD at 39.6/45.4, COD at 297.6/242.5, NO₃ + NO₂-N at 0.95/0.75, TKN at 2.57/2.32, Tot. Phosphorus at 23.91/6.29; TSS at 1108/575, arsenic at .025/.028, copper at .047/.041, total phenols at .02/.007, oil and grease at 15.2, and pH at 3.6. These data may help in characterizing the potential stormwater pollutants at the facility.

Wood Treatment

SIC: 2491

Description: This group includes both anti-staining and wood preserving. The wood stock must be brought to the proper moisture content prior to treatment, which is achieved by either air-drying or kiln drying. Some wood trimming may occur. After treatment, the lumber is typically stored outside. Forklifts are used to move both the raw and finished product. Wood treatment consists of a pressure process using the chemicals described below. Anti-staining treatment is conducted using dip tanks or by spraying. Wood preservatives include creosote, creosote/coal tar, pentachlorophenol, copper naphthenate or inorganic arsenicals such as chromated copper arsenate dissolved in water. The use of pentachlorophenol is declining in the Puget Sound region.

Potential Pollutant Generating Sources: Potential pollutant generating sources/activities include the retort area, handling of the treated wood, outside storage of treated materials/products, equipment/vehicle storage and maintenance, and the unloading, handling, and use of the preservative chemicals. Based on EPA's multi-sector permit/fact sheet (U.S. EPA, 1995) the following stormwater contaminants have been reported: COD, TSS, BOD, and the specific pesticide(s) used for the wood preservation.

Other Manufacturing Businesses

SIC: 2200, 2300, 2873/74, 3100, 3200, 3250-69, 3280, 3290

Description: Includes manufacturing of textiles and apparel, agricultural fertilizers, leather products, clay products such as bricks, pottery, bathroom fixtures; and nonmetallic mineral products.

Potential Pollutant Generating Sources: Pollutant generating sources at facilities in these categories include fueling, loading & unloading, material storage and handling (especially fertilizers), and vehicle and equipment cleaning and maintenance. Potential pollutants include TSS, BOD, COD,

Oil and Grease, heavy metals and fertilizer components including nitrates, nitrites, ammonia nitrogen, Kjeldahl Nitrogen, and phosphorous compounds.

A.2 Transportation and Communication

2.——Airfields and Aircraft Maintenance

SIC: 4513, 4515

Description: Industrial activities include vehicle and equipment fueling, maintenance and cleaning, and aircraft/runway deicing.

Potential Pollutant Generating Sources: Fueling is accomplished by tank trucks at the aircraft and is a source of spills. Dripping of fuel and engine fluids from the aircraft and at vehicle/equipment maintenance/cleaning areas application of deicing materials to the aircraft and the runways are potential sources of stormwater contamination. Aircraft maintenance and cleaning produces a wide variety of waste products, similar to those found with any vehicle or equipment maintenance, including: used oil and cleaning solvents, paints, oil filters, soiled rags, and soapy wastewater. Deicing materials used on aircraft and/or runways include ethylene and propylene glycol, and urea. Other chemicals currently considered for ice control are sodium and potassium acetates, isopropyl alcohol, and sodium fluoride. Pollutant constituents include oil and grease, TSS, BOD, COD, TKN, pH and specific deicing components such as glycol and urea.

Fleet Vehicle Yards

SIC: 4100, 4210, 4230, 7381/2, 7510

Description: Includes all businesses which own, operate and maintain or repair large vehicle fleets, including cars, buses, trucks and taxis, as well as the renting or leasing of cars, trucks, and trailers.

Potential Pollutant Generating Sources:

1. Spills/leaks of fuels, used oils, oil filters, antifreeze, solvents, brake fluid, and batteries, sulfuric acid, battery acid sludge, and leaching from empty contaminated containers and soiled rags.

1-2. Leaking underground storage tanks that can cause ground water contamination and is a safety hazard.

2-3. 3.—Dirt, oils and greases from outside steam cleaning and vehicle washing.

3-4. 4.—Dripping of liquids from parked vehicles.

4-5. 5.—Solid and liquid wastes (noted above) that are not properly stored while awaiting disposal or recycling.

5-6. 6.—Loading and unloading area.

Railroads

SIC: 4011/13

Description: Railroad activities are spread over a large geographic area: along railroad lines, in switching yards, and in maintenance yards. Railroad activity occurs on both property owned or leased by the railroad and at the loading or unloading facilities of its customers. Employing BMPs at commercial or public loading and unloading areas is the responsibility of the particular property owner.

Potential Pollutant Generating Sources: The following are potential sources of pollutants: dripping of vehicle fluids onto the road bed, leaching of wood preservatives from the railroad ties, human waste disposal, litter, locomotive sanding areas, locomotive/railcar/equipment cleaning areas, fueling areas, outside material storage areas, the erosion and loss of soil particles from the bed, and herbicides used for vegetation management.

Maintenance activities include maintenance shops for vehicles and equipment, track maintenance, and ditch cleaning. In addition to the railroad stock, the maintenance shops service highway vehicles and other types of equipment. Waste materials can include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions, brake fluids, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips with residual machining oil and any toxic fluids or solids lost during transit. The following are potential pollutants at railyards: Oil and grease, TSS, BOD, organics, pesticides, and heavy metals.

Warehouses and Mini-Warehouses

SIC: 4220

Description: Businesses that store goods in buildings and other structures.

Potential Pollutant Generating Sources: The following are potential pollutant sources from warehousing operations: Loading and unloading areas, outside storage of materials and equipment, fueling and maintenance areas. Potential pollutants include oil and grease and TSS.

Other Transportation and Communication

SIC: 4700-4900

Description: This group includes travel agencies, communication services such as TV and radio stations, cable companies, and electric and gas services. It does not include railroads, airplane transport services, airlines, pipeline companies, and airfields.

Potential Pollutant Generating Sources: Gas and electric services are likely to own vehicles that are washed, fueled and maintained on site. Communication service companies can generate used oils and Dangerous Wastes. The following are the potential pollutants: Oil and grease, TSS, BOD, and heavy metals.

A.3 Retail and Wholesale Businesses

Gas Stations

SIC: 5540

Refer to [S409 BMPs Fueling at Dedicated Stations](#) in [Chapter 2](#) of this Volume to select applicable BMPs.

Recyclers and Scrap Yards

SIC: 5093, 5015

Refer to [S423 BMPs for Recyclers and Scrap Yards](#)

Commercial Composting

SIC 2875

Description: This typically applies to businesses that have numerous compost piles that require large open areas to break down the wastes. Composting can contribute nutrients, organics, coliform bacteria, low pH, color, and suspended solids to stormwater runoff.

Potential Pollutant Generating Sources: The compost is required to be contained, but may be a cause for concern during loading and unloading. Compost can have high levels of nutrients, organics, coliform bacteria, low pH, color concerns and suspended solids. Composting requires heavy equipment such as trucks and loaders. The equipment can generate oil and grease.

Restaurants/Fast Food

SIC: 5800

Description: Businesses that provide food service to the general public, including drive through facilities.

Potential Pollutant Generating Sources: Potential pollutant sources include high-use customer parking lots and garbage dumpsters. The cleaning of roofs and other outside areas of restaurant and cooking vent filters in the parking lot can cause cooking grease to be discharged to the storm drains. The discharge of washwater or grease to storm drains or surface water is not allowed.

Retail/General Merchandise

SIC: 5300, 5600, 5700, 5900, and 5990

Description: This group includes general merchandising stores such as department stores, shopping malls, variety stores, 24-hour convenience stores, and general retail stores that focus on a few product types such as clothing and shoes. It also includes furniture and appliance stores.

Potential Pollutant Generating Sources: Of particular concern are the high-use parking lots of shopping malls and 24-hour convenience stores. Furniture and appliance stores may provide repair services in which Dangerous Wastes may be produced.

Retail/Wholesale Vehicle and Equipment Dealers

SIC: 5010, 5080, and 5500, 751 excluding fueling stations (5540)

Description: This group includes all retail and wholesale businesses that sell, rent, or lease cars, trucks, boats, trailers, mobile homes, motorcycles and recreational vehicles. It includes both new and used vehicle dealers. It also includes sellers of heavy equipment for construction, farming, and industry. With the exception of motorcycle dealers, these businesses have large parking lots. Most retail dealers that sell new vehicles and large equipment also provide repair and maintenance services.

Potential Pollutant Generating Sources: Oil and other materials that have dripped from parked vehicles can contaminate stormwater at high-use parking areas. Vehicles are washed regularly generating vehicle grime and detergent pollutants. The storm or washwater runoff will contain oils and various organics, metals, and phosphorus. Repair and maintenance services generate a variety of waste liquids and solids including used oils and engine fluids, solvents, waste paint, soiled rags, and dirty used engine parts. Many of these materials are Dangerous Wastes.

Retail/Wholesale Nurseries and Building Materials

SIC: 5030, 5198, 5210, 5230, and 5260

Description: These businesses are placed in a separate group because they are likely to store much of their merchandise outside of the main building. They include nurseries, and businesses that sell building and construction materials and equipment, paint (5198, 5230) and hardware.

Potential Pollutant Generating Sources: Some businesses may have small fueling capabilities for forklifts and may also maintain and repair their vehicles and equipment. Some businesses may have unpaved areas, with the potential to contaminate stormwater by leaching of nutrients, pesticides, and herbicides. Businesses in this group surveyed in the Puget Sound area for Dangerous Wastes were found to produce waste solvents, paints and used oil. Storm runoff from exposed storage areas can contain suspended solids, and oil and grease from vehicles and forklifts and high-use customer parking lots, and other pollutants. Runoff from nurseries may contain nutrients, pesticides and/or herbicides.

Retail/Wholesale Chemicals and Petroleum

SIC: 5160, 5170

Description: These businesses sell plastic materials, chemicals and related products. This group also includes the bulk storage and selling of petroleum products such as diesel oil, automotive fuels, etc.

Potential Pollutant Generating Sources: The general areas of concern are the spillage of chemicals or petroleum during loading and unloading, and the washing and maintenance of tanker trucks and other vehicles. Also, the fire code requires that vegetation be controlled within a tank farm to avoid a fire hazard. Herbicides are typically used. The

concentration of oil in untreated stormwater is known to exceed the water quality effluent guideline for oil and grease. Runoff is also likely to contain significant concentrations of benzene, phenol, chloroform, lead, and zinc.

Retail/Wholesale Foods and Beverages
SIC: 5140, 5180, 541, 542, 543

Description: Included are businesses that provide retail food stores including general groceries, fish and seafood, meats and meat products, dairy products, poultry, soft drinks, and alcoholic beverages.

Potential Pollutant Generating Sources: Vehicles may be fueled, washed and maintained at the business. Spillage of food and beverages may occur. Waste food and broken contaminated glass may be temporarily stored in containers located outside. High-use customer parking lots may be sources of oil and other contaminants

Other Retail/Wholesale Businesses
SIC: 5010 (not 5012), 5040, 5060, 5070, 5090, 515

Description: Businesses in this group include sellers of vehicle parts, tires, furniture and home furnishings, photographic and office equipment, electrical goods, sporting goods and toys, paper products, drugs, and apparel.

Potential Pollutant Generating Sources: Pollutant sources include high-use parking lots, and delivery vehicles that may be fueled, washed, and maintained on premises.

A.4 Service Businesses

Animal Care Services
SIC: 0740, 0750

Description: This group includes racetracks, kennels, fenced pens, veterinarians and businesses that provide boarding services for animals including horses, dogs, and cats.

Potential Pollutant Generating Sources: The primary sources of pollution include animal manure, washwaters, waste products from animal treatment, runoff from pastures where larger livestock are allowed to roam, and vehicle maintenance and repair shops. Pastures may border streams and direct access to the stream may occur. Both surface water and ground water may be contaminated. Potential stormwater contaminants include fecal coliform, oil and grease, suspended solids, BOD, and nutrients.

Commercial Car and Truck Washes

SIC: 7542

Description: Facilities include automatic systems found at individual businesses or at gas stations and 24-hour convenience stores, as well as self-service. There are three main types: tunnels, rollovers and hand-held wands. The tunnel wash, the largest, is housed in a long building through which the vehicle is pulled. At a rollover wash the vehicle remains stationary while the equipment passes over. Wands are used at self-serve car washes. Some car washing businesses also sell gasoline.

Potential Pollutant Generating Sources: Wash wastewater may contain detergents and waxes. Wastewater should be discharged to sanitary sewers. In self-service operations a drain is located inside each car bay. Although these businesses discharge the wastewater to the sanitary sewer, some washwater can find its way to the storm drain, particularly with the rollover and wand systems. Rollover systems often do not have air-drying. Consequently, as it leaves the enclosure the car sheds water to the pavement. With the self-service system, washwater with detergents can spray outside the building and drain to storm sewer. Users of self-serve operations may also clean engines and change oil, dumping the used oil into the storm drain. Potential pollutants include oil and grease, detergents, soaps, BOD, and TSS.

Equipment Repair

SIC: 7353, 7600

Description: This group includes several businesses that specialize in repairing different equipment including communications equipment, radio, TV, household appliances, and refrigeration systems. Also included are businesses that rent or lease heavy construction equipment as miscellaneous repair and maintenance may occur on site.

Potential Pollutant Generating Sources: Potential pollutant sources include storage and handling of fuels, waste oils and solvents, and loading/unloading areas. Potential pollutants include oil and grease, low/high pH, and suspended solids.

Laundries and Other Cleaning Services

SIC: 7211 through 7217

Description: This category includes all types of cleaning services such as laundries, linen suppliers, diaper services, coin-operated laundries and dry cleaners, and carpet and upholstery services. Wet washing may involve the use of acids, bleaches and/or multiple organic solvents. Dry cleaners use an organic-based solvent, although small amounts of water and detergent are sometimes used. Solvents may be recovered and filtered for further use. Carpets and upholstery may be cleaned with dry materials, hot water extraction process, or in-plant processes using solvents followed by a detergent wash.

Potential Pollutant Generating Sources: Wash liquids are discharged to sanitary sewers. Stormwater pollutant sources include: loading and unloading of liquid materials, particularly at large commercial operations, disposal of spent solvents and solvent cans, high-use customer parking lots, and outside storage and handling of solvents and waste materials. Potential stormwater contaminants include oil and grease, chlorinated and other solvents, soaps and detergents, low/high pH, and suspended solids.

Marinas and Boat Clubs

SIC: 7999

Description: Marinas and yacht clubs provide moorage for recreational boats. Marinas may also provide fueling and maintenance services. Other activities include cleaning and painting of boat surfaces, minor boat repair, and pumping of bilges and sanitary holding tanks. Not all marinas have a system to receive pumped bilge water.

Potential Pollutant Generating Sources: Both solid and liquid wastes are produced as well as stormwater runoff from high-use customer parking lots. Waste materials include sewage and bilge water. Maintenance by the tenants will produce used oils, oil filters, solvents, waste paints and varnishes, used batteries, and empty contaminated containers and soiled rags. Potential stormwater contaminants include oil and grease, suspended solids, heavy metals, and low/high pH.

Golf and Country Clubs

SIC: 7992, 7997

Description: Public and private golf courses and parks are included.

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algacides and/or mosquito larvicides. ~~**Potential Pollutant**~~

~~**Generating Sources:** Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algacides and/or mosquito larvicides.~~ The fertilizer and pesticide application process can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow ground water resources. The use of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained.

Miscellaneous Services

SIC: 4959, 7260, 7312, 7332, 7333, 7340, 7395, 7641, 7990, 8411

Description: This group includes photographic studios, commercial photography, funeral services, amusement parks, furniture and upholstery repair and pest control services, and other professional offices. Pollutants

from these activities can include pesticides, waste solvents, heavy metals, pH, and suspended solids, soaps and detergents, and oil and grease.

Potential Pollutant Generating Sources: Leaks and spills of materials from the following businesses can be sources of stormwater pollutants:

1. Building maintenance produces wash and rinse solutions, oils, and solvents.
2. Pest control produces rinsewater with residual pesticides from washing application equipment and empty containers.
3. Outdoor advertising produces photographic chemicals, inks, waste paints, organic paint sludges containing metals.
4. Funeral services produce formalin, formaldehyde, and ammonia.
5. Upholstery and furniture repair businesses produce oil, stripping compounds, wood preservatives and solvents.

Professional Services

SIC: 6000, 7000 and 8000, 806, 807 not listed elsewhere

Description: The remaining service businesses include theaters, hotels/motels, finance, banking, hospitals, medical/dental laboratories, medical services, nursing homes, schools/universities, and legal, financial and engineering services. Stormwater from parking lots will contain undesirable concentrations of oil and grease, suspended particulates, and metals such as lead, cadmium and zinc. Dangerous wastes might be generated at hospitals, nursing homes and other medical services.

Potential Pollutant Generating Sources: The primary concern is runoff from high use parking areas, maintenance shops, and storage and handling of dangerous wastes.

Vehicle Maintenance and Repair

SIC: 4000, 7530, 7600

Description: This category includes businesses that paint, repair and maintain automobiles, motorcycles, trucks, and buses and battery, radiator, muffler, lube, tune-up and tire shops, excluding those businesses listed elsewhere in this manual.

Potential Pollutant Generating Sources: Pollutant sources include storage and handling of vehicles, solvents, cleaning chemicals, waste materials, vehicle liquids, batteries, and washing and steam cleaning of vehicles, parts, and equipment. Potential pollutants include waste oil, solvents, degreasers, antifreeze, radiator flush, acid solutions with chromium, zinc, copper, lead and cadmium, brake fluid, soiled rags, oil filters, sulfuric acid and battery sludge, and machine chips in residual machining oil.

Multi-Family Residences

SIC: NA

Description: Multifamily residential buildings such as apartments and condominiums. The activities of concern are vehicle parking, vehicle washing and oil changing, minor repairs, and temporary storage of garbage.

Potential Pollutant Generating Sources: Stormwater contamination can occur at vehicle parking lots and from washing of vehicles. Runoff from parking lots may contain undesirable concentrations of oil and grease, suspended particulates, and metals such as lead, cadmium, and zinc.

Construction Businesses

SIC: 1500, 1600, 1700

Description: This category includes builders of homes, commercial and industrial buildings, and heavy equipment as well as plumbing, painting and paper hanging, carpentry, electrical, roofing and sheet metal, wrecking and demolition, stonework, drywall, and masonry contractors. It does not include construction sites.

Potential Pollutant Generating Sources: Potential pollutant sources include leaks/spills of used oils, solvents, paints, batteries, acids, strong acid/alkaline wastes, paint/varnish removers, tars, soaps, coatings, asbestos, lubricants, anti-freeze compounds, litter, and fuels at the headquarters, operation, staging, and maintenance/repair locations of the businesses.

Demolition contractors may store reclaimed material before resale. Roofing contractors generate residual tars and sealing compounds, spent solvents, kerosene, and soap cleaners, as well as non-~~hazardous~~ dangerous waste roofing materials. Sheet metal contractors produce small quantities of acids and solvent cleaners such as kerosene, metal shavings, adhesive residues and enamel coatings, and asbestos residues that have been removed from buildings. Asphalt paving contractors are likely to store application equipment such as dump trucks, pavers, tack coat tankers and pavement rollers at their businesses. Stormwater passing through this equipment may be contaminated by the petroleum residuals. Potential pollutants include oil and grease, suspended solids, BOD, heavy metals, pH, COD, organic compounds, etc.

A.5 Public Agency Activities

Introduction

Local, state, and federal governments conduct many of the pollutant generating activities conducted at business facilities. Local governments include cities and counties, and also single-purpose entities such as fire, sewer and water districts.

Public Facilities and Streets

Description: Included in this group are public buildings. Also included are maintenance (deicing), and repair of streets and roads.

Potential Pollutant Generating Sources: Wastes generated include deicing and anti-icing compounds, solvents, paint, acid and alkaline wastes, paint and varnish removers, and debris. Large amounts of scrap materials are also produced throughout the course of construction and street repair. Potential pollutants include suspended solids, oil and grease, and low/high pH.

Potential Pollutant Generating Sources: Wastes generated include deicing and anti-icing compounds, solvents, paint, acid and alkaline wastes, paint and varnish removers, and debris. Large amounts of scrap materials are also produced throughout the course of construction and street repair. Potential pollutants include suspended solids, oil and grease, and low/high pH.

Maintenance of Open Public Space Areas

Description: The maintenance of large open spaces that are covered by expanses of grass and landscaped vegetation. Examples are zoos and public cemeteries. Golf courses and parks are covered in [Chapter 2](#).

Potential Pollutant Generating Sources: Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algacides and/or mosquito larvicides.

~~**Potential Pollutant Generating Sources:** Maintenance of grassed areas and landscaped vegetation has historically required the use of fertilizers and pesticides. Golf courses contain small lakes that are sometimes treated with algacides and/or mosquito larvicides.~~ The application of pesticides can lead to inadvertent contamination of nearby surface waters by overuse, misapplication, or the occurrence of storms shortly after application. Heavy watering of surface greens in golf courses may cause pesticides or fertilizers to migrate to surface and shallow ground water resources. The application of pesticides and fertilizers generates waste containers. Equipment must be cleaned and maintained. Maintenance shops where the equipment is maintained must comply with the BMPs specified under BMP Maintenance and Repair of Vehicles and Equipment.

Maintenance of Public Stormwater Pollutant Control Facilities

Description: Facilities include roadside catch basins on arterials and within residential areas, conveyance pipes, detention facilities such as ponds and vaults, oil and water separators, biofilters, settling basins, infiltration systems, and all other types of stormwater treatment systems presented in Volume III, [Runoff Control](#).

Potential Pollutant Generating Sources: Research has shown that roadside catch basins can remove from 5 to 15 percent of the pollutants present in stormwater. However, to be effective they must be cleaned. Research has indicated that once catch basins are about 60 percent full of sediment, they cease removing sediments. Generally in urban areas, catch basins become 60 percent full within 6 to 12 months.

Water and solids produced during the cleaning of stormwater treatment systems, including oil and water separators, can adversely affect both surface and ground water quality if disposed of improperly. Ecology has documented water quality violations and fish kills due to improper disposal of decant water (water that is removed) and catch basin sediments from maintenance activities. Disposal of decant water and solids shall be conducted in accordance with local, state, and federal requirements.

Historically, decant water from trucks has been placed back in the storm drain. Solids have been disposed of in permitted landfills and in unpermitted vacant land including wetlands. Research has shown that these residuals contain pollutants at concentrations that exceed water quality criteria. For example, limited sampling by King County and the Washington Department of Transportation of sediments removed from catch basins in residential and commercial areas has found the petroleum hydrocarbons to frequently exceed 200 mg/gram. Above this concentration, regulations require disposal at a lined landfill.

Water and Sewer Districts and Departments

Description: The maintenance of water and sewer systems can produce residual materials that, if not properly handled, can cause short-term environmental impacts in adjacent surface and/or ground waters. With the exception of a few simple processes, both water and sewage treatment produce residual sludge that must be disposed of properly. However, this activity is controlled by other Ecology regulatory programs and is not discussed in this manual. Larger water and sewer districts or departments may service their own vehicles.

Potential Pollutant Generating Sources: Maintenance operations of concern include the cleaning of sewer and water lines, and water reservoirs, general activities around treatment plants, disposal of sludge, and the temporary shutdown of pump stations for either normal maintenance or emergencies. During the maintenance of water transmission lines and reservoirs, water district/departments must dispose of wastewater, both when the line or reservoir is initially emptied, as well as when it is cleaned and then sanitized. Sanitation requires chlorine concentrations of 25 to 100 ppm, considerably above the normal concentration used to chlorinate drinking water. These waters are discharged to sanitary sewers where available.

However, transmission lines from remote water supply sources often pass through both rural and urban-fringe areas where sanitary sewers are not available. In these areas, chlorinated water may have to be discharged to a nearby stream or storm drain, particularly since the emptying of a pipe section occurs at low points that frequently exist at stream crossings. Although prior to disposal the water is dechlorinated using sodium thiosulfate or a comparable chemical, malfunctioning of the dechlorination system can kill fish and other aquatic life. The drainage from reservoirs located in unsewered areas is conveyed to storm drains. The cleaning of sewer lines and manholes generates sediments. These sediments contain both inorganic and organic materials are odorous and contaminated with microorganisms and heavy metals. Activities around sewage treatment plants can be a source of non-point pollution. Besides the normal runoff of stormwater from paved surfaces, grit removed from the headworks of the plant is stored temporarily in dumpsters that may be exposed to the elements. Maintenance and repair shops may produce waste paints, used oil, cleaning solvents, and soiled rags.

Port Districts

Description: The port districts considered here include the following business activities: recreational boat marinas and launch ramps, airfields, container trans-shipment, bulk material import/export including farm products, lumber, logs, alumina, and cement; and break-bulk (piece) material such as machinery, equipment, and scrap metals. Port districts frequently have tenants whose activities are not marine-dependent.

Potential Pollutant Generating Sources: Marine terminals require extensive use of mobile equipment that may drip liquids. Waste materials associated with containers/vehicle/equipment washing/steam cleaning, maintenance and repair may be generated at a marine terminal. Debris can accumulate in loading/unloading or open storage areas, providing a source of stormwater contamination. Wooden debris from the crating of piece cargo crushed by passing mobile loading equipment leaches soluble pollutants when in contact with pooled stormwater. Log sorting yards produce large quantities of bark that can be a source of suspended solids and leached pollutants. Potential pollutants include oil and grease, TSS, heavy metals, and organics.

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Appendix IV-B Stormwater Pollutants and Their Adverse Impact

The stormwater pollutants of most concern are total suspended solids (TSS), oil and grease, nutrients, pesticides, other organics, pathogens, biochemical oxygen demand (BOD), heavy metals, and salts (chlorides) (USEPA, 1995, Field and Pitt, 1997, Strecker, et.al., 1997)

Total Suspended Solids

This represents particulate solids such as eroded soil, heavy metal precipitates, and biological solids (all considered as conventional pollutants), which can cause sedimentation in streams and turbidity in receiving surface waters. These sediments can destroy the desired habitat for fish and can impact drinking water supplies. The sediment may be carried to streams, lakes, or Puget Sound where they may be toxic to aquatic life and make dredging necessary.

Oil and Grease

Oil and grease can be toxic to aquatic life. Concentrations in stormwater from commercial and industrial areas often exceed the Washington Department of Ecology (Ecology) guidelines of: 10 mg/l maximum daily average, 15 mg/L maximum at any time, and no ongoing or frequently recurring visible sheen.

Nutrients

Phosphorus and nitrogen compounds can cause excessive growth of aquatic vegetation in lakes and marine waters.

BOD

Biological Oxygen Demand (BOD) is a measure of the oxygen demand from organic, nitrogenous, and other materials that are consumed by bacteria present in receiving waters. BOD in the water may deplete Oxygen in the process, threatening higher organisms such as fish.

Toxic Organics

A study found 19 of the U.S. Environmental Protection Agency's 121 priority pollutants present in the runoff from Seattle streets. The most frequently detected pollutants were pesticides, phenols, phthalates, and polynuclear aromatic hydrocarbons (PAHs).

Heavy Metals

Stormwater can contain heavy metals such as lead, zinc, cadmium, and copper at concentrations that often exceed water quality criteria and that can be toxic to fish and other aquatic life. Research in Puget Sound has shown that metals and toxic organics concentrate in sediments and at the water surface (microlayer) where they interfere with the reproductive cycle of many biotic species as well as cause tumors and lesions in fish.

pH

A measure of the alkalinity or acidity that can be toxic to fish if it varies appreciably from neutral pH, which is 7.0.

Bacteria and Viruses

Stormwater can contain disease-causing bacteria and viruses, although not at concentrations found in sanitary sewage. Shellfish subjected to stormwater discharges near urban areas are usually unsafe for human consumption.

Research has shown that the concentrations of pollutants in stormwater from residential, commercial, and industrial areas can exceed Ecology's water quality standards and guidelines. ~~See table below.~~

- A.—Eric Strecker, "Analysis of Oregon Urban Runoff Water Quality Data Collected from 1990 to 1996"—2/1997 Report
- B.—Santa Clara 1990: median data
- C.—WSDOT Stormwater Management Plan, 3/25/97, WA, and Oregon data
- D.—Dissolved metal criteria in freshwater at a hardness of 50 ppm (Chapter 173-201A WAC); saltwater criteria expressed as a function of water effect ratio (40 CFR Part 131)
- E.—Ecology geometric mean criterion for class AA waters.

Appendix IV-C Recycling/Disposal of Vehicle Fluids/Other Wastes*

	RECOMMENDED MANAGEMENT
Antifreeze	Store separately for resale. Separate ethylene glycol from propylene glycol for off-site recycling. If not recyclable, send to Treatment, Storage, and Disposal Facility (TSDF) for disposal.
Batteries	INTACT: Accumulate under cover prior to sale, deliver to recycler, or return to manufacturer. BROKEN: Accumulate acid from broken batteries in resistant containers with secondary containment. Send to TSDF for disposal.
Brake fluid	Accumulate in separate, marked, closed container. Do not mix with waste oil. Recycle.
Fuel	Store gasoline, and diesel separately for use or resale. Mixtures of diesel, gasoline, oil, and other fluids may not be recyclable and may require expensive disposal.
Fuel filters	Drain fluids for use as product. With approval of local landfill operator, dispose to dumpster, if needed.
Oil filters	Puncture the filter dome and drain it for 24 hours. Put oil drained from filters into a "USED OIL ONLY" container. Keep drained filters in a separate container marked "USED OIL FILTERS ONLY." Locate a scrap metal dealer who will pick up and recycle filters. With approval of local landfill operator, dispose of drained filters to dumpster.
Paint	Accumulate oil-based and water-based paints separately for use or resale. If not recyclable, send accumulations to TSDF for disposal.
Power steering fluid	Same as for used oils
Shop towels/oily rags	Use cloth towels that can be laundered and reused. Accumulate used shop towels in a closed container. Sign up with an industrial laundry service that can recycle towels.
Solvents	Consider using less hazardous solvents or switching to a spray cabinet that doesn't use solvent. Accumulate solvents separately. Consider purchasing a solvent still and recycling solvent on site. Do not mix with used oil. Do not evaporate as a means of disposal.
Transmission oil, differential and rear end fluids	Accumulate in a "USED OIL ONLY" container. Arrange for pickup for off-site recycling.
Used oils; including, crankcase oil, transmission oil, power steering fluid and differential/rear end oil	Keep used oil in a separate container marked "USED OIL ONLY." Do not mix with brake fluid, or used antifreeze. Do not mix with any other waste if burning for heating. Arrange for pickup for off-site recycling.
Windshield washer fluid	Accumulate separately for use or resale. Discharge to on-site sewage disposal, or, if acceptable by the local sewer authority, discharge to sanitary sewer.

* This information was obtained from Ecology's Hazardous Waste Program.

For a copy of " developed this information. The Hazardous Waste Services Directory is now available online at: <http://apps.ecy.wa.gov/hwsd/default.htm>. " Publication #91-12s, Revised December 1994, listing facilities which recycle/dispose of wastes, solvents, paints, photographic wastes, refrigerants, oils, oil filters, and silver; provide spill assistance and oil/water separator cleanout service, and drum disposal/recycling; TSD facilities; and waste brokers; call Ecology's Hazardous Waste and Toxic Reduction Program at (360) 407-6721.

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Appendix IV-D Regulatory Requirements That Impact Stormwater Programs

R.1 Stormwater Discharges to Public Sanitary Sewers, Septic Systems, Dead-End Sumps, and Industrial Waste Treatment Systems

Stormwater Discharges to Sanitary Sewers. Discharging stormwater to a public sanitary sewer is normally prohibited, as this tends to overload the sewage treatment plant during storm events when flows are already high. Direct discharge of relatively uncontaminated or treated stormwater from businesses typically poses less of a threat to the environment than pass through of solids due to “wash out” at the sewage treatment plant during storm events. Such discharges require the approval of the local Sewer Authority if the Department of Ecology (Ecology) has delegated the authority to set pretreatment requirements. If the Sewer Authority has not received such authority, the business or public agency that wishes to discharge stormwater to the sanitary sewer must also apply for a State Waste Discharge Permit.

In setting pretreatment requirements, the local Sewer Authority or Ecology must operate within state regulations (~~Chapter 173-216 WAC~~[Chapter 173-216 WAC](#) – State Waste Water Discharge Permit Program) which in turn must comply with federal regulations (40 CFR Part 403.5 – National Pretreatment). These regulations specifically prohibit discharge of any materials which:

- Pass through the municipal treatment plant untreated or interfere with its operation~~;~~
- Create a fire or explosion hazard, including, but not limited to, ~~wastestreams~~[waste-streams](#) with a closed cup flash point of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21~~;~~
- Will cause corrosive structural damage to the Publicly Owned Treatment Works (POTW), but in no case Discharges with pH lower than 5.0, or greater than 11, unless the works is specifically designed to accommodate such Discharges; and the discharge authorized by a permit issued under [Chapter 173-216 WAC](#). (~~See WAC 173-216-060 (2) (iv)~~[Chapter 173-216 WAC. \(See WAC 173-216-060 \(2\) \(iv\)\);](#));
- Solid or viscous pollutants in amounts ~~which that~~ will cause obstruction to the flow in the POTW resulting in interference~~;~~
- Heat in amounts ~~which that~~ will inhibit biological activity in the POTW resulting in interference, but in no case heat in such quantities that the temperature at the POTW Treatment Plant exceeds 40 degrees Centigrade (104 degrees Fahrenheit) unless the system is specifically designed to accommodate such discharge, and the discharge is

authorized by a permit under [Ch 173-216 WAC](#). (~~See WAC 173-216-060 (2) (v) Ch 173-216 WAC. (See WAC 173-216-060 (2) (v));~~).

- Petroleum oil, nonbiodegradable cutting oil or products of mineral oil origin in amounts that will cause interference or pass through the treatment plant;
- Pollutants ~~which~~that result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that may cause acute worker health and safety problems;
- Any trucked or hauled pollutants, except at discharge points designated by the POTW;
- Any discharge which would violate the dangerous waste regulations, [Chapter 173-303 WAC](#) (see [WAC 173-216-060\(1\) WAC 173-216-060\(1\)\);](#));
- Any of the following discharges, unless approved by the department under extraordinary circumstances, such as lack of direct discharge alternatives due to combined sewer service or need to augment sewage flows due to septic conditions: ([WAC 173-216-060\(2\)\(vii\)](#))(~~WAC 173-216-060(2)(vii);~~);
 - Noncontact cooling water in significant volumes;
 - Stormwater, and other direct inflow sources;
 - Wastewater significantly affecting system hydraulic loading, which do not require treatment or would not be afforded a significant degree of treatment by the system.

Discharges of stormwater authorized under [Chapter 173-216 WAC](#) ~~Chapter 173-216 WAC~~, typically limit flows entering the sanitary sewer based on the available hydraulic capacity of the collection system or the treatment plant by the combined flow of sanitary sewage and stormwater. The allowable concentrations of particular materials such as metals and grease vary with the particular sewer system. Discharges must ~~be in compliance~~comply with all local government limits. Please contact both the POTW and the regional water quality program to find out what discharge limits apply to a particular sewerage system.

Stormwater Discharges to an Industrial Waste Treatment System:
Operators may process treatment ~~may be used~~ to dispose of polluted stormwater depending on the NPDES permit constraints of the particular business.

Stormwater Discharges to Dead-end Sumps: ~~A substance~~Do not discharge substances that causes a violation of water quality standards ~~must not be discharged~~ to a septic system, surface water, or ground water. If a sanitary or industrial wastewater treatment system is not available, an alternative is the use of a dead-end sump. Sumps are tanks with drains that can be periodically pumped for appropriate disposal. Depending on the

composition of the waste, it may or may not be considered Dangerous Waste.

For more information on disposal requirements for sumps, see [Step By Step: Fact Sheets for Hazardous Waste Generators](#)~~[Step By Step: Fact Sheets for Hazardous Waste Generators](#)~~, publication #91-12, available from Ecology's Regional Offices.

R.2 Uniform Fire Code Requirements

[Storage of flammable, ignitable, and reactive chemicals and materials must comply with the stricter of local zoning codes, local fire codes, the Uniform Fire Code, Uniform Fire Code standards or the National Electric Code.](#)

R.3 Ecology Requirements for Generators of Dangerous Wastes

[The State's Dangerous Waste Regulations \(Chapter 173-303 WAC\) cover accumulation, storage, transportation, treatment and disposal of dangerous wastes. Of interest to this manual are those businesses or public agencies that accumulate the waste at their building until taken from the site by a contract hauler.](#)

For more information on applicable requirements for ~~hazardous~~ dangerous wastes, see [Step By Step: Fact Sheets for Hazardous Waste Generators](#)~~[Step By Step: Fact Sheets for Hazardous Waste Generators](#)~~, publication #91-12, available from Ecology's Regional Offices.

R.4 Standards for Solid Waste Containers

[Standards for solid waste containers are identified in WAC 173-350-300. On-site Storage, Collection, and Transportation Standards.](#)

R.5 Coast Guard Requirements For Marine Transfer of Petroleum Products

[Federal regulations 33 CFR Parts 153, 154 and 155 cover, respectively, general requirements on spill response, spill prevention at marine transfer facilities, and spill prevention for vessels. These regulations specify technical requirements for transfer hoses, loading arms, closure, and monitoring devices. The regulations also cover small discharge containment: they require the use of "fixed catchments, curbing, and other fixed means" at each hose handling and loading arm area and each hose connection manifold area. Operators can use portable containment in exceptional situations where fixed containment is not feasible. The capacity of the containment area varies from the volume of 1 to 4 barrels depending on the size of the transfer hoses.](#)

The regulations also require an operations plan and specify its general contents. The plan shall describe the responsibilities of personnel, nature

of the facility, hours of operation, sizes and numbers of vessels using the facility, nature of the cargo, procedures if spills occur, and petroleum transfer procedures. The plan must also include a description and location of equipment for monitoring, containment, and fire fighting. *See also, NFPA 30A Automotive and Marine Service Station Code, American National Standard Institute and the National Fire Protection Association.*

R.6 Washington State/Federal Emergency Spill Cleanup Requirements

Washington State Requirements:

The Oil and Hazardous Substance Spills Act of 1990 and the Oil Spill Prevention and Response Act of 1991 (Chapter 90.56 RCW) authorized Ecology to develop effective oil spill response regulations.

The Facility Contingency Plan and response Contractor Standards (Chapter 173-182 WAC(~~Chapter 173-181 WAC~~)):

This Ecology regulation applies to all oil handling facilities (including pipelines) that are on or near navigable waters and transfer bulk oil by tank, ship, or pipeline. It contains the following elements:

- Standards for contingency plan content
- Procedures to determine the adequacy of contingency plans
- Requirements for periodic review
- Standards for cleanup and containment contractors

The Oil Handling Training and Certification Rule ([Chapter 173-180 WAC\(~~Chapter 173-180 WAC~~\)](#)) establishes oil spill training and certification requirements for key facility personnel including applicable contractors involved in oil handling, transfer, storage, and monitoring operations.

In accordance with [WAC 173-303-350](#)~~WAC 173-303-350~~ of Ecology's Dangerous Waste Regulations, generators of dangerous wastes must have a Contingency Plan that includes:

- Actions to be taken in the event of spill
- Descriptions of arrangements with local agencies
- The name of the owner's Emergency Coordinator
- A list of emergency equipment available
- An evaluation plan for business personnel

For more information on disposal requirements for solid and ~~hazardous~~ dangerous wastes, see [Step By Step: Fact Sheets for Hazardous Waste Generators](#)~~Step By Step: Fact Sheets for Hazardous Waste Generators~~, publication #91-12, available from Ecology's Regional Offices.

Federal Requirements:

The Oil Pollution Act of 1990 is a comprehensive federal law ~~which~~that addresses marine oil spill issues including contingency plans, financial responsibility, marine safety regulations, etc.

Spill Prevention Control and Countermeasure (SPCC) Plans:

Federal Regulations require that owners or operators of facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, or consuming oil and oil products are required to have a Spill Prevention and Control Plan (SPCC), provided that the facility is non-transportation related; and, that the above-ground storage of a single container is in excess of 660 gallons, or an aggregate capacity greater than 1,320 gallons, or a total below-ground capacity in excess of 42,000 gallons. The Plan must:

- Be well thought out in accordance with good engineering;
- Achieve three objectives - prevent spills, contain a spill that occurs, and clean up the spill;
- Identify the name, location, owner, and type of facility;
- Include the date of initial operation and oil spill history;
- Name the designated person responsible;
- Show evidence of approval and certification by the person in authority; and
- Contain a facility analysis.

R.7 WSDA Pesticide Regulations

The Washington State Department of Agriculture (WSDA) administers pesticide laws, under the Washington Pesticide Control Act (Chapter 15.58 RCW), Washington Pesticide Application Act (Chapter 17.21 RCW), and regulations under Chapter 16-228 WAC. The requirements relevant to water quality protection are:

Licenses are required for persons who apply pesticides ~~are required to be licensed~~ except:

- People who use general-use pesticides on their own or their employer's property;
- Grounds maintenance people using only general-use pesticides on an occasional basis not amounting to a regular occupation;
- Governmental employees who apply general-use pesticides without utilizing any kind of motorized or pressurized apparatus;
- Employees of a commercial applicator or a government agency who are under direct on-site supervision by a licensed applicator.

Licensed applicators must undergo 40 hours of continuing education to keep their license.

No person shall pollute streams, lakes, or other water supplies while loading, mixing or applying pesticides.

No person shall transport, handle, store, load, apply, or dispose of any pesticide, pesticide container, or apparatus in such a manner as to pollute water supplies or waterways, or cause damage or injury to land, including humans, desirable plants, and animals.

For more information on pesticide application and disposal requirements the following publications may be useful:

“Hazardous Waste Pesticides: A Guide for Growers, Applicators, Consultants and Dealers,” Ecology Publication #89-41, August 1989, available from Ecology’s Regional Offices.

“Suspended, Canceled and Restricted Pesticides,” EPA, available from the EPA Region 10 Office in Seattle.

“Best Management Practices for Agricultural Chemicals-A Guide for Pesticide Secondary Containment,” Ecology Publication #94-189.

“Site Evaluation-A Guide for Pesticide Secondary Containment,” Ecology Publication #94-188.

“Reducing and Managing Wastes From Catchbasins-A Guide for Pesticide Secondary Containment,” Ecology Publication #94-186.

“Spill Reporting and Cleanup in Washington State-A Guide for Pesticide Secondary Containment,” Ecology Publication #94-187.

“Pesticide Container Cleaning and Disposal,” Ecology Publication #96-431.

“Step By Step: Fact Sheets for Hazardous Waste Generators,” Ecology Publication #91-12.

R.8 Air Quality Regulations

Regulation of air pollutant emissions in Washington is controlled by seven local air pollution control agencies, three Ecology regional offices and two Ecology programs (Central Program’s Industrial Section, and Nuclear and Mixed Waste Program). All of the local air pollution agencies and the regional offices enforce local, state and federal air pollution regulations. The Industrial Section of Ecology’s Central Program enforces state and federal air pollution regulations at chemical pulp mills and aluminum reduction facilities. The Nuclear and Mixed Waste Program enforces state and federal air pollution regulation on the Hanford Nuclear Reservation.

Whether it is to control the generation of fugitive emissions or point source (smoke stack) emissions, new and existing sources of air pollutants must comply with the requirements contained in their air pollution permits, regulatory orders, and local, state, and federal air pollution regulations. This will minimize the effects of each facility’s emissions on stormwater.

Fugitive Particulate Matter Emissions: The local and state air pollution control agencies require that all reasonable precautions be taken to prevent fugitive particulate matter (~~wind-blown~~windblown dust) from becoming airborne when handling, loading, transporting, and storing particulate material. Particulate materials of concern can include grain and grain dust, saw dust, coal, gravel and crushed rock, cement, and boiler fly ash.

Some of the local authorities take the general requirement to control fugitive emissions further. For example, the Puget Sound and Benton County Air Pollution Control Agencies have defined what “reasonable precautions” means for various dust causing activities in their jurisdictions.

Some actions that have been defined as “reasonable precautions” to prevent fugitive particulate emissions include paving of parking and storage areas, minimizing the area of land that has been cleared for housing development, various housekeeping activities such as sweeping paved areas, minimization of the accumulation of mud and dust and preventing mud and dust being tracked onto public roads, and stabilization of materials piles and open, cleared land areas with water sprays, chemical stabilizers or other means that minimize dust generation. All air authorities require sand blasting and spray painting activities be performed indoors with proper air pollution controls in use or, if that is not possible, out of doors but within acceptable, temporary enclosures.

Gaseous Air Pollutant Emissions: Gaseous air pollutants are controlled at the point of origin through add-on emission controls or pollution prevention measures. Each emission point at a plant generally has emission limits that must be complied with.

Sources of gaseous air pollutants can include petroleum storage tank breather and pressure release systems, combustion units (boilers and heaters), commercial printers, can manufacturers, steel mills, pulp and paper plants, auto body repair shops, etc. Examples of gaseous air pollutants that can be emitted include acetone, methylene chloride, styrene, nitrogen oxides, benzene, carbon monoxide, alcohol, organic sulfides and petroleum, and chlorinated solvents.

Some gaseous pollutants can be washed out of the air during rainstorms and enter stormwater. Others are photochemically degraded or converted in the air to other compounds that can be removed by rainfall or by settling on the ground. Gaseous air pollutants such as sulfur dioxide react in the air to generate acidic particulate matter. These particulates are usually removed from the atmosphere by settling out or being washed out of the air. In the case of sulfur oxides, this removal usually occurs at some distance (tens to hundreds of miles) from the facility that emitted the pollutant.

R.9 Ecology Waste Reduction Program

The 1990 Hazardous Waste Reduction Act, Chapter 70.95C RCW, established a goal to reduce dangerous waste generation by 50 percent. The primary means for achieving this goal is through implementation of a pollution prevention-planning program, also established in the Act. Facilities that generate in excess of 2,640 pounds of dangerous waste per year, or who are required to report under the Toxic Release Inventory (TRI) of Title III of the Superfund Amendments and Reauthorization Act (SARA), are subject to this law. Some 650 facilities in Washington currently participate in this planning program.

Pollution prevention planning is an activity that involves:

Inventorying ~~hazardous~~ substances used and ~~hazardous~~~~dangerous~~ waste generated;

Identifying opportunities to prevent pollution;

Analyzing the feasibility of these prevention opportunities; and

Setting goals for hazardous substance use reduction and ~~hazardous~~~~dangerous~~ waste reduction, recycling and treatment.

Ecology promotes pollution prevention through initiatives other than planning. Several campaigns targeting specific industries have been conducted and more are being planned. These campaigns have a joint focus of pollution prevention and regulatory compliance, and help target future technical assistance. Ecology provides technical assistance through its regional offices, with emphasis on the reduction of hazardous substance use and ~~hazardous~~~~dangerous~~ waste generation. Site visits, phone consultations, and workshops are some of the ways assistance is provided to businesses and governmental entities.

Pollution prevention has emerged as a key strategy for protecting the environment. Business, industry and government alike recognize the benefits of prevention rather than end of pipe controls. Many factors, including regulatory compliance, cost savings, worker safety and reduced liabilities help validate pollution prevention as an approach to be incorporated into all business practices.

R.10 Washington State Ground Water Quality Standards

In December 1990, the state of Washington adopted ground water quality standards to prevent ground water pollution and protect both current and future beneficial uses of the resource. Beneficial uses of ground water include drinking water, irrigation, and support of wildlife habitat. These standards apply to any activity, including point and non-point, which has a potential to contaminate ground water. The standards protect all ground water within the saturated zone throughout the State of Washington and do not distinguish ground water that is isolated, seasonal, or artificial from that which is extensive and naturally occurring. The standards incorporate an existing part of state water quality law: the antidegradation policy.

which is an integral part of both the ground and surface water quality standards.

The standards consist of both numeric criteria and narrative standards designed to protect both current and future beneficial uses of ground water. The numeric criteria for primary, secondary, and radionuclide contaminants have been adopted from the Federal Safe Drinking Water Act of 1971. Numeric criteria for carcinogenic compounds are based upon human health criteria. These criteria represent the maximum allowable contaminant concentration in ground water within the aquifer. However, the antidegradation policy requires that ground water quality be protected to the greatest extent possible prior to contaminant concentrations reaching those specified within the numeric criteria. To address this requirement, narrative standards were developed which are based upon background water quality and use of treatment technologies and are site specific in nature. Under these standards, specific early warning and enforcement limits are set at a point of compliance which must be met by a facility or activity if enforcement action is to be avoided. All facilities or activities within the State of Washington must first attempt to meet these narrative standards. The determination of specific limits is outlined in Implementation Guidance for the Ground Water Quality Standards, Ecology publication #96-02 (Ecology, 1996).

~~these narrative standards. The determination of specific limits is outlined in Implementation Guidance for the Ground Water Quality Standards, Ecology publication #96-02 (Ecology, 1996).~~

In addition to using background ground water quality as a basis for determining specific early warning and enforcement limits, Washington law requires that all activities with the potential to contaminate water implement practices known as AKART – short for “all known available and reasonable methods of prevention, control and treatment.” AKART must be used regardless of the quality of the receiving waters. As technology and preventive controls are refined to better protect water quality, AKART is also redefined. In individual cases where AKART fails to protect water quality, the activity must apply additional controls.

State law requires the permitting of any industrial, commercial, or municipal operation, which discharges waste material into ground and/or surface waters. These permits, issued by Ecology, set limits and conditions for discharges. Underground injection activities, while exempt from the State Waste Discharge Program, Chapter 173-216 WAC~~Chapter 173-216 WAC~~₂ are required to meet the ground water quality standards and may be permitted under Chapter 173-218 WAC~~Chapter 173-218 WAC~~₂ Underground Injection Control Program. Guidance for permit development will describe how an industry or commercial or municipal operation must conduct its activities in order to protect ground water quality.

The ground water quality standards provide for several exemptions. One of these exceptions provides that the standards do not apply in the root zone of saturated soils where agricultural pesticides or nutrients have been applied at agronomic rates for agricultural purposes. The standards do apply below the crop's root zone. State approved BMPs may be considered one type of AKART for agriculture, and other point and non-point sources. Another exemption applies to any remedial or clean-up activity conducted under federal CERCLA or state Model Toxics Control Act.

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Appendix IV-E NPDES Stormwater Discharge Permits

Summary:

The Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System Permit (NPDES) regulations for stormwater (40 CFR Parts 122, 123, and 124) became effective on November 16, 1990. Because Washington is an NPDES delegated state, it issues NPDES permits for designated industries, construction sites, and municipalities.

Industrial Stormwater Permits:

USEPA regulations list certain industrial activities (Reference: [40 CFR 122.26\(b\)\(14\)](#)~~40 CFR 122.26(b)(14)~~) which may need to have a stormwater discharge permit. The following categories (1 through 10) of facilities are considered to be engaging in "industrial activity." They are required by EPA to have a stormwater NPDES permit if they have a stormwater discharge to surface water.

- 1) ~~1)~~ Facilities subject to stormwater effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR subchapter N (except facilities with toxic pollutant effluent standards under category 11 below).
- 2) ~~2)~~ Facilities classified by the Standard Industrial Classification (SIC) system as:
 - 24 - Lumber and Wood Products except Furniture (except 2434-Wood Kitchen Cabinets)
 - 26 - Paper and Allied Products (except 265-Paperboard Containers and Boxes, and except 267-Converted Paper and Paperboard Products except Containers and Boxes)
 - 28 - Chemicals and Allied Products (except 283-Drugs; and 285-Paints, Varnishes, Lacquers, Enamels, and Allied Products)
 - 29 - Petroleum Refining and Related Industries
 - 311- Leather Tanning and Finishing
 - 32 - Stone, Clay, Glass and Concrete Products (except 323-Glass Products, made of Purchased Glass)
 - 33 - Primary Metal Industries
 - 3441 - Fabricated Structural Metal Products
 - 373- Ship and Boat Building and Repair

- 3) ~~3)~~ Facilities classified by the Standard Industrial Classification (SIC) system as:
- 10 - Metal Mining
 - 12 - Coal Mining
 - 13 - Oil and Gas Extraction
 - 14 - Mining and Quarrying of Nonmetallic Minerals, except Fuels (Includes active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(1) or except for areas of non-coal mining operations which have been released from applicable state or federal reclamation requirements by December 17, 1990) and oil and gas exploration, production, processing or treatment operations, or transmission facilities that discharge storm water that has come into contact with any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operation.
- 4) ~~4)~~ ~~Hazardous~~ Dangerous waste treatment, storage, or disposal facilities, including those that are operated under interim status or a permit under subtitle C of RCRA.
- 5) ~~5)~~ Landfills, land application sites and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA.
- 6) ~~6)~~ Facilities involved in the recycling of materials including metal scrap yards, battery reclaimers, salvage yards and automobile junkyards, including but not limited to those classified as SIC 5015-Wholesale Trade Activities of Motor Vehicle Parts, Used; and SIC 5093-Scrap and Waste Materials.
- 7) ~~7)~~ Steam electric power generating facilities, including coal-handling sites.
- 8) ~~8)~~ Transportation facilities classified under the following SIC codes, which have vehicle maintenance shops, equipment-cleaning operations, and airport deicing operations. ~~-(Only those portions of the facility involved in the above activities, or which are otherwise identified in one of the other 10 categories.)~~
- 40 - Railroad Transportation
 - 41 - Local and Suburban Transit and Interurban Highway Passenger Transportation
 - 42 - Motor Freight Transportation and Warehousing (except 4221-Farm Product Warehousing and Storage, 4222-Refrigerated

Warehousing and Storage, and 4225-General Warehousing and Storage)

43 - United States Postal Service

44 - Water Transportation

45 - Transportation by Air

5171- Petroleum Bulk Stations and Terminals

9) ~~99~~ Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 MGD or more, or required to have an approved pretreatment program under 40 CFR part 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with section 405 of the Clean Water Act.

10) ~~40~~ Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than one acre of total land area which are not part of a larger common plan of development or sale. (See "Construction Stormwater Permits" below)

11) ~~44~~ Facilities under the following SIC classifications need to apply for a stormwater NPDES permit only if they are engaged in an "industrial activity" which is exposed to stormwater and they have a point source stormwater discharge to surface water.

20 - Food and Kindred Products

21 - Tobacco Products

22 - Textile Mill Products

23 - Apparel and Other Finished Products made from Fabrics and Similar Materials Wood Kitchen Cabinets

25 - Furniture and Fixtures

265 - Paperboard Containers and Boxes

267 - Converted Paper and Paperboard Products, Except Containers and Boxes

27 - Printing, Publishing and Allied Industries

283 - Drugs

285 - Paints, Varnishes, Lacquers, Enamels, and Allied Products

30 - Rubber and Miscellaneous Plastic Products

- 31 - Leather and Leather Products (except 311, Leather Tanning and Finishing)
- 323 - Glass Products made of Purchased Glass
- 34 - Fabricated Metal Products, Except Machinery and Transportation Equipment (except 3441, Fabricated Structural Metal Products)
- 35 - Industrial and Commercial Machinery and Computer Equipment
- 36 - Electronic and Other Electrical Equipment and Components, Except Computer Equipment
- 37 - Transportation Equipment (except 373, Ship and Boat Building and Repair)
- 38 - Measuring, Analyzing, and Controlling Instruments, Photographic, Medical and Optical Goods, Watches and Clocks
- 39 - Miscellaneous Manufacturing Industries
- 4221 - Farm Product Warehousing and Storage
- 4222 - Refrigerated Warehousing and Storage
- 4225 - General Warehousing and Storage

For the industries identified in SIC categories (1) through (10), a permit is necessary if there is a point source stormwater discharge to a surface water, storm drain which discharges to surface water directly or indirectly, or a municipal storm sewer from any of the following areas of industrial activity: industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR part 401); 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 (including tank farms) 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 storm water.

Industries in Categories 1 through 9 can submit an application and qualify for a Conditional "No Exposure" Certificate.

For the industries identified in SIC category (11), a permit is required for point source discharges from any of the areas that are listed above (except access roads and rail lines of SIC category 11 industries), only if material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are

exposed to stormwater. However, they must submit a “No Exposure” Certificate to be excused from the permit.

How and When Do I Apply for A Permit?

Three types of permits are possible. Each has a different application process.

General Permit for Industrial Activities: An application for coverage under the ~~general stormwater~~ Industrial Stormwater General Permit, referred to as a Notice of Intent (NOI), ~~should~~ must be submitted to Ecology.

Individual Permit: An industrial facility that is required to have a stormwater permit may volunteer or be required to apply for an individual permit. An individual permit is a permit that is written for and issued to a specific facility. EPA regulations require that industries not covered under a general ~~(baseline)~~ permit must apply for an individual stormwater permit. Individual permit applicants for discharges composed entirely of stormwater, must comply with 40 CFR 122.21, and complete EPA forms 1 and 2F. Ecology is prepared to issue individual permits for facilities not already under permit only for exceptional circumstances. ~~All facilities are encouraged to participate in receiving coverage under the baseline general permit by submitting a Notice of Intent.~~

Industry-Specific General Permits: Ecology will consider development of industry-specific general permits, as needed. An industry-specific permit is a permit that can apply to all industries of a similar type. Examples of industry-specific general permits that include stormwater are Sand and Gravel, and Boatyards.

What Does The Industrial Stormwater General Permit Require Industries To Do?

The development of an Industrial Stormwater Pollution Prevention Plan (SWPPP) by each industry is a key Permit requirement. The Industrial SWPPP requirements include:

- Identifying the potential sources of pollutants that may contaminate stormwater.
- A description and implementation of operational and structural source control BMPs to reduce the stormwater pollutants and comply with the stormwater general permit.

The permit also includes requirements for:

- Effluent limitations for certain types of industrial facilities, and certain discharges to 303(d) impaired waterbodies;
- Monitoring: All facilities are required to conduct quarterly monitoring and sampling. There are additional monitoring requirements for certain, identified industry groups;

- Application of additional ~~operational and structural~~ source control and treatment BMPs to control pollutants further if certain “benchmark” levels of pollutants, as identified in the permit, are exceeded;
- ~~Application of additional operational and structural source control BMPs if “action” levels of pollutants, as identified in the permit, are exceeded in two out of the previous four quarterly samples;~~
- ~~Application of additional operational and structural source control BMPs and treatment BMPs if “action” levels of pollutants are exceeded in any four quarterly samples.~~
- Reporting and Recordkeeping;
- Operation and Maintenance

Municipalities May Have To Apply for an Industrial Stormwater Permit or Other General Permit

Some municipalities own or operate an “industrial activity.” If that industrial activity has a stormwater discharge to surface waters or storm drains tributary to surface waters, the municipality must apply for the Industrial Stormwater General Permit (or applicable industry-specific general permit, e.g., Sand & Gravel General Permit, Boatyard General Permit, etc.) unless the site qualifies for a Conditional “No Exposure” Certificate. In the latter case, a “no exposure” application form should be submitted.

Examples of industrial activities conducted by municipalities that are required to apply for a stormwater permit, if they have a discharge to a surface water, include, but may not be limited to: sand and gravel mining; crushed and broken stone operations; rip rap mining and quarrying; landfills, recycling facilities, land application sites, and open dumps that receive or have received industrial waste; ~~*transportation~~ services facilities which have vehicle maintenance shops; equipment cleaning; airport de-icing operations; and sewage treatment plants with a design flow above one million gallons per day; ~~construction activities, including clearing, grading, or excavating sites, which disturb five acres or more of land area;~~ and power plants.

Construction Stormwater Permits

Construction sites that will disturb ~~five acres~~ one acre or more and will have a discharge of stormwater from the project site to surface water must apply for Ecology's Construction Stormwater ~~permit~~ General Permit. The permit requires application of stabilization and structural practices to reduce the potential for erosion and the discharge of sediments from the site. The stabilization and structural practices cited in the permit are similar to the minimum requirements for sedimentation and erosion control in Volume I ~~of the SWMM~~ and II of the SWMM; refer to the Construction Stormwater General Permit for specific requirements.

The permit also requires construction sites within the Puget Sound basin to “select from BMPs described in Volume II of the most recent edition of Ecology’s Stormwater Management Manual (SWMM) that has been available at least 120 days prior to the BMP selection.” Sites outside the basin are required to select BMPs from the manual, from the Erosion and Sediment Control Handbook, by Goldman et al, or to select other appropriate BMPs. The permit also states that where Ecology has determined that the local government requirements for construction sites are at least as stringent as Ecology’s, Ecology will accept compliance with the local requirements.

The existing construction stormwater general permit expires in November 2005. However, that permit was appealed. The parties to the case have entered into a settlement agreement (stipulation and order for dismissal) that stipulates that the construction stormwater general permit must be revised and reissued according to specified dates. Ecology expects the permit will be available by September 2005.

This revised permit will incorporate identified changes and implement applicable USEPA Phase II regulations. According to those regulations, coverage under the Construction General Permit is required for any clearing, grading, or excavating that will disturb one or more acres of land area, and that will discharge stormwater from the site into surface water(s), or into storm drainage systems that discharge to a surface water.

In developing the revised permit, Ecology anticipates drawing upon Minimum Requirement #2 and the BMP’s in this volume.

Municipal Stormwater Permits

Municipal Stormwater Permits

NPDES Permit Program for Municipal Stormwater Discharges

Phase I. Ecology has issued stormwater discharge general permits to the cities of Seattle and Tacoma; the counties of King, Pierce, Clark, and Snohomish; and the discharges from state highways managed by the Department of Transportation within those jurisdictions. These permits contain conditions for compliance with both federal and state requirements and are issued as combined NPDES and State Wastewater Discharge Permits. Ecology reissued the Phase I general permit in 2007 and plans to reissue the next permit in 2012.

Phase II. The EPA adopted Phase II stormwater regulations in December 1999. Those rules identify additional municipalities as subject to NPDES municipal stormwater permitting requirements. Over 100 municipalities in Washington are subject to the requirements. Federal regulations required issuance of Phase II permits by December 2002, and required the Phase II communities to submit their stormwater programs to comply with permit

requirements by March 2003. Ecology ~~made a standard permit application format available to municipalities and encouraged all to apply by March 2003. Ecology anticipates issuing~~issued the Phase II ~~permit~~permits for Eastern Washington and Western Washington in 2005~~2007~~ and plans to ~~reissue these two general permits in 2012.~~

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Appendix IV-F Example of an Integrated Pest Management Program

Integrated Pest Management (IPM) is a natural, long-term, ecologically based systems approach to controlling pest populations. This system uses techniques either to reduce pest populations or maintain them at levels below those causing economic injury, or to so manipulate the populations that they are prevented from causing injury. The goals of IPM are to encourage optimal selective ~~pesticide use~~ pesticide use (away from prophylactic, broad spectrum use), and to maximize natural controls to minimize the environmental side effects.

A step-by-step comprehensive Integrated Pest Management (IPM) Program is provided below as a guide:

Introduction

This section provides a sound cultural approach to managing lawns and landscapes and minimizing runoff. Many homeowners or property managers will be able to implement most or all of this approach, others will wish to hire these services out. For the do-it yourselfer, an array of resources are available to assist in the effort. Landscaping businesses, agricultural extensions, local agencies, master gardener programs, local nurseries and even the library can all provide assistance. Landscaping professionals (businesses) are particularly encouraged to practice IPM.

Definition

“Integrated pest management, or IPM, is an approach to pest control that uses regular monitoring to determine if and when treatments are needed, and employs physical, mechanical, cultural, and biological tactics to keep pest numbers low enough to prevent intolerable damage or annoyance. Least-toxic chemical controls are used as a last resort.”

True IPM is a powerful approach that anticipates and prevents most problems through proper cultural practices and careful observation. Knowledge of the life cycles of the host plants and both beneficial and pest organisms is also important. The IPM section of this study guide is adapted from Least Toxic Pest Management for Lawns by Sheila Daar, Following the IPM process gives you the information you need to minimize damage by weeds, diseases and pests and to treat those problems with the least toxic approaches.

The Integrated Pest Management Process

Step One: Correctly identify problem pests and understand their life cycle.

Learn more about the pest. Observe it and pay attention to any damage that may be occurring. Learn about the life cycle. Many pests are only a problem during certain seasons, or can only be treated effectively in certain phases of the life cycle.

Step Two: Establish tolerance thresholds for pests.

Every landscape has a population of some pest insects, weeds, and diseases. This is good because it supports a population of beneficial species that keep pest numbers in check. Beneficial organisms may compete with, eat, or parasitize disease or pest organisms. Decide on the level of infestation that must be exceeded before treatment needs to be considered. Pest populations under this threshold should be monitored but don't need treatment. For instance, European crane flies usually don't do serious damage to a lawn unless there are between 25 – 40 larvae per square foot feeding on the turf in February (in normal weather years). Also, most people consider a lawn healthy and well maintained even with up to 20% weed cover, so treatment, other than continuing good maintenance practices, is generally unnecessary.

Step Three: Monitor to detect and prevent pest problems.

Regular monitoring is a key practice to anticipate and prevent major pest outbreaks. It begins with a visual evaluation of the lawn or landscape's condition. Take a few minutes before mowing to walk around and look for problems. Keep a notebook, record when and where a problem occurs, then monitor for it at about the same time in future years. Specific monitoring techniques can be used in the appropriate season for some potential problem pests, such as European crane fly.

Step Four: Modify the maintenance program to promote healthy plants and discourage pests.

A healthy landscape is resistant to most pest problems. Lawn aeration and overseeding along with proper mowing height, fertilization, and irrigation will help the grass out-compete weeds. Correcting drainage problems and letting soil dry out between waterings in the summer may reduce the number of crane-fly larvae that survive.

Step Five: If pests exceed the tolerance thresholds

Use cultural, physical, mechanical or biological controls first. If those prove insufficient, use the chemical controls described below that have the

least non-target impact. When a pest outbreak strikes (or monitoring shows one is imminent), implement IPM then consider control options that are the least toxic, or have the least non-target impact. Here are two examples of an IPM approach:

1. **Red thread disease** is most likely under low nitrogen fertility conditions and most severe during slow growth conditions. Mow and bag the clippings to remove diseased blades. Fertilize lightly to help the grass recover, then begin grasscycling and change to fall fertilization with a slow-release or natural-organic fertilizer to provide an even supply of nutrients. Chemical fungicides are not recommended because red thread cannot kill the lawn.
2. **Crane fly damage** is most prevalent on lawns that stay wet in the winter and are irrigated in the summer. Correct the winter drainage and/or allow the soil to dry between irrigation cycles; larvae are susceptible to drying out so these changes can reduce their numbers. It may also be possible to reduce crane fly larvae numbers by using a power de-thatcher on a cool, cloudy day when feeding is occurring close to the surface. Studies are being conducted using beneficial nematodes that parasitize the crane fly larvae; this type of treatment may eventually be a reasonable alternative.

Only after trying suitable non-chemical control methods, or determining that the pest outbreak is causing too much serious damage, should chemical controls be considered. Study to determine what products are available and choose a product that is the least toxic and has the least non-target impact. Refer to the Operational BMPs for the use of Pesticides below for guidelines on choosing, storing and using lawn and garden chemicals.

Step Six: Evaluate and record the effectiveness of the control, and modify maintenance practices to support lawn or landscape recovery and prevent recurrence.

Keep records! Note when, where, and what symptoms occurred, or when monitoring revealed a potential pest problem. Note what controls were applied and when, and the effectiveness of the control. Monitor next year for the same problems. Review your landscape maintenance and cultural practices to see if they can be modified to prevent or reduce the problem.

A comprehensive IPM Program should also include the proper use of pesticides as a last resort, and vegetation/fertilizer management to eliminate or minimize the contamination of stormwater:

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Appendix IV-G Recommendations for Management of Street Wastes

Introduction

~~This appendix is a summary, taken from the June 1999 draft Ecology publication titled Recommendations for Management of Street Waste (Publication WQ 99-09). The guidance document~~ This appendix addresses waste generated from stormwater maintenance activities such as street sweeping and the cleaning of catch basins, and to a limited extent, other stormwater conveyance and treatment facilities. Limited information is available on the characteristics of wastes from detention/retention ponds, bioswales, and similar stormwater treatment facilities. The recommendations provided here may be generally applicable to these facilities, with extra diligence given to waste characterization.

These recommendations do not constitute rules or regulations, but are suggestions for street waste handling, reuse, and disposal using current regulations and the present state of knowledge of street waste constituents. The recommendations ~~are intended to~~ address the liquid and solid wastes collected during routine maintenance of stormwater catch basins, detention/retention ponds ~~and~~, ditches and similar storm water treatment and conveyance structures, and street and parking lot sweeping. In addition to these recommendations, end users and other authorities may have their own requirements for street waste reuse and handling.

"**Street Wastes**" include liquid and solid wastes collected during maintenance of stormwater catch basins, detention/retention ponds ~~and~~, ditches and similar storm water treatment and conveyance structures, and solid wastes collected during street and parking lot sweeping.

"**Street Wastes,**" as defined here, **does not include** solids and liquids from street washing using detergents, cleaning of electrical vaults, vehicle wash sediment traps, restaurant grease traps, industrial process waste, sanitary sewage, mixed process, or combined sewage/stormwater wastes. Wastes from oil/water separators at sites that load fuel are not included as street waste. Street waste also does not include flood debris, land ~~slide~~ debris, and chip seal gravel.

Street waste does not ordinarily classify as dangerous waste. The owner of the storm water facility and/or collector of street waste is considered the waste generator and is responsible for determining whether ~~or not~~ the waste designates as dangerous waste. Sampling to date has shown that material from routine maintenance of streets and stormwater facilities does not classify as dangerous waste (See [Table G.6](#) ~~Table G.6~~ below). However, it is possible that street waste from spill sites could classify as dangerous waste. Street waste from areas with exceptionally high average daily traffic counts may contain contaminants - such as

heavy metals, total petroleum hydrocarbons (TPH), and carcinogenic polycyclic aromatic hydrocarbons (c-PAH) - at levels that limit reuse options.

Contamination in Street Waste Solids

Street waste is solid waste. While street waste from normal street and highway maintenance is not dangerous waste, it is solid waste, as defined under The Solid Waste Management Act (~~Chapter 70.95 RCW~~~~(Chapter 70.95 RCW)~~) and under ~~Minimum Functional the Solid Waste Handling Standards (Chapter 173-350 WAC for Solid Waste Handling (Chapter 173-304 WAC). Under~~ The Solid Waste Management Act, gives local health departments ~~have~~ primary jurisdiction over solid waste management. Street waste solids may contain contaminants at levels too high to allow unrestricted reuse. ~~At the time this document is being prepared, the Minimum Functional Standards are being revised. Chapter 173-304 WAC will be replaced with Chapter 173-350 WAC.~~ There are ~~currently~~ no specific references in the ~~Minimum Functional Solid Waste Handling Standards~~ to facilities managing street waste solids; ~~although~~ these facilities ~~will~~ typically fit under the section dealing with Piles Used for Storage and Treatment (Section 320 ~~of the proposed revisions~~). There are no specific references for reuse and disposal options for street wastes in the ~~Minimum Functional Solid Waste Handling Standards~~; ~~although the Minimum Functional Standards because they~~ do not apply to clean soils. ~~In the proposed rule, Clean soils are defined as "soils that do not contain contaminants at concentrations and dredged material which could degrade the quality of air, waters of the state, are not dangerous wastes, contaminated soils, or contaminated dredged material ..." (WAC 173-350-100 sediments; or pose a threat to the health of humans or other living organisms" (WAC 173-350-100)).~~ Whether or not a soil is a clean soil depends primarily upon the level of contaminants and, to a lesser degree, on the background level of contaminants at a particular location and the exposure potential to humans or other living organisms. Therefore, evaluate both the soil and potential land application sites ~~must be evaluated~~ to determine if a soil is a clean soil. ~~Local health departments should be contacted to determine if a street waste meets the definition of "clean soil" when it will be reused as a soil.~~

There is no simple regulatory mechanism available to classify street waste solids ~~as "clean"~~ for uncontrolled reuse or disposal. Street wastes are defined simply as solid waste. Local health districts have historically used the Model Toxics Control Act Cleanup Regulation (MTCA) Method A residential soil cleanup levels to approximate "clean" and to make decisions on land application proposals. ~~These regulations were amended in February 2001.~~ The MTCA regulation is not intended to be directly applied to setting contaminant concentration levels for land application proposals. However, they may provide human health and environmental

threat information and a useful framework for such decisions, when used in conjunction with other health and environmental considerations. In addition to MTCA, Ecological Soil Screening Levels from EPA, ODEQ Risk-based concentrations, Toxicological benchmarks from Oak Ridge National Labs, and natural background levels can be considered. Contact the local health department ~~should be contacted~~ to determine local requirements for making this determination.

Using the old MTCA regulations, many local health departments have set a ~~criterion~~ criterion of 200 mg/Kg Total Petroleum Hydrocarbons (TPH) for diesel and heavy fuel oils as a threshold level for clean soil. Using the new MTCA terrestrial ecological evaluation procedures, allowable TPH levels for land application could range from 200 – 460, depending on site characteristics and intended land use. Street waste sampling has historically yielded TPH values higher than 200 mg/kg for hydrocarbons in the diesel and heavy oil range. These values typically reflect interference from natural organic material and, to a lesser extent, relatively immobile petroleum hydrocarbons. The mobile hydrocarbons that are of concern for ground water protection are generally not retained with street waste solids. Ecology's Manchester Lab has developed an analytical method to reduce the problem of natural organic material being included in the TPH analysis for diesel and heavier range hydrocarbons. This ~~new~~ method, called NWTPH-Dx, reduces the background interference associated with vegetative matter by as much as 85% to 95%. However, even with the new methodology, TPH test results for street waste may still be biased by the presence of natural vegetative material and may still exceed 200 mg/kg. ~~Where the~~ laboratory results report no 'fingerprint' or chromatographic match to known petroleum hydrocarbons, the soils should not be considered to be petroleum contaminated soils. Table G.1 lists Typical TPH levels in street sweeping and catch basin solids.

Table G.1 - Typical TPH Levels in Street Sweeping and Catch Basin Solids

Reference:	Street Sweeping (mg/kg)	Catch Basin Solid (mg/kg)
Snohomish County (1) (Landau 1995)	390 – 4300	
King County (1) (Herrera 1995)		123 – 11049 (Median 1036)
Snohomish County & Selected Cities (1) (W & H Pacific, 1993)	163 - 1500 (Median 760)	163 – 1562 (Median 760)
City of Portland (2)) (Bresch)		MDL – 1830 (Median – 208)
City of Seattle – Diesel Range(2) (Herrera 2009)	330-520	780-1700
City of Seattle – Motor Oil(2) (Herrera 2009)	2000-2800	3500-7000
Oregon (1) (Collins; ODOT 1998)	1600 – 2380	

Oregon (3) (Collins; ODOT 1998)	98 - 125	
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- (1) Method WTPH 418.1; does not incorporate new methods to reduce background interference due to vegetative material
- (2) Method NWTPH-Dx
- (3) Method WTPH – HCID

Street waste solids frequently contain levels of carcinogenic PAHs (c-PAH) that make unrestricted use inappropriate. This is complicated further by analytical interference caused by organic matter that raises practical quantitation or reporting limits. To greatly reduce the level of interference, the use of US EPA Test Method 8270, incorporating the silica gel cleanup step, is recommended. The calculated c-PAH value can vary greatly depending upon how non-detect values are handled. The new MTCA Method A criterion for c-PAH is 0.1 mg/kg (the sum of all seven c-PAH parameters multiplied by the appropriate toxicity equivalency factor)) for unrestricted land uses. The MTCA criteria for soil cleanup levels for industrial properties is 2.0 mg/kg. Following this guidance, most sites where street wastes could be reused as soil will be commercial or industrial sites, or sites where public exposure will be limited or prevented. [See Table G.2 for typical c-PAH values in Street Waste Solids and Related Materials.](#) [See Table G.3 for typical metals concentrations in Catch Basin Sediments.](#)

Table G.2 - Typical c-PAH Values in Street Waste Solids and Related Materials

Sample Source Analyte	City of Everett					WSDOT	
	Street Sweepings	Soil	3-Way Topsoil	Vactor Solids	Leaf & Sand	Sweepings – Fresh	Sweepings Weathered
Benzo(a)anthracene	0.1U	0.076U	0.074U	0.21	0.45	0.56	0.40
Chrysene	0.14	0.09	0.074U	0.32	0.53	0.35	0.35
Benzo(b)fluoranthene	0.11	0.076U	0.074U	0.27	0.52	0.43	0.51
Benzo(k)fluoranthene	0.13	0.076U	0.074U	0.25	0.38	0.39	0.40
Benzo(a)pyrene	0.13	0.076U	0.074U	0.26	0.5	0.41	0.33U
Indeno(1,2,3-cd)pyrene	0.1U	0.076U	0.074U	0.19	0.39	NR	NR
Dibenzo(a,h)anthracene	0.1U	0.076U	0.074U	0.081	0.12	0.39	0.33U
Revised MTCA Benzo(a)pyrene [ND=PQL]	0.215	0.134	0.134	0.388	0.727	0.708	0.597
Benzo(a)pyrene [ND=1/2 PQL]	0.185	0.069	0.067	0.388	0.727	0.708	0.366
Benzo(a)pyrene [See * below]	0.185	0.069	0	0.388	0.727	0.708	0.366
Benzo(a)pyrene [ND=0]	0.155	0.001	0	0.388	0.727	0.708	0.135

*If the analyte was not detected for any PAH, then ND=0; If analyte was detected in at least 1 PAH, then ND=1/2PQL; If the average concentration (using ND=1/2 PQL) is greater than the maximum detected value, then ND=Maximum value.

The new Method A soil cleanup level for unrestricted land use is 0.1 mg/Kg for BAP. ([WAC 173-340-900](#) ~~(WAC 173-340-900~~, Table 740-1)

The new Method A soil cleanup level for industrial properties is 2 mg/Kg for BAP. ([WAC 173-340-900](#) ~~(WAC 173-340-900, Table 745-1)~~)

Table G.3 - Typical Metals Concentrations in Catch Basin Sediments

PARAMETER	Ecology 1993	Thurston 1993	King County 1995	King County 1995	City of Seattle 2003 through 2011
METALS; TOTAL (mg/kg)	(Min – Max)	(Min – Max)	(Min - Max)	Mean	Min- Max (Mean)
As	<3 -- 24	.39 -- 5.4	4 – 56	0.250	<5 – 50 (9.3)
Cd	0.5 -- 2.0	< 0.22 -- 4.9	0.2 – 5.0	0.5	
Cr	19 -- 241	5.9 -- 71	13 - 100	25.8	
Cu	18 -- 560	25 -- 110	12 - 730	29	9.1 - 3,280 (166)
Pb	24 -- 194	42 -- 640	4 – 850	80	3 - 3,690 (154)
Ni	33 -- 86	23 -- 51	14 – 41	23	
Zn	90 -- 558	97 -- 580	50 – 2000	130	44 - 4,170 (479)
Hg	.04 -- .16	.024 -- .193			<0.03 - 3.8 (0.16)

Permitting of street waste treatment and storage facilities as solid waste handling facilities by the local health department is required.

Under the Solid Waste Management Act, local health departments have primary jurisdiction over solid waste management.

Street waste handling facilities are subject to the requirements of the ~~Minimal Functional Standards for Solid Waste Handling. The Standards.~~ Specific requirements ~~will~~ depend upon the manner in which the waste is managed. Most facilities ~~will probably be~~ permitted under the section dealing with Piles Used for Storage and Treatment (Section 320 ~~of the proposed revisions~~).

For most facilities, permit requirements include a plan of operation, sampling, record keeping and reporting, inspections, and compliance with other state and local requirements. The plan of operation should include a procedure for characterization of the waste and appropriate reuse and disposal options, consistent with the recommendations in this document and applicable federal, State and local requirements.

Ecology suggests a street waste site evaluation (see sample at end of this appendix) is suggested for all street waste as a method to identify spill sites or locations that are more polluted than normal. Ecology based the disposal and reuse options listed below ~~are based on~~ characteristics of routine street waste and are not appropriate for more polluted wastes. The collector of street waste should evaluate it ~~both~~ for its potential to be classified as dangerous waste ~~and to~~. The collector should also be aware that this waste may not meet end users requirements.

Street waste that is suspected to be dangerous waste should not be collected with other street waste. Material in catch basins with obvious contamination (unusual color, staining, corrosion, unusual odors, fumes,

and oily sheen) should be left in place or segregated until tested. ~~Testing should be based~~ Base testing activities on probable contaminants. Street waste ~~that is~~ suspected to be dangerous waste should be collected and handled by someone experienced in handling dangerous waste. If collecting potential dangerous waste ~~must be collected~~ because of emergency conditions, or if the waste becomes suspect after it is collected, it should be handled and stored separately until a determination as to proper disposal is made. Street waste treatment and storage facilities should have separate "hot load" storage areas for such waste. **Dangerous Waste** includes street waste known ~~and/or~~ suspected to be dangerous waste. This waste must be handled following the Dangerous Waste Regulations (Chapter 173-303 WAC ~~(Chapter 173-303 WAC)~~) unless testing determines it is not dangerous waste.

Spills should be handled by trained specialists. Public works maintenance crews and private operators conducting street sweeping or cleaning catch basins should have written policies and procedures for dealing with spills or suspected spill materials. Emergency Spill Response telephone numbers should be immediately available as part of these operating policies and procedures.

The end recipient of street waste must be informed of its source and may have additional requirements for its use or testing that are not listed here. This document is based primarily on average street waste's chemical constituents and their potential affect on human health and the environment. There are physical constituents (for example, broken glass or hypodermic needles) or characteristics (for example, fine grain size) that could also limit reuse options. Additional treatment such as drying, sorting, or screening may also be required, depending on the needs and requirements of the end user.

Street waste treatment and storage facilities owned or operated by governmental agencies should be made available to private waste collectors and other governmental agencies on a cost recovery basis. Proper street waste collection and disposal reduces the amount of waste released to the environment. The operators of street waste facilities should restrict the use of their facilities to certified and/or licensed waste collectors who meet their training and liability requirements.

The use of street waste solids under this guidance should not lead to designation as a ~~hazardous~~ dangerous waste site, requiring cleanup under MTCA. Exceeding MTCA Method A unrestricted land use cleanup levels in street waste and products made from street waste, does not automatically make the site where street waste is reused a cleanup site. A site is reportable only if "-a release poses a threat to human health or the environment-" (Model Toxic Control Act). The reuse options proposed below are designed to meet the condition of not posing a threat to human health or the environment.

Testing of street waste solids will generally be required as part of a plan of operation that includes procedures for characterization of the waste. Testing frequency, numbers of samples, parameters to be analyzed, and contaminant limit criteria should all be provided as part of an approved plan of operation. However, street sweepings that consist primarily of leaves, pine needles, branches, and grass clippings do not require testing. ~~Tables G.4~~ Tables G.4 and G.5 and G.5 below provide some recommended parameters and sampling frequencies for piles of street waste solids from routine street maintenance. These are provided as guidance only, and are intended to assist the utility and the local health department in determining appropriate requirements. Sampling requirements may be modified, over time, based on accumulated data. When the material is from a street waste facility or an area that has never been characterized by testing, the test should be conducted on a representative sample before co-mingling with other material. Testing in these instances would be to demonstrate that the waste does not designate as dangerous waste and to characterize the waste for reuse. At a minimum, the parameters in ~~Table G.4~~ Table G.4 are recommended for these cases. Note that it will generally not be necessary to conduct TCLP analyses when the observed values do not exceed the recommended values in ~~Table G.4~~ Table G.4. ~~Table G.6~~ Table G.6 illustrates some observed relationships between total metals and TCLP metals values.

For further information on testing methods and sampling plans, refer to:

- SW 846 (US EPA, Office of Solid Waste, Test Methods for Evaluating Solid Wastes, 3rd Ed.) and
- Standard Methods for the Examination of Water and Wastewater (American Public Health Association, et al., 18th Edition 1992)

Table G.4 - Recommended Parameters and Suggested Values for Determining Reuse & Disposal Options

Parameter	Suggested Maximum Value
Arsenic, Total	20.0 mg/kg (a)
Cadmium, Total	2.0 mg/kg (b)
Chromium, Total	42 mg/kg (c)
Lead, total	250 mg/kg (d)
Nickel	100 mg/kg (e)
Zinc	270 mg/kg (e)
Mercury (Inorganic)	2.0 mg/kg (f)
PAHs (Carcinogenic)	0.1 – 2.0 mg/kg (see Note at (g) below)
TPH (Heavy Fuel Oil)	2,000 mg/kg (see Note at (h) below)
TPH (Diesel)	200 mg/kg (see Note at (i) below)
TPH (Gasoline)	100 mg/kg (j)
Benzene	0.03 mg/kg (j)
Ethylbenzene	6 mg/kg (j)
Toluene	7 mg/kg (j)
Xylenes (Total)	9 mg/kg (j)

- (a) Arsenic; from MTCA Method A - Table 740-1: Soil cleanup levels for unrestricted land uses
- (b) Cadmium; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses.
- (c) Chromium; from MTCA Method A - Table 740-1: Soil cleanup levels for unrestricted land uses
- (d) Lead; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
- (e) Nickel and Zinc; from MTCA Table 749-2: Protection of Terrestrial Plants and Animals
- (f) Mercury; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
- (g) PAH-Carcinogenic; from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses and Table 745-1, industrial properties, based on cancer risk via direct contact with contaminated soil (ingestion of soil) in residential land use situations and commercial/industrial land uses. Note: The local health department may permit higher levels as part of a Plan of Operation, where they determine that the proposed end use poses little risk of direct human contact or ingestion of soil.
- (h) TPH (Heavy Fuel Oil); from MTCA Method A – Table 740-1: Soil cleanup levels for unrestricted land uses
- (i) TPH (Diesel); from MTCA Table 749-3: Protection of Terrestrial Plants and Animals..
- (j) BETX; from MTCA Method A - Table 740-1: Soil cleanup levels for unrestricted land uses.

Table G.5 - Recommended Sampling Frequency for Street Waste Solids

Cubic Yards of Solids	Minimum Number of Samples
0 – 100	3
101 – 500	5
501 – 1000	7
1001 – 2000	10
>2000	10 + 1 for each additional 500 cubic yards

Modified from Ecology's Interim Compost Guidelines

Table G.6 - Pollutants in Catch Basin Solids – Comparison to Dangerous Waste Criteria

PARAMETER	Range of Values in Catch Basin Waste	Range of Values in Catch Basin Waste	Dangerous Waste Criteria
METALS	Total Metals (mg/kg)	TCLP Metals (mg/kg)	TCLP values (mg/l)
As	<3 - 56	< .02 - 0 .5	5.0
Cd	<.22 - 5	.0002 - .03	1.0
Cr	5.9 - 241	.0025 - .1	5.0
Cu	12 - 730	.002 -- .88	none
Pb	4 - 850	.015 -- 3.8	5.0
Ni	23 - 86	< .01 -- .36	none
Zn	50 - 2000	.04 -- 6.7	none
Hg	.02 - .19	.0001 -- .0002	0.2

Data from Thurston County (Thurston County 1993), King County (Herrera 1995) and Ecology (Serdar; Ecology 1993).

For street waste not exceeding the suggested maximum values in [Table G.4](#), Ecology recommends the following street waste solids reuse and disposal options ~~are recommended~~:

- Compost street sweepings that consist primarily of leaves, pine needles and branches, and grass cuttings from mowing grassy swales ~~can be composted~~. Remove litter and other foreign material ~~must be removed~~ prior to composting or the composting facility must provide for such removal as part of the process. Dispose of the screened trash is solid waste at an appropriate solid waste handling facility.
- It is possible to reuse coarse sand screened from street sweeping after recent road sanding, for street sanding, providing there is no obvious contamination from spills. The screened trash is solid waste and must be disposed of at an appropriate solid waste handling facility.
- ~~Coarse sand screened from street sweeping after recent road sanding, may be reused for street sanding, providing there is no obvious~~

~~contamination from spills. The screened trash is solid waste and must be disposed of at an appropriate solid waste handling facility.~~

- Screen roadside ditch cleanings, not contaminated by a spill or other release and not associated with a stormwater treatment system such as a bioswale, ~~may be screened~~ to remove litter and ~~separated~~separate into soil and vegetative matter (leaves, grass, needles, branches, etc.). The soils from these activities are ~~not generally regulated~~typically unregulated as solid waste. Ditching material that may be contaminated must be stored, tested, and handled in the same manner as other street waste solids. It is the generator's responsibility to visually inspect and otherwise determine whether the materials may be contaminated.
- Construction street wastes—~~solids collected from sweeping or in storm water treatment systems at active construction sites - may be placed back onto the site that generated it, or managed by one on the methods listed below, provided that it has not been contaminated as a result of a spill. For concrete handling at construction site, refer to BMP C151 in Volume II, Construction Stormwater Pollution Prevention.~~
- Use screened street waste soils ~~may be used~~ as feedstock materials for topsoil operations. Reserve this option ~~should be reserved~~ for street waste soils with very low levels of contaminants. ~~Diluting~~Evaluate the allowable level of contaminants based on the proposed use of the soil. At a minimum, the contaminate level in the soil should be below established action levels for in situ soils. Do not dilute street waste soils with clean soils or composted material ~~must not be used~~ as a substitute for treatment or disposal. There may be unscreened physical contaminants (for example, glass, metal, nails, etc.) in street waste ~~that cannot be entirely screened from the waste.~~ Where present, these contaminants in street waste could preclude its use as feedstock material for topsoil operations.
- Fill in parks, play fields, golf courses and other recreational settings, where direct exposure by the public is limited or prevented. One way to accomplish is to cover the fill with sod, grass or other capping material to reduce the risk of soil ~~being ingested, ingestion.~~ Evaluate the level of contaminants in the street waste ~~must be evaluated~~ to ensure that the soils meet the definition of clean soils when used in this manner.
- Fill in commercial and industrial areas, including soil or top dressing for use at industrial sites, roadway medians, airport infields and similar sites, where there is limited direct human contact with the soil, and stabilize the soils ~~will be stabilized~~ with vegetation or other means. Evaluate the level of contaminants in the street waste ~~must be~~

~~evaluated~~ to ensure that the soils meet the definition of clean soils when used in this manner.

- Top dressing on roadway slopes, road or parking lot construction material and road subgrade, parking lot subgrade, or other road fill. ~~Evaluate~~ the level of contaminants in the street waste ~~must be evaluated~~ to ensure that the soils meet the definition of clean soils when used in this manner.
- Daily cover or fill in a permitted municipal solid waste landfill; provided the street waste solids have been dewatered. Street waste solids may be acceptable as final cover during a landfill closure. Consult the local health department and landfill operator ~~should be consulted~~ to determine conditions of acceptance.
- Treatment at a permitted contaminated soil treatment facility.
- Recycling through incorporation into a manufactured product, such as Portland cement, prefabricated concrete, or asphalt. Consult the facility operator to determine conditions of acceptance.
- Other end-use as approved by the local health department
- Disposal at an appropriate solid waste handling facility.

For street waste that exceeds the suggested maximum values in Table G.4, Ecology recommends the following street waste solids reuse and disposal options:

- Treatment at a permitted contaminated soil treatment facility.
- ~~Recycling through incorporation into a manufactured product, such as Portland cement, ~~prefab~~prefabricated concrete, or asphalt. Consult the facility operator ~~should be consulted to determine conditions of acceptance.~~~~
- ~~Other end-use as approved by the local health department~~
- ~~Disposal at an appropriate solid waste handling facility.~~

For street waste that exceed the suggested maximum values in Table G.4, the following street waste solids reuse and disposal options are recommended:

- ~~Treatment at a permitted contaminated soil treatment facility.~~
- ~~Recycling through incorporation into a manufactured product, such as Portland cement, prefab concrete, or asphalt. The facility operator ~~should be consulted~~ to determine conditions of acceptance.~~
- Other end-use as approved by the local health department
- Disposal at an appropriate solid waste handling facility.

Street Waste Liquids

General Procedures:

Street waste collection should emphasize retention of solids in preference to liquids. Street waste solids are the principal objective in street waste collection and are substantially easier to store and treat than liquids.

Street waste liquids require treatment ~~and/or must follow location limitations~~ before their discharge. Street waste liquids usually contain high amounts of suspended and total solids and adsorbed metals. Treatment requirements depend on the discharge location.

~~Discharges to sanitary sewer and storm sewer systems must be approved by~~ The entity responsible for operation and maintenance of the system must approve discharges to sanitary sewer and storm sewer systems. Ecology will not generally require waste discharge permits for discharge of stormwater decant to sanitary sewers or to stormwater treatment BMPs constructed and maintained in accordance with Ecology's Stormwater Management Manual for Western Washington. (See Volume 5, Sections 7 through 12 for further detail) ~~on approved BMPs~~.

Follow the following ~~disposal options are recommended, in required~~ order of preference, for disposal of catch basin decant liquid and ~~for~~ water removed from stormwater treatment facilities.

~~Under the Municipal General Permit, municipalities are required to use this guidance in determining appropriate means of dealing with street wastes from stormwater maintenance activities. Your regional Department of Ecology water quality staff can help you with treatment standards and permit requirements for your particular situation.~~

1. Discharge of catch basin decant liquids to a municipal sanitary sewer connected to a Public Owned Treatment Works (POTW) is the preferred disposal option. Discharge to a municipal sanitary sewer requires the approval of the sewer authority. ~~Street waste liquids discharged~~ Approvals for discharge to a POTW ~~may be treated at a combined street waste liquid and solid facility (decant facility) or at separate liquids only facilities. These liquid-only facilities may consist of modified type 2 catch basins (with a flow restrictor or oil/water separator) or water quality vaults, strategically located through the sanitary collection system. These should provide 24-hour detention for the expected volumes and should be constructed and operated to ensure that the decant discharge does not resuspend sediments. Sewer authorities should require periodic sampling and decant facility operators should test their waste effluent on a regular basis, but street waste decant liquid should meet the most~~

~~restrictive local limits with 24 hours of undisturbed gravity settling. Overnight settling is more practical and will likely meet most local contain pretreatment requirements. (See Table G.9 Catch Basin Decant Values, quantity, and location conditions to protect the POTW. Following Settling for typical the local sewer authority's conditions is a permit requirement.~~

Discharge of catch basin decant values from King County's decant facility at Renton).

~~State and local regulations generally prohibit discharge of stormwater runoff into sanitary sewers, to avoid hydraulic overloads and treatment performance problems. The volume of storm water discharged from catch basins and small stormwater treatment facilities is generally not sufficient to be a problem, provided the discharge point is properly selected and designed.~~

Stormwater removed from catch basins and stormwater treatment wetvaults may be discharged liquids may be allowed into a Basic or Enhanced Stormwater Treatment BMP.

1.2. Decant, if option 1 is not available. Only discharge liquid collected from cleaning catch basins and stormwater treatment wetvaults ~~may be discharged~~ back into the storm sewer system under the following conditions:

- The preferred disposal option of discharge to sanitary sewer is not reasonably available, ~~and~~
- The discharge is to a Basic or Enhanced Stormwater Treatment Facility ~~(See Volume V, Chapters 3 and 4), and. If pretreatment does not remove visible sheen from oils, the treatment facility must be able to prevent the discharge of oils causing a visible sheen.~~
- The discharge is as near to the treatment facility as is practical, to minimize contamination or recontamination of the collection system.
- The storm sewer system owner/operator has granted approval and has determined that the treatment facility will accommodate the increased loading. Part of the approval process may include pretreatment conditions to protect the treatment BMP. Following local pretreatment conditions is a requirement of this permit.

~~Pretreatment may be required to protect~~ Ecology must approve in advance flocculants for the treatment BMP.

- Reasonably available will be determined by the stormwater utility and by pretreatment of catch basin decant liquids. The liquids must be non-toxic under the circumstances, including of use.

The discharger shall determine if reasonable availability of sanitary sewer discharge exists, by evaluating such factors as distance, time of travel, load restrictions, and capacity of the stormwater treatment facility. ~~Some~~

jurisdictions may choose not to allow discharge back to the storm sewer system. Currently King County does not allow such discharges, under King County Code 9.12 Water Quality.

Discharge back into the storm sewer is an acceptable option, under certain conditions:

- ~~Other practical means are not reasonably available, and~~
- ~~Pretreatment is provided by discharging to a modified type 2 catch basin (with a flow restrictor or oil/water separator) or water quality vault, and~~
- ~~The discharge is upstream of a basic or enhanced stormwater treatment BMP, and~~
- ~~The storm sewer system owner/operator has granted approval. Other practical means includes the use of decanting facilities and field decant sites that discharge to sanitary sewers or discharge to an approved stormwater treatment BMP.~~

~~Limited field testing of flocculent aids has been conducted. While the use of flocculent aids is promising, sufficient testing has not been conducted to allow approval of any specific product or process. In general, the following conditions must be met for flocculent use to be approved:~~

- ~~The flocculent must be non-toxic under circumstances of use and approved for use by the Department of Ecology~~
- ~~The decant must be discharged to an approved basic or enhanced stormwater treatment BMP, with sufficient capacity and appropriate design to handle the anticipated volume and pollutant loading~~
- ~~The discharge must be approved by the storm sewer system owner/operator.~~

- 2.3. Operators may return water removed from stormwater ponds, vaults, and oversized catch basins may be returned to the storm sewer system.** Stormwater ponds, vaults, and oversized catch basins contain substantial amounts of liquid, which hampers the collection of solids and poses problems in hauling the removed waste must be hauled away from the site. Water removed from these facilities may be discharged back into the pond, vault, or catch basin provided:
- **Operators may discharge** clear water removed from a stormwater treatment structure ~~may be discharged~~ directly to a ~~downgradient~~ **down gradient** cell of a treatment pond or into the storm sewer system.
 - Turbid water may be discharged back into the structure it was removed from if the removed water has been stored in a clean container (eductor truck, Baker tank, or other appropriate container used specifically for handling stormwater or clean water); and there will be no discharge from the treatment structure for at least 24 hours.

- The ~~discharge must be approved by the~~ storm sewer system owner/operator must approve the discharge.

~~Vegetation management and structural integrity concerns sometimes require that the ponds be refilled as soon after solids removal as possible. For ponds and other systems relying on biological processes for waste treatment, it is often preferable to reuse at least some portion of the removed water.~~

Table G.7 - Typical Catch Basin Decant Values Compared to Surface Water Quality Criteria

PARAMETER	State Surface Water Quality Criteria		Range of Values Reported	Range of Values Reported
METALS	Freshwater Acute (ug/l – dissolved metals)	Freshwater Chronic (ug/l – dissolved metals)	Total Metals (ug/l)	Dissolved Metals (ug/l)
Arsenic	360	190	100 – 43000	60 - 100
Cadmium*	2.73	0.84	64 - 2400	2 - 5
Chromium (total)			13 -- 90000	3 - 6
Chromium (III)*	435	141		
Chromium (VI)	0.5	10		
Copper*	13.04	8.92	81 -- 200000	3 - 66
Lead*	47.3	1.85	255 -- 230000	1 - 50
Nickel*	1114	124	40 -- 330	20 - 80
Zinc*	90.1	82.3	401 -- 440000	1900 - 61000
Mercury	2.10	.012	0.5 -- 21.9	

*Hardness dependent; hardness assumed to be 75 mg/l

Table G.8 - Typical Values for Conventional Pollutants in Catch Basin Decant

PARAMETER	Ecology 1993	(Min - Max)	King County 1995	(Min - Max)
Values as mg/l; except where stated	Mean		Mean	
pH	6.94	6.18 - 7.98	8	6.18 - 11.25
Conductivity (umhos/cm)	364	184 - 1110	480	129 - 10,100
Hardness (mg/l CaCO ₃)	234	73 - 762		
Fecal Coliform (MPN/100 ml)	3000			
BOD	151	28 - 1250		
COD	900	120 - 26,900		
Oil & Grease	11	7.0 - 40	471	15 - 6242
TOC	136	49 - 7880	3670	203 - 30,185
Total Solids	1930	586 - 70,400		
Total Dissolved Solids	212	95 - 550		
Total Suspended Solids	2960	265 - 111,000		
Settleable Solids (ml/hr)	27	2 - 234	57	1 - 740
Turbidity (ntu)	1000	55 - 52,000	4673	43 - 78,000

Table G.9 - Catch Basin Decant Values Following Settling¹

Parameter; Total Metals in mg/l	Portland – Inverness Site Min - Max	King County - Renton Min - Max	METRO Pretreatment Discharge Limits
Arsenic	.0027 .015	< MDL – 0.12	4
Cadmium	.0009 - .0150	< MDL – 0.11	0.6
Chromium	.0046 - .0980	.017 – .189	5
Copper	.015 - .8600	.0501 – .408	8
Lead	.050 – 6.60	.152 – 2.83	4
Nickel	.0052 - .10	.056 - .187	5
Silver	.0003 - .010	< MDL	3
Zinc	.130 – 1.90	.152 – 3.10	10
Settleable Solids; ml/L	No Data	.02 - 2	7
Nonpolar FOG	5.7 - 25	5 - 22	100
Ph (std)	6.1 – 7.2	6.74 – 8.26	5.0 - 12.0
TSS	2.8 - 1310		
Recorded Total Monthly Flow; Gallons	Data not available	31,850 - 111,050	
Recorded Max. Daily Flow; Gallons	Data not available	4,500 - 18,600	25,000 GPD
Calculated Average Daily Flow; GPD	Data not available	1517 - 5428	

1) Data from King County's Renton Facility (data from 1998 – 1999) and the City of Portland's Inverness Site (data from 1999 – 2001); detention times not provided

Site Evaluation

Ecology suggests use of a site evaluation is suggested as method to identify spill sites or locations that are more polluted than normal potentially contain dangerous wastes.

The site evaluation will aid in determining if waste ~~should be handled as is~~ a dangerous waste and in determining what to test for if dangerous waste is suspected. The site evaluation will also help to determine if the waste does not meet the requirements of the end users.

There are three steps to a site evaluation:

1. ~~1.~~—An **historical review** of the site for spills, previous contamination and nearby toxic cleanup sites and dangerous waste and materials.

The historical review will be easier if done on an area wide basis prior to scheduling any waste collection. The historical review should be more thorough for operators who never collected waste at a site before. At a minimum, the historical review should include operator knowledge of the area's collection history or records kept from previous waste collections.

Private operators should ask the owner of the site for records of previous contamination and the timing of the most recent cleaning. Ecology's Hazardous Substance Information Office maintains a Toxic Release Inventory and a "Facility Site" webpage, tracking more than 15,000 sites. This information is available from Ecology through the Internet at

http://www.ecy.wa.gov/epcra/chemical_summary_2008/tri_intro_numbers.html or by calling a toll-free telephone number (1-800-633-7585).

The webpage allows anyone with web-access to search for facility information by address, facility name, town, zip code, and SIC code, etc. It lists why the Department of Ecology is tracking each one (NPDES, TSCA, RCRA, Clean Air Act, etc.), as well as who to call within Ecology to find out more about the given facility. EPA's toxic release website is http://iaspub.epa.gov/triexplorer/tri_release.chemical

2. ~~2.~~—An area visual inspection for potential contaminant sources such as a past fire, leaking tanks and electrical transformers, and surface stains.

Evaluate the area around the site ~~should be evaluated~~ for contaminant sources prior to collection of the waste. The area visual inspection may be done either as part of multiple or as single site inspections. If the inspection finds a potential contaminant source ~~is found~~, delay the waste collection ~~should be delayed~~ until the potential contaminant is assessed.

A second portion of the area visual inspection is a subjective good housekeeping evaluation of the area. Locations with poor

housekeeping commonly cut corners in less obvious places ~~and should be inspected~~. Inspect these sites in greater detail for illegal dumping and other contamination spreading practices.

3. ~~3.~~—A waste and container inspection before and during collection.

The inspection of the waste and catch basin or vault is the last and perhaps most critical step in the site evaluation.

For example, if the stormwater facility has an unusual color in or around it, then there is a strong possibility that someone dumped something ~~could have been dumped~~ into it. Some colors to be particularly wary of are yellow-green from antifreeze dumping and black and ~~rainbow~~ sheen from oil and/or grease dumping. In addition, if the inspector observes any staining or corrosion ~~is observed~~, then a solvent may have been dumped.

Fumes are also good indicators of potential dangerous or dangerous waste. Avoid deliberate smelling of catch basins ~~should be avoided~~ for worker safety, but suspicious odors may be encountered from catch basins thought to be safe. Some suspicious odors are rotten eggs (hydrogen sulfide is present), gasoline or diesel fumes, or solvent odors. If unusual odors are noted, contact a dangerous waste inspector before cleaning the basin.

Finally, operator experience is the best guide to avoid collection of contaminated waste.

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Chapter 1. - Introduction

1.1 Purpose of this Volume

Best Management Practices (BMPs) are schedules of activities, prohibitions of practices, maintenance procedures, managerial practices, or structural features that prevent or reduce adverse impacts to waters of Washington State. As described in Volume I of this stormwater manual, there are three main categories of BMPs for long-term management of stormwater at developed sites ~~can be divided into three main categories:~~

- BMPs addressing the amount and timing of stormwater flows;
- BMPs addressing prevention of pollution from potential sources; and
- BMPs addressing treatment of runoff to remove sediment and other pollutants.

This volume of the stormwater manual focuses on the third category, treatment of runoff to remove sediment and other pollutants at developed sites. The purpose of this volume is to provide guidance for selection, design, and maintenance of permanent runoff treatment facilities.

The Manual presents BMPs with respect to controlling stormwater flows and control of pollutant sources ~~are presented~~ in Volumes III and IV, respectively.

1.2 Content and Organization of this Volume

Volume V of the stormwater manual contains 12 chapters. Chapter 1 ~~Chapter 1~~ serves as an introduction and summarizes available options for treatment of stormwater. Chapter 2 ~~Chapter 2~~ outlines a step-by-step process for selecting treatment facilities for new development and redevelopment projects. Chapter 3 ~~Chapter 3~~ presents treatment facility “menus” that are used in applying the step-by-step process presented in Chapter 2. These menus cover different treatment needs that are associated with different sites. Chapter 4 ~~Chapter 4~~ discusses general requirements for treatment facilities. Chapter 5 ~~Chapter 5~~ presents information regarding on-site stormwater management BMPs. The intent of these BMPs ~~are intended~~ is to infiltrate, disperse, or contain runoff on site, as well as to provide treatment. Chapters 6 ~~Chapters 6~~ through 11 provide detailed information regarding specific types of treatment identified in the menus. Chapter 12 ~~Chapter 12~~ discusses special considerations for emerging technologies for stormwater treatment.

The Appendices ~~Appendices~~ to this volume contain more detailed information on selected topics described in the various chapters.

1.3 How to Use this Volume

~~This volume~~The Reader should ~~be consulted~~consult this volume to select specific BMPs for runoff treatment for ~~inclusion in the~~ Stormwater Site Plans (see Volume I). After ~~you have identified~~ the Minimum Requirements ~~have been identified~~ from Volume I, ~~this volume~~you can be ~~used~~use this volume to select specific treatment facilities for permanent use at developed sites, and as an aid in designing and constructing these facilities.

1.4 Runoff Treatment Facilities

1.4.1 General Considerations

Runoff treatment facilities are designed to remove pollutants contained in stormwater runoff. The pollutants of concern include sand, silt, and other suspended solids; metals such as copper, lead, and zinc; nutrients (e.g., nitrogen and phosphorous); certain bacteria and viruses; and organics such as petroleum hydrocarbons and pesticides. Methods of pollutant removal include sedimentation/settling, filtration, plant uptake, ion exchange, adsorption, and bacterial decomposition. Floatable pollutants such as oil, debris, and scum can be removed with separator structures.

1.4.2 Maintenance

Maintenance is required for all types of runoff treatment facilities. See [Section 4.6](#)~~Section 4.6~~ for maintenance standards for the treatment facilities discussed in this volume.

1.4.3 Treatment Methods

Methods used for runoff treatment facilities and common terms used in runoff treatment are discussed below:

- **Wetpools.** Wetpools provide runoff treatment by allowing settling of particulates during quiescent conditions (sedimentation), by biological uptake, and by vegetative filtration. Wetpools may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond or vault to also provide flow control. If combined, the wetpool facility can often be stacked under the detention facility with little further loss of development area.
- **Biofiltration.** Biofiltration uses vegetation in conjunction with slow and shallow-depth flow for runoff treatment. As runoff passes through the vegetation, pollutants are removed through the combined effects of filtration, infiltration, and settling. These effects are aided by the reduction of the velocity of stormwater as it passes through the biofilter. Biofiltration facilities include swales that are designed to

convey and treat concentrated runoff at shallow depths and slow velocities, and filter strips that are broad areas of vegetation for treating sheet flow runoff.

- **Oil/Water Separation.** Oil/water separators remove oil floating on the top of the water. There are two general types of separators - the American Petroleum Institute (API) separators and coalescing plate (CP) separators. Both use gravity to remove floating and dispersed oil. API separators, or baffle separators, are generally composed of three chambers separated by baffles. The efficiency of these separators is dependent on detention time in the center, or detention chamber, and on droplet size. CP separators use a series of parallel plates, which improve separation efficiency by providing more surface area, thus reducing the space needed for the separator. Oil/water separators must be located off-line from the primary conveyance/detention system, bypassing flows greater than the water quality design flow. Other devices/facilities that may be used for removal of oil include “~~emerging technologies~~ catch basin inserts” (see definition below), and linear sand filters. Oil control devices/facilities should ~~always~~ be placed upstream of other treatment facilities and as close to the source of oil generation as possible.
- **Pretreatment.** Presettling basins are often used to remove sediment from runoff prior to discharge into other treatment facilities. Basic treatment facilities, listed in Step 6 – Figure 2.1.1 ~~Figure 2.1.~~, can also be used to provide pretreatment. Pretreatment often must be provided for filtration and infiltration facilities to protect them from clogging or to protect ground water. Appropriate pretreatment devices include a pre-settling basin, wet pond/vault, biofilter, constructed wetland, or oil/water separator. A number of patented technologies have received General and Conditional Use Level Designations for Pretreatment through Ecology’s TAPE (Technology Assessment Protocol – Ecology) Program. A listing and descriptions are available at Ecology’s Emerging Technologies website <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html>
- **Infiltration.** Infiltration refers to the use of the filtration, adsorption, and biological ~~decomposition~~ properties of native soils, with or without amendments, to remove pollutants– as stormwater soaks into the ground. Infiltration can provide multiple benefits including pollutant removal, peak flow control, ground water recharge, and flood control. ~~However,~~ One condition that can limit the use of infiltration is the potential adverse impact on ground water quality. ~~To adequately address the protection of ground water when evaluating infiltration it is important to~~ You must understand the difference between infiltrating in soils that are suitable for runoff treatment and soils only suitable for flow control– to protect ground water. Sufficient organic content and sorption capacity to remove pollutants must be present for soils to

provide runoff treatment. Examples of suitable soils are silty and sandy loams. Coarser soils, such as gravelly sands, can provide flow control but are not suitable for providing runoff treatment. The use of coarser soils to provide flow control for runoff from pollutant generating surfaces must always be preceded by treatment to protect ground water quality. Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa.

- **Bioretention.** Bioretention refers to the use of imported soils as a treatment medium. As in infiltration, the pollutant removal mechanisms include filtration, adsorption, and biological action. Bioretention facilities can be built within earthen swales or placed within vaults. Water that has passed through the Bioretention Soil Mix (or approved equivalent) may be discharged to the ground or collected and discharged to surface water.
- **Filtration.** A relatively new application. Another of a pollutant removal system for stormwater is the use of various media such as sand, perlite, zeolite, and carbon, to remove low levels of total suspended solids (TSS). Specific media such as activated carbon or zeolite can remove hydrocarbons and soluble metals. Filter systems can be configured as basins, vaults, trenches or ~~the novel~~ cartridges. Several Sand Filtration BMPs are discussed in Chapter 9. A number of “Emerging Technologies” filtration devices have completed or are in the process of being assessed through the “Emerging Technologies” process described in the following bullet.
- **“Emerging Technologies.”** Emerging technologies are new technologies that have not been evaluated using approved protocols, but for which preliminary data indicate that they may provide a desirable level of those new stormwater pollutant removal. They have not been evaluated in sufficient detail. Treatment devices that are continually being added to be acceptable as stand-alone BMPs for general usage in new development or redevelopment situations requiring Basic Treatment. In the instances noted in Chapter 3, a few stormwater treatment marketplace. Ecology has established a program – Technology Assessment Protocol – Ecology (TAPE) - to evaluate the capabilities of these emerging technologies. Emerging technologies are allowed to help remove metals, hydrocarbons, and nutrients. Otherwise, that have been evaluated by this program are approved at some level of use designation under specified conditions. Their use is restricted in accordance with their level of development evaluation as explained in Chapter 12. The recommendations for use of these emerging technologies will may change as we collect more data on their performance. Updated recommendations on their use will be posted to the Ecology website. Meanwhile, Emerging technologies can also be used considered for retrofit situations where TAPE approval is not required.

- **“On-line” Systems.** Most treatment facilities can be designed as “On-line” systems with flows above the water quality design flow or volume simply passing through the facility with lesser or no pollutant removal efficiency. ~~However,~~ It is sometimes desirable to restrict flows to treatment facilities and bypass ~~the remaining higher~~ excess flows around them. These are called “Off-line” systems. An example of an on-line system is a wetpool that maintains a permanent pool of water for runoff treatment purposes.
- **Design Flow.** For information on determining the design storm and flows for sizing treatment facilities refer to [Chapter 4](#)~~Chapter 4~~ of this volume.

Chapter 2. - Treatment Facility Selection Process

This chapter describes a step-by-step process for selecting the type of treatment facilities that will apply to individual projects. Physical features of sites that are applicable to treatment facility selection are also discussed. Refer to [Chapter 3](#) for additional detail on the four treatment menus - oil control treatment, phosphorous treatment, enhanced treatment, and basic treatment.

[Section 12.5 includes links to menus for emerging technologies that have a Use-Level Designation for pretreatment, oil, phosphorous, enhanced, or basic treatment. Only technologies with a General Use-Level Designation \(GULD\) can have an unlimited number of installations.](#)

2.1 Step-by-Step Selection Process for Treatment Facilities

Please refer to [Figure 2.1.1](#). Use the step-by-step process outlined below to determine the type of treatment facilities applicable to the project.

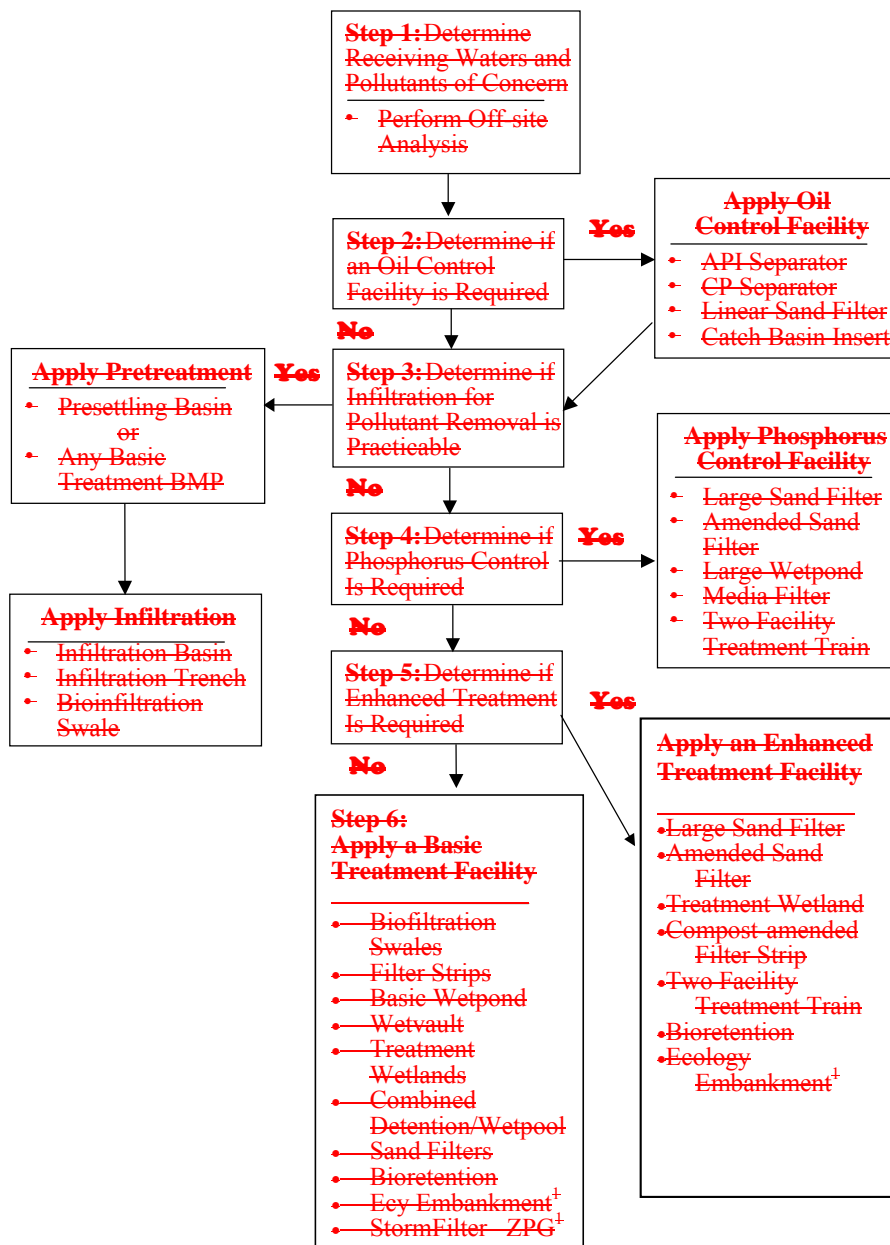
Step 1: Determine the Receiving Waters and Pollutants of Concern Based on Off-Site Analysis

To obtain a more complete determination of the potential impacts of a stormwater discharge, Ecology encourages local governments to require an Off-site Analysis similar to that in Chapter 2 of Volume 1 (Vol. I [Section 2.6.2](#)). Even without an off-site analysis requirement, the project proponent must determine the natural receiving water for the stormwater drainage from the project site (ground water, wetland, lake, stream, or salt water). This is necessary to determine the applicable treatment menu from which to select treatment facilities. The identification of the receiving water should be verified by the local government agency with review responsibility. If the discharge is to the local municipal storm drainage system, the receiving water for the drainage system must be determined.

The local government should verify whether any type of water quality management plans and/or local ordinances or regulations have established specific requirements for that (those) receiving waters. Examples of plans to be aware of include:

- **Watershed or Basin Plans:** These can be developed to cover a wide variety of geographic scales (e.g., Water Resource Inventory Areas, or sub-basins of a few square miles), and can be focused solely on establishing stormwater requirements (e.g., “Stormwater Basin Plans”), or can address a number of pollution and water quantity issues, including urban stormwater (e.g., Puget Sound Non-Point Action Plans).
- **Water Clean-up Plans:** These plans ~~are written to~~ establish a Total Maximum Daily Load (TMDL) of a pollutant or pollutants in a specific receiving water or basin, and to identify actions necessary to remain

below that maximum loading. The plans may identify discharge limitations or management limitations (e.g., use of specific treatment facilities) for stormwater discharges from new and redevelopment projects.



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⁴ See Section 3.5, Chapter 3 of Volume V for more information

Figure 2.1 – Treatment Facility Selection Flow Chart

- ~~Groundwater~~Ground water Management Plans (Wellhead Protection Plans): To protect ~~groundwater~~ground water quality and/or quantity, these plans may identify actions required of stormwater discharges.
- Lake Management Plans: These plans are developed to protect lakes from eutrophication due to inputs of phosphorus from the drainage basin. Control of phosphorus from new development is a likely requirement in any such plans.

An analysis of the proposed land use(s) of the project should also be used to determine the stormwater pollutants of concern. [Table 2.2.1](#) ~~Table 2.1~~ lists the pollutants of concern from various land uses. Refer to this table for examples of treatment options after determining whether “basic,” “enhanced,” or “phosphorus” treatment requirements apply to the project. You make those decisions ~~are made~~ in the steps below.

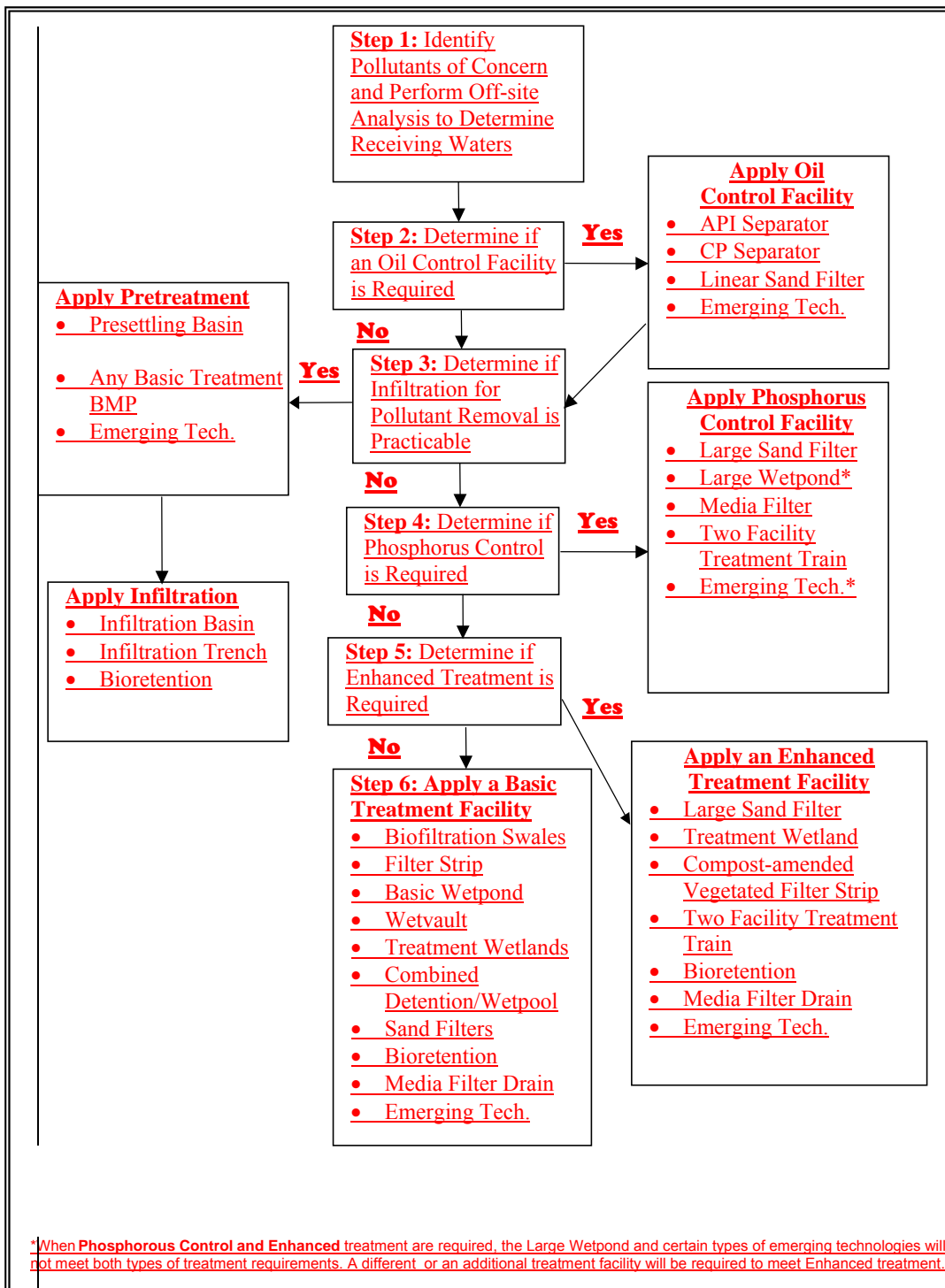


Figure 2.1.1 – Treatment Facility Selection Flow Chart

Step 2: Determine if an Oil Control Facility/Device is Required

The use of oil control devices and facilities is dependent upon the specific land use proposed for development.

Where Applied: The Oil Control Menu (~~see Section 3.2~~~~Chapter 3,~~
~~Section 3.2 for more details~~) applies to projects that have “high-use sites.” High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:

- An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area.

Note: Gasoline stations, with or without small food stores, will likely exceed the high-use site threshold.

- An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil. Some examples are discussed below.

Note: The petroleum storage and transfer criterion is intended to address regular transfer operations such as gasoline service stations, not occasional filling of heating oil tanks.

- An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.). Some examples are discussed below.

Note: In general, all-day parking areas are not intended to be defined as high-use sites, and should not require an oil control facility.

- A road intersection with a measured average daily traffic (ADT) count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Note: The traffic count can be estimated using information from “Trip Generation,” published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation. See: <http://www.ite.org/>.

The following land uses may have areas that fall within the definition of “high-use sites” and require oil control treatment. Further, these sites require special attention to the oil control treatment selected. Refer to Section 3.2. Please refer to the Oil Control Menu for a listing of oil control facility options. Then see Chapter 11 of this volume for guidance on the proper selection of options and design details.

Note that some land use types require the use of a spill control (SC-type) oil/water separator. Those situations are described in Volume IV and are separate from this treatment requirement. While a number of activities may be required to use spill control (SC-type) separators, only a few will necessitate an American Petroleum Institute (API) or a coalescing plate (CP) type separators for treatment. The following urban land uses are likely to have areas that fall within the definition of “high use sites” or have sufficient quantities of free oil present that can be treated by an API or CP-type oil/water separator:

- for more details.
 - Industrial machinery and equipment, and railroad equipment maintenance areas
 - Log storage and sorting yards
 - Aircraft maintenance areas
 - Railroad yards
 - Fueling stations
 - Vehicle maintenance and repair sites
 - Construction businesses (paving, heavy equipment storage and maintenance, storage of petroleum products).)

Note: Some land use types require the use of a spill control (SC-type) oil/water separator. Those situations are described in Volume IV and are separate from this treatment requirement.

If oil control is required for the site, please refer to the General Requirements in Chapter 4~~Chapter 4. These. The general~~ requirements may affect the design and placement of facilities on the site (e.g., flow splitting). Then see Chapter 11 of this volume for guidance on the proper selection of options and design details.

If an Oil Control Facility is required, select and apply an appropriate Oil Control Facility. Please refer to the Oil Control Menu in Section 3.2~~Chapter 3, Section 3.2.~~ After selecting an Oil Control Facility, proceed to Step 3.

If an Oil Control Facility is not required, proceed directly to Step 3.

Step 3: Determine if Infiltration for Pollutant Removal is Practicable

Please check the infiltration treatment design criteria as discussed in ~~Chapter~~the Site Suitability Criteria (SSC) in Section 3.3.7 of Volume III.

Infiltration can be effective at treating stormwater runoff, but soil properties must be appropriate to achieve effective treatment ~~while~~. This

effectiveness is discussed in *SSC-6 Soil Physical and Chemical Suitability for Treatment*.

The infiltration facility must also be checked to ensure that it does not adversely ~~impacting~~ impact ground water resources. These are discussed in:

- *SSC-2 Ground Water Protection Areas*
- *SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer*
- *SSC-1 Setback Criteria*.

These suitability criteria check the location and depth to bedrock, the water table, or impermeable layers (such as glacial till), and the proximity to wells, foundations, septic tank drainfields, ~~and~~.

Unstable slopes can preclude the use of infiltration— (discussed in *SSC-7 Seepage Analysis and Control*).

Infiltration treatment facilities must be preceded by a pretreatment facility, such as a presettling basin or vault, to reduce the occurrence of plugging. ~~Any of the basic treatment facilities, and detention ponds designed to meet flow control requirements, can also be used for pre-treatment. If an oil/water separator is necessary for oil control, it can also function as the pre-settling basin as long as the influent suspended solids concentrations are not high. However, frequent inspections are necessary to determine when accumulated solids exceed the 6-inch depth at which clean-out is recommended (See *Chapter 4*Chapter 4).~~

If infiltration is planned, please refer to the General Requirements in *Chapter 4*~~Chapter 4~~. They can affect the design and placement of facilities on your site. ~~For non-residential developments, if your infiltration site is within ¼ mile of a fish-bearing stream, a tributary to a fish-bearing stream, or a lake, please refer to the Enhanced Treatment Menu (Chapter 3, Section 3.4). Read the “Where Applied” paragraph in that section to determine if the Enhanced Treatment Menu applies to part of, or all of the site. If it does apply, read the Note under “Infiltration with appropriate pretreatment” to identify special pretreatment needs. If your infiltration site is within ¼ mile of a phosphorus-sensitive receiving water, please refer to the Phosphorus Treatment Menu (Chapter 3, Section 3.3) for special pretreatment needs.~~

Note: Infiltration through soils that do not meet the site suitability criteria *SSC-6* in *ChapterSection 3.3.7* of Volume III is allowable as a flow control BMP. However, the Use of infiltration through such soils is acceptable provided:

- The flow control only infiltration facility must be preceded by at least is NOT within a basic ¼ mile of a phosphorus-sensitive receiving water.

Note: When the flow control only infiltration facility IS within ¼ mile of a phosphorous-sensitive water body, phosphorous treatment facility. Following a basic is required. Refer to the phosphorous treatment menu in Section 3.3 for the special treatment needed prior to infiltration.

- The flow control only infiltration facility (or is NOT within ¼ mile of a fresh water body designated for aquatic life use or that has an existing aquatic life use.

Note: When the flow control only infiltration facility IS within a ¼ mile of such a fresh water body, enhanced treatment or a phosphorus treatment facility is required for land use types described in Step 5 below. Refer to Section 3.4 Enhanced Treatment Menu for the treatment options.

- The appropriate level of treatment for the land use precedes the infiltration. Refer to Section 3.4 Enhanced Treatment Menu or Section 3.5 accordance with Basic Treatment Menu for the previous paragraph); treatment needed prior to infiltration.

Infiltration can also be used as part of other treatments and flow control measures. For example, infiltration through the bottom of a detention/retention facility for flow control can also be acceptable as a way to help reduce direct discharge volumes to streams and reduce the size of the facility.

If infiltration is practicable, select and apply pretreatment and an infiltration facility.

If infiltration is not practicable, proceed to Step 4.

Step 4: Determine if Control of Phosphorous is Required

~~Please refer to~~ The plans, ordinances, and regulations identified in Step 1 ~~as sources of information, are a good reference to help determine if the subject site is in an area where phosphorous control is required.~~

The requirement to provide phosphorous control is determined by the local government with jurisdiction, the Department of Ecology, or the USEPA. The local government may have developed a management plan and implementing ordinances or regulations for control of phosphorus from new development and redevelopment for the receiving water(s) of the stormwater drainage. The local government can use the following sources of information for pursuing plans and implementing ordinances and/or regulations:

- Those waterbodies reported under section 305(b) of the Clean Water Act, and designated as not supporting beneficial uses due to phosphorous;
- Those listed in Washington State's Nonpoint Source Assessment required under section 319(a) of the Clean Water Act due to nutrients.

If phosphorus control is required, select and apply a phosphorous treatment facility. Please refer to the Phosphorus Treatment Menu in [Section 3.3](#) ~~Chapter 3 Section 3.3.~~ Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site. ~~You may also use Tables 2.1 through 2.3 as an initial screening of options.~~

If you have selected a phosphorus treatment facility, please refer to the General Requirements in [Chapter 4](#) ~~Chapter 4.~~ They may affect the design and placement of the facility on the site.

Note: Project sites subject to the Phosphorus Treatment requirement could also be subject to the Enhanced Treatment requirement (see Step 5). In that event, apply a facility or a treatment train that is listed in both the Enhanced Treatment Menu and the Phosphorus Treatment Menu.

If phosphorus treatment is not required for the site, proceed to Step 5.

Step 5: Determine if Enhanced Treatment is Required

~~Except where specified under Step 6,~~ Enhanced treatment for reduction in dissolved metals is required for the following project sites that: 1) discharge directly to fish-bearing streams, lakes, or to fresh waters or conveyance systems tributary to fish-bearing streams fresh waters designated for aquatic life use or that have an existing aquatic life use; or lakes 2) use infiltration strictly for flow control – not treatment – and the discharge is within ¼ mile of a fresh water designated for aquatic life use or that has an existing aquatic life use:

Industrial project sites,

Commercial project sites,
Multi-family residential project sites, and
High AADT roads as follows:

Within Urban Growth Management Areas:

- Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more
- All other roads with an AADT of 7,500 or greater
- ~~Outside of Urban Growth Management Areas: Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger; Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).~~

~~However, such sites listed above that discharge directly (or, indirectly through a municipal storm sewer system) to Basic Treatment Receiving Waters (Appendix V-A), and~~ Outside of Urban Growth Management Areas:

- Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger;
- Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

Any areas of the above-listed project sites that are identified as subject to Basic Treatment requirements (see Step 6) are not also ~~not~~ subject to Enhanced Treatment requirements. For developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

If the project must apply Enhanced Treatment, select and apply an appropriate Enhanced Treatment facility. Please refer to the Enhanced Treatment Menu in Section 3.4 ~~Chapter 3, Section 3.4.~~ Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site. ~~You may also use Tables 2.1 through 2.3 for an initial screening of options.~~

Note: Project sites subject to the Enhanced Treatment requirement could also be subject to a phosphorus removal requirement if located in an area designated for phosphorus control. In that event, apply a facility or a

treatment train that is listed in both the Enhanced Treatment Menu and the Phosphorus Treatment Menu. If you have selected an Enhanced Treatment facility, please refer to the General Requirements in [Chapter 4](#)~~Chapter 4.~~ They may affect the design and placement of the facility on the site.

If Enhanced Treatment does not apply to the site, please proceed to Step 6.

Step 6: Select a Basic Treatment Facility

The Basic Treatment Menu is ~~generally applied to~~required in the following circumstances:

- Project sites that discharge to the ground (see [Step 3](#)~~Step 3).~~), UNLESS:
 - The soil suitability criteria for infiltration treatment are met (see Chapter 3 of Volume III), and alternative pretreatment is provided (See Chapter 6). or
 - The project site uses infiltration strictly for flow control – not treatment - and the discharge is within ¼-mile of a phosphorus sensitive lake (use the Phosphorus Treatment Menu), or
 - The project site is industrial, commercial, multi-family or a high AADT (consistent with the Enhanced Treatment-type thresholds listed above) and is within ¼ mile of a fish-bearing stream, or a lake/fresh water designated for aquatic life use or that has an existing aquatic life use. (use the Enhanced Treatment Menu).
- Residential projects not otherwise needing phosphorus control in Step 4 as designated by USEPA, the Department of Ecology, or a local government; ~~and.~~
- Project sites discharging directly (or indirectly through a municipal separate storm sewer system) to salt waters, river segments, and lakes~~Basic Treatment Receiving Waters~~ listed in Appendix ~~V-A; and I-C of Volume I.~~
- Project sites that drain to ~~streams~~fresh water that ~~are~~is not ~~fish-bearing, or designated for aquatic life use, and does not have an existing aquatic life use; and project sites that drain~~ to waters not tributary to ~~fish-bearing streams; waters designated for aquatic life use or that have an existing aquatic life use.~~
- Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites, dedicated solely to parking of employees' private vehicles that do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals). For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the

areas subject to the Basic Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

Please refer to the Basic Treatment Menu in [Section 3.5](#) ~~Chapter 3, Section 3.5.~~ Select an option from the menu after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site. ~~You may also use Tables 2.1 through 2.3 as an initial screening of options.~~

After selecting a Basic Treatment Facility, please refer to the General Requirements in [Chapter 4](#) ~~Chapter 4.~~ They may affect the design and placement of the facility on the site.

You have completed the treatment facility selection process.

2.2 Other Treatment Facility Selection Factors

The selection of a treatment facility should be based on site physical factors and pollutants of concern. The requirements for use of Enhanced Treatment or Phosphorus Treatment represent facility selection based on pollutants of concern. Even if the site is not subject to those requirements, try to choose a facility that is more likely to do a better job removing the types of pollutants generated on the site. The types of site physical factors that influence facility selection are summarized below.

Pollutants of Concern (Table 2.1 and Table 2.2)

~~Table 2.1 summarizes the pollutants of concern and those land uses that are likely to generate pollutants. It also provides suggested basic and enhanced treatment options for each land use. For example, oil and grease are the expected pollutants from an uncovered fueling station. Using Table 2.1, a combination of an oil/water separator and a biofilter could be considered as the basic treatment for runoff from uncovered fueling stations. Table 2.2 is a general listing of the relative effectiveness of classes of treatment facilities in removing key stormwater pollutants.~~

Soil Type ([Table 2.2.1](#) ~~(Table 2.3)~~)

The permeability of the soil underlying a treatment facility has a profound influence on its effectiveness. This is particularly true for infiltration treatment facilities that are ~~best~~ sited in sandy to loamy sand soils. They are not generally appropriate for sites that have final infiltration rates (f) of less than 0.5 inches per hour. Wet pond facilities situated on coarser soils will need a synthetic liner or the soils amended to reduce the infiltration rate and provide treatment. Maintaining a permanent pool in the first cell is necessary to avoid resuspension of settled solids. Biofiltration swales in coarse soils can also be amended to reduce the infiltration rate.

High Sediment Input

High TSS loads can clog infiltration soil, sand filters and coalescing plate oil & water separators. Pretreatment with a presettling basin, wet vault, or another basic treatment facility would typically be necessary.

Other Physical Factors

Slope: Steep slopes restrict the use of several BMPs. For example, biofiltration swales are usually situated on sites with slopes of less than 6%, although greater slopes can be considered. Infiltration BMPs are not suitable when the slope exceeds 15%.

High Water Table: Unless there is sufficient horizontal hydraulic receptor capacity the water table acts as an effective barrier to exfiltration and can sharply reduce the efficiency of an infiltration system. If the high water table extends to within five (5) feet of the bottom of an infiltration BMP, the site is seldom suitable.

Depth to Bedrock/ Hardpan/Till: The downward exfiltration of stormwater is also impeded if a bedrock or till layer lies too close to the surface. If the impervious layer lies within five feet below the bottom of the infiltration BMP the site is not suitable. Similarly, pond BMPs are often not feasible if bedrock lies within the area that must be excavated.

Proximity to Foundations and Wells: Since infiltration BMPs convey runoff back into the soil, some sites may experience problems with local seepage. This can be a real problem if the BMP is located too close to a building foundation. Another risk is ground water pollution; hence the requirement to site infiltration systems more than 100 feet away from drinking water wells.

Maximum Depth: Wet ponds are also subject to a maximum depth limit for the "permanent pool" volume. Deep ponds (greater than 8 feet) may stratify during summer and create low oxygen conditions near the bottom resulting in re-release of phosphorus and other pollutants back into the water.

Table 2.2.1 Screening Treatment Facilities Based on Soil Type			
Soil Type	Infiltration/ Bioretention	Wet Pond*	Biofiltration* (Swale or Filter Strip)
Coarse Sand or Cobbles	X	X	X
Sand	✓	X	X
Loamy Sand	✓	X	✓
Sandy Loam	✓	X	✓
Loam	X	X	✓
Silt Loam	X	X	✓
Sandy Clay Loam	X	✓	✓
Silty Clay Loam	X	✓	✓
Sandy Clay	X	✓	✓
Silty Clay	X	✓	X
Clay	X	✓	X

Notes:

✓ Indicates that use of the technology is generally appropriate for this soil type.

X Indicates that use of the technology is generally not appropriate for this soil type

* Coarser soils may be used for these facilities if a liner is installed to prevent infiltration, or if the soils are amended to reduce the infiltration rate.

Note: Sand filtration is not listed because its feasibility is not dependent on soil type.

Notes:

1—Though phosphorus is not typically listed as a pollutant of concern, it is present in most urban runoff situations. It becomes a pollutant of concern when identified by USEPA, the Department of Ecology, or a local government in a local management plan and when requirements are established in local ordinance or rules. If phosphorus is identified as a pollutant of concern, consider the treatment options listed here.

2—Application of effective source control measures is the preferred approach for pollutant reduction. Where source control measures are not used, or where they are ineffective, stormwater treatment is necessary.

Legend:

ASF = Amended Sand Filter	INF = Infiltration
BF = Biofilter (includes swales and strips)	CBI = Catch Basin Insert, if applicable
	(See Chapter 10)
Cu = Copper	Com/Ind = Commercial or industrial
LSF = Large Sand Filter	LinSF = Linear Sand Filter
LWP = Large Wet Pond	O & G = Oil and Grease
OWS = Oil & Water Separator	PAH = Polycyclic Aromatic Hydrocarbons
PSB = Presettling Basin	PGPS = Pollution-generating pervious surface
SF = Sand Filter	STW = Stormwater Treatment Wetland
TSS = Total Suspended Solids	WP = Wet Pond
WV = Wetvault	Zn = Zinc

/= or :—The slashes between the abbreviations for treatment types are intended to indicate equivalent treatment options

Additional Notes:

If a detention facility is needed for flow control to meet Min. Requirement #7 or #8, a combined detention and Wetpool (Basic or Large depending upon the discharge circumstance) facility should be considered.

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Chapter 3. - Treatment Facility Menus

This chapter identifies choices that comprise the treatment facility menus referred to in [Chapter 2](#)~~Chapter 2-~~. The menus in this chapter are discussed in the order of the decision process shown in [Figure 2.1.1](#)~~Figure 2-1~~ and are as follows:

Oil Control Menu, [Section 3.2](#)~~Section 3-2~~

Phosphorus Treatment Menu, [Section 3.3](#)~~Section 3-3~~

Enhanced Treatment Menu, [Section 3.4](#) ~~Section 3-4~~

Basic Treatment Menu, [Section 3.5](#)

[Section 12.5](#)~~Section 3-5~~ includes links to menus for emerging technologies that have a Use-Level Designation for pretreatment, oil, phosphorous, enhanced, or basic treatment. Only technologies with a General Use-Level Designation (GULD) can have an unlimited number of installations.

3.1 Guide to Applying Menus

Read the step-by-step selection process for treatment facilities in [Section 2.1](#)~~Chapter 2-~~.

Determine which menus apply to the discharge situation. This will require knowledge of (1) the receiving water(s) that the project site ultimately discharges to, and (2) whether the local government with jurisdiction, the Department of Ecology or the USEPA, has identified the receiving water as subject to phosphorus control requirements, and (3) whether the site qualifies as subject to oil control.

Determine if your project requires oil control.

If the project requires oil control, or if you elect to provide enhanced oil pollution control, choose one of the options presented in the Oil Control Menu, [Section 3.2](#)~~Section 3-2-~~. Detailed designs for oil control facilities are given in subsequent chapters.

Note: One of the other three treatment menus will also need to be applied along with oil control.

Find the Treatment Menu that applies to the project – Basic, Enhanced, or Phosphorus.

Each menu presents treatment options. Select one option. Since all options are intended to provide equivalent removal of the target pollutant, the choice will depend only on the constraints and opportunities of the site. A project site may be subject to both the Enhanced Treatment requirement and the Phosphorus Treatment requirement. In that event, select a facility or a treatment train that is listed in both treatment menus. Note: If flow control requirements apply, it will usually be more economical to use the

combined detention/wetpool facilities. Detailed facility designs for all the possible options are given in subsequent chapters in this Volume.

Read [Chapter 4](#) concerning general facility requirements.

They apply to all facilities and may affect the design and placement of facilities on the site.

3.2 Oil Control Menu

Note: Where this menu is applicable, it is in addition to facilities required by one of the other Treatment Menus.

Where Applied: ~~The Oil Control Menu applies to projects that have high-use sites. High-use sites are those that typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil. High-use sites include:~~

- ~~• An area of a commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area;~~
- ~~• An area of a commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil;~~
- ~~• An area of a commercial or industrial site subject to parking, storage or maintenance of 25 or more vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.);~~
- ~~• A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.~~

Note: ~~The traffic count can be estimated using information from “Trip Generation” published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.~~

~~Oil control facilities from this menu should be used on other sites that generate high concentrations of oil. In general, all day parking areas are not intended to be defined as high-use sites, and should not require the oil control options listed in this menu. Gasoline stations, with or without small food stores, will likely exceed the high use site threshold. The petroleum storage and transfer criterion is intended to address regular transfer operations such as gasoline service stations, not occasional filling of heating oil tanks.~~

Application on the Project Site: Oil control facilities are to be placed upstream of other facilities, as close to the source of oil generation as practical. For high-use sites located within a larger commercial center, only the impervious surface associated with the high-use portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the high-use business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.

High-use roadway intersections shall treat lanes where vehicles accumulate during the signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket. If no left turn pocket exists, the treatable area shall begin at a distance equal to three car lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

Performance Goal: The facility choices in the Oil Control Menu are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a 24-hour average Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l, and a maximum of 15 mg/l for a discrete sample (grab sample).

Note: Use the method for NWTPH-Dx in Ecology Publication No. [ECY 97-602, Analytical Methods for Petroleum Hydrocarbons](#)~~ECY 97-602, Analytical Methods for Petroleum Hydrocarbons~~. If the concentration of gasoline is of interest, the method for NWTPH-Gx should be used to analyze grab samples.

Options: Oil control options include facilities that are small, treat runoff from a limited area, and require frequent maintenance. The options also include facilities that treat runoff from larger areas and generally have less frequent maintenance needs.

- **API-Type Oil/Water Separator** – See [Chapter 11](#)~~Chapter 11~~
- **Coalescing Plate Oil/Water Separator** – See [Chapter 11](#)~~Chapter 11~~

~~Catch Basin Inserts~~

- **Emerging Stormwater Treatment Technologies** – See [Chapter 12](#)
- **Linear Sand Filter** – See [Chapter 8](#)

Note: The linear sand filter is used in the Basic, Enhanced, and Phosphorus Treatment menus also. If used to satisfy one of those treatment requirements, the same facility shall not also be used to satisfy the oil control requirement unless **enhanced** maintenance is assured. This **increase in maintenance** is to prevent clogging of the filter by oil so that it will function for suspended solids, **metals** and phosphorus removal as well. Quarterly cleaning is required unless specified otherwise by the designer.

3.3 Phosphorus Treatment Menu

Where Applied: The Phosphorus Treatment Menu applies to projects within watersheds that have been determined by local governments, the Department of Ecology, or the USEPA to be sensitive to phosphorus and that are being managed to control phosphorus inputs from stormwater. This menu applies to stormwater conveyed to the lake by surface flow as well as to stormwater infiltrated within one-quarter mile of the lake in soils that do not meet the soil suitability criteria in Chapter 3 of Volume III.

Performance Goal: The Phosphorus Menu facility choices are intended to achieve a goal of 50% total phosphorus removal for a range of influent concentrations of 0.1 – 0.5 mg/l total phosphorus. In addition, the choices are intended to achieve the Basic Treatment performance goal. The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate. This is acceptable provided that the overall reduction in phosphorus loading (treated plus bypassed) is at least equal to that achieved with initiating bypass at the water quality design flow rate. Note that wetpool facilities are always designed to be on-line.

Options: Any one of the following options may be chosen to satisfy the phosphorus treatment requirement.

- **Infiltration** ([Chapter 3 of Volume III](#)) **with appropriate pretreatment** ([Chapter 6 of Volume V](#) – See [Chapter 6 of Volume V](#), and [Chapter 3 of Volume III](#)).
- **Infiltration treatment**

If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (See ~~Chapter~~[Section 3.3.7](#) of Volume III), a presettling basin or a basic treatment facility can serve for pretreatment.

- Infiltration preceded by Basic Treatment

If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a basic treatment facility unless the soil and site fit the description in the next option below.

- Infiltration preceded by Phosphorus Treatment

If the soils do not meet the soil suitability criteria **and** the infiltration site is within ¼ mile of a phosphorus-sensitive receiving water, or a tributary to that water, treatment must be provided by one of the other treatment facility options listed below.

- **Large Sand Filter** – See [Chapter 8](#)~~Chapter 8~~

- ~~**Amended Sand Filter** – See Chapter 12~~

~~**Note:** Processed steel fiber and crushed calcitic limestone are the only sand filter amendments for which Ecology has data that documents increased dissolved metals removal. Though Ecology is interested in obtaining additional data on the effectiveness of these amendments, local governments may exercise their judgment on the extent to which to allow their use.~~

- **Large Wetpond** – See [Chapter 10](#)~~Chapter 10~~

- ~~**Media Filter**~~**Emerging Stormwater Treatment Technologies targeted for phosphorus removal** – See [Chapter 12](#)~~Chapter 12~~

~~**Note:** The use of a Stormfilter™ with iron-infused media is approved for use in limited circumstances, provided a monitoring program consistent with the TAPE protocols (Ch. 12) is implemented.~~

- **Two-Facility Treatment Trains** – See Table 3.3.1

Table 3.3.1 Treatment Trains for Phosphorus Removal	
First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault
Filter Strip	Linear Sand Filter (no presettling needed)
Linear Sand Filter	Filter Strip
Basic Wetpond	Basic Sand Filter or Sand Filter Vault
Wetvault	Basic Sand Filter or Sand Filter Vault
Stormwater Treatment Wetland	Basic Sand Filter or Sand Filter Vault
Basic Combined Detention and Wetpool	Basic Sand Filter or Sand Filter Vault

3.4 Enhanced Treatment Menu

Where Applied: ~~Except where specified in Section 3.5 - Basic Treatment,~~
Enhanced treatment is required for the following project sites that
~~discharge to fish-bearing streams, lakes, or to:~~

- ~~1) Discharge directly to fresh~~ waters or conveyance systems tributary to
~~fish-bearing streams~~ fresh waters designated for aquatic life use or that
have an existing aquatic life use; ~~or lakes~~
- ~~1)2) Use infiltration strictly for flow control – not treatment – and the~~
discharge is within ¼ mile of a fresh water designated for aquatic life
use or that has an existing aquatic life use:

Industrial project sites,

Commercial project sites,

Multi-family project sites, and

High AADT roads as follows:

Within Urban Growth Management Areas:

- Fully controlled and partially controlled limited access highways with Annual Average Daily Traffic (AADT) counts of 15,000 or more
- All other roads with an AADT of 7,500 or greater

Outside of Urban Growth Management Areas:

- Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger;
- Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).

~~Any~~ Outside of Urban Growth Management Areas:

- ~~Roads with an AADT of 15,000 or greater unless discharging to a 4th Strahler order stream or larger;~~
- ~~Roads with an AADT of 30,000 or greater if discharging to a 4th Strahler order stream or larger (as determined using 1:24,000 scale maps to delineate stream order).~~

~~However, such sites listed above that discharge directly (or, indirectly through a municipal storm sewer system) to Basic Treatment Receiving Waters (Appendix V-A), and areas of the above-listed project sites that are identified as subject to Basic Treatment requirements (see Section 3.5 Step 6 below) are not also subject to Enhanced Treatment requirements. For~~

developments with a mix of land use types, the Enhanced Treatment requirement shall apply when the runoff from the areas subject to the Enhanced Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

Performance Goal: The Enhanced Menu facility choices are intended to provide a higher rate of removal of dissolved metals than Basic Treatment facilities. ~~Due to the sparse data available concerning~~ Based on a review of dissolved metals removal in stormwater of basic treatment facilities options, a specific numeric “higher rate of removal efficiency goal could not be established at the time of publication. Instead, Ecology relied on available nationwide and local data, and knowledge of the pollutant” is currently defined as greater than 30% dissolved copper removal mechanisms of treatment facilities to develop the list of options below, and greater than 60% dissolved zinc removal. In addition, the menu choices are intended to achieve the Basic Treatment performance goal. The performance goal assumes that the facility is treating stormwater with dissolved Copper typically ranging from 0.003005 to 0.02 mg/l, and dissolved Zinc ranging from 0.02 to 0.3 mg/l.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable, and on an annual average basis. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net pollutant reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in dissolved metals loading exceeds that achieved with initiating bypass at the water quality design flow rate. Note that wetpool facilities are always designed to be on-line. **Options:** Any one of the following options may be chosen to satisfy the enhanced treatment requirement:

- **Infiltration** (Chapter 3 of Volume III) **with appropriate pretreatment** (Chapter 6 of Volume V—See Chapter 3 of Volume III)

- Infiltration treatment

If infiltration is through soils meeting the minimum site suitability criteria for infiltration treatment (See ~~Chapter~~Section 3.3.7 of Volume III), a presettling basin or a basic treatment facility can serve for pretreatment.

- Infiltration preceded by Basic Treatment

If infiltration is through soils that do not meet the soil suitability criteria for infiltration treatment, treatment must be provided by a

basic treatment facility unless the soil and site fit the description in the next option below.

- Infiltration preceded by Enhanced Treatment

If the soils do not meet the soil suitability criteria **and** the infiltration site is within ¼ mile of a ~~fish-bearing stream, a tributary to a fish-bearing stream, or a lake,~~ fresh water designated for aquatic life use or that has an existing aquatic life use, treatment must be provided by one of the other treatment facility options listed below.

- **Large Sand Filter** – See [Chapter 8](#)~~Chapter 8~~

- ~~**Amended Sand Filter** – See Chapter 12~~

~~**Note:** Processed steel fiber and crushed calcitic limestone are the only sand filter amendments for which Ecology has data that documents increased dissolved metals removal. Though Ecology is interested in obtaining additional data on the effectiveness of these amendments, local governments may exercise their judgment on the extent to which to allow their use.~~

- **Stormwater Treatment Wetland** – See [Chapter 10](#)~~Chapter 10~~
- **Compost-amended Vegetated Filter Strip (CAVFS)** – See [Chapter 7](#)~~Chapter 9~~
- **Two Facility Treatment Trains** – See [Table 3.4.1](#)~~Table 3.2~~

Table 3.4.1 Treatment Trains for Dissolved Metals Removal	
First Basic Treatment Facility	Second Treatment Facility
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault or Media Filter ⁽¹⁾
Filter Strip	Linear Sand Filter with no pre-settling cell needed
Linear Sand Filter	Filter Strip
Basic Wetpond	Basic Sand Filter or Sand Filter Vault or Media Filter ⁽¹⁾
Wetvault	Basic Sand Filter or Sand Filter Vault or Media Filter ⁽¹⁾
Basic Combined Detention/Wetpool	Basic Sand Filter or Sand Filter Vault or Media Filter ⁽¹⁾
Basic Sand Filter or Sand Filter Vault with a presettling cell if the filter isn't preceded by a detention facility	Media Filter ⁽¹⁾
Footnote: (1) The media must be a type approved for basic or enhanced treatment use by Ecology. See Chapter 12 for approved media filters.	

- **Bioretention/~~rain garden~~** – See [Chapter 7](#)~~Appendix III-C₂~~, and the *Low Impact Development Technical Guidance Manual for Puget Sound* (LID Manual).

Note: ~~Any~~ Stormwater runoff that infiltrates through the imported soil mix will have received ~~the equivalent of~~ Enhanced Treatment. Where bioretention/~~rain gardens are~~ is intended to fully meet treatment requirements, ~~they~~ for its drainage area, it must be designed, using an approved continuous runoff model, to ~~infiltrate~~ pass at least 91% of the influent runoff file through the imported soil mix.

Media Filter Drain (MFD) – See [Chapter 8](#)

- ~~**Ecology Embankment**~~ – At the time of publication, this treatment option has received a “Conditional Use” approval for road runoff. See www.ecy.wa.gov/programs/wq/stormwater/newtech/treatment_train for the current status of this treatment option and for design details.

- Emerging Stormwater Treatment Technologies – See Chapter 12

3.5 Basic Treatment Menu

Where Applied: The Basic Treatment Menu is ~~generally applied~~ required in the following circumstances:

- Project sites that discharge to the ground (see Step 3 in Chapter 2) ~~Step 3).~~ UNLESS:
 - The soil suitability criteria for infiltration treatment are met (see Chapter 3 of Volume III), ~~or~~ and pretreatment is provided; OR
 - The project uses infiltration strictly for flow control – not treatment – and the discharge is within ¼-mile of a phosphorus sensitive lake (use the Phosphorus Treatment Menu), or within ¼ mile of a ~~fish-bearing stream, fresh water designated for aquatic life use or a lake that has an existing aquatic life use.~~ fish-bearing stream, fresh water designated for aquatic life use or a lake that has an existing aquatic life use. (use the Enhanced Treatment Menu).
- Residential projects not otherwise needing phosphorus control in Step 4 (See Chapter 2) ~~Chapter 2))~~ as designated by USEPA, the Department of Ecology, or a local government; ~~and~~
- Project sites discharging directly (or indirectly through a municipal separate storm sewer system) to ~~salt waters, river segments, and lakes~~ Basic Treatment Receiving Waters listed in Appendix ~~V-A; and I-C;~~
- Project sites that drain to ~~streams that are not fish-bearing, fresh waters,~~ streams that are not fish-bearing, fresh waters, or to waters ~~not tributary to fish-bearing streams; fresh waters, that are not designated for aquatic life use or that do not have an existing aquatic life use.~~ not tributary to fish-bearing streams; fresh waters, that are not designated for aquatic life use or that do not have an existing aquatic life use.

Landscaped areas of industrial, commercial, and multi-family project sites, and parking lots of industrial and commercial project sites, dedicated solely to parking of employees' private vehicles, which do not involve any other pollution-generating sources (e.g., industrial activities, customer parking, storage of erodible or leachable material, wastes or chemicals).

For developments with a mix of land use types, the Basic Treatment requirement shall apply when the runoff from the areas subject to the Basic Treatment requirement comprises 50% or more of the total runoff within a threshold discharge area.

Performance Goal: The Basic Treatment Menu facility choices are intended to achieve 80% removal of total suspended solids for influent concentrations that are greater than 100 mg/l, but less than 200 mg/l. For influent concentrations greater than 200 mg/l, a higher treatment goal may be appropriate. For influent concentrations less than 100 mg/l, the

facilities are intended to achieve an effluent goal of 20 mg/l total suspended solids.

The performance goal applies to the water quality design storm volume or flow rate, whichever is applicable. The goal also applies on an average annual basis to the entire annual discharge volume (treated plus bypassed). The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the facility (off-line treatment facilities), or can be passed through the facility (on-line treatment facilities) provided a net TSS reduction is maintained. Ecology encourages the design and operation of treatment facilities that engage a bypass at flow rates higher than the water quality design flow rate as long as the reduction in TSS loading exceeds that achieved with initiating bypass at the water quality design flow rate. Note that wetpool facilities are always designed to be on-line. The performance goal assumes that the facility is treating stormwater with a typical particle size distribution. For a description of a typical particle size distribution, please refer to the stormwater monitoring protocol on the Department of Ecology website.

Options: Any one of the following options may be chosen to satisfy the basic treatment requirement:

- ~~Bio-infiltration Swale~~ – See Chapter 7
- **Infiltration** – See [Chapter 7 of this volume](#), and Chapter 3 of ~~Volume~~ [Vol. III](#)
- **Sand Filters** – See [Chapter 8](#) ~~Chapter 8~~
- **Biofiltration Swales** – See [Chapter 9](#) ~~Chapter 9~~
- **Vegetated Filter Strip** – See [Chapter 9](#) ~~Strips~~
- **Compost-amended Vegetated Filter Strip (CAVFS)** – See [Chapter 7](#) ~~Chapter 9~~
- **Basic Wetpond** – See [Chapter 10](#) ~~Chapter 10~~
- **Wetvault** – See [Chapter 10](#) ~~Chapter 10~~ (see note)
- **Stormwater Treatment Wetland** – See [Chapter 10](#) ~~Chapter 10~~
- **Combined Detention and Wetpool Facilities** – See [Chapter 10](#) ~~Chapter 10~~
- **Bioretention/~~rain garden~~** – See [Chapter 7](#) ~~Appendix III-C₂~~, and the [Low Impact Development Technical Guidance Manual for Puget Sound](#) ~~Low Impact Development Technical Guidance Manual for Puget Sound~~ (LID Manual)-)

Note: ~~Any stormwater runoff that infiltrates through the imported soil mix will have received the equivalent of Enhanced Treatment.~~ Where bioretention/~~rain gardens are~~ is intended to fully meet treatment requirements, ~~they for its drainage area, it~~ must be designed, using an approved continuous runoff model, to ~~infiltrate~~ pass at least 91% of the influent runoff file through the imported soil mix.

Media filter Drain (MFD) – See [Chapter 8](#)

- ~~Ecology Embankment~~ – At the time of publication, this treatment option has received a “Conditional Use” approval for road runoff. See www.ecy.wa.gov/programs/wq/stormwater/newtech/treatment_train for the current status of this treatment option and for design details.
- ~~“StormFilter” with ZPG™ media~~ – A canister-type filter with zeolite/perlite/granular activated carbon manufactured by Stormwater Management, Inc. See Ecology website for pertinent design and maintenance criteria.
-
- **Emerging Stormwater Treatment Technologies** – See [Chapter 12](#)

Note: A wetvault may be used for commercial, industrial, or road projects if there are space limitations. Ecology discourages the use of wetvaults for residential projects. Combined detention/wetvaults are allowed; see [Section 10.3](#) ~~Section 10.3~~.

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Chapter 4. - General Requirements for Stormwater Facilities

Note: All Figures in Chapter 4 are courtesy of King County

This chapter addresses general requirements for treatment facilities. Requirements discussed in this chapter include design volumes and flows, sequencing of facilities, liners, and hydraulic structures for splitting or dispersing flows.

4.1 Design Volume and Flow

4.1.1 Water Quality Design Storm Volume

The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Alternatively, ~~the 91st percentile, 24-hour runoff volume indicated by~~ when using an approved continuous runoff model, the water quality design storm volume shall be equal to the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record.

Wetpool facilities are sized based upon use of the NRCS (formerly known as SCS) curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm. Treatment facilities sized by this simple runoff volume-based approach are the same size whether they precede detention, follow detention, or are integral with the detention facility (i.e., a combined detention and wetpool facility).

Unless amended to reflect local precipitation statistics, the 6-month, 24-hour precipitation amount may be assumed to be 72 percent of the 2-year, 24-hour amount. Precipitation estimates of the 6-month and 2-year, 24-hour storms for certain towns and cities are listed in Appendix I-B of Volume I. For other areas, interpolating between isopluvials for the 2-year, 24-hour precipitation and multiplying by 72% yields the appropriate storm size. Isopluvials for 2-year, 24-hour amounts for Western Washington are reprinted in Volume III.

4.1.2 Water Quality Design Flow Rate

Downstream of Detention Facilities: The full 2-year release rate from the detention facility.

An approved continuous runoff model should identify the 2-year return frequency flow rate discharged by a detention facility that is designed to meet the flow duration standard.

Preceding Detention Facilities or when Detention Facilities are not required: The flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated.

At the time of publication, all BMPs except wetpool-types should use the 15-minute time series from an approved continuous runoff model.

Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., 80 percent TSS removal).

- *Off-line facilities:* For treatment facilities not preceded by an equalization or storage basin, and when runoff flow rates exceed the water quality design flow rate, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the higher incremental portion of flow rates are bypassed around a treatment facility. Ecology encourages design of systems that engage a bypass at higher flow rates provided the reduction in pollutant loading exceeds that achieved with bypass at the water quality design flow rate.

Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of an approved continuous runoff model is treated to the applicable performance goals (e.g., 80 percent TSS removal at the water quality design flow rate and 80 percent TSS removal on an annual average basis).

- *On-line facilities:* Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met.

~~Treatment facilities that are located downstream of detention facilities should only be designed as on-line facilities.~~

4.1.3 Flows Requiring Treatment

Runoff from pollution-generating ~~impervioushard~~ or pervious surfaces must be treated. Pollution-generating ~~impervioushard~~ surfaces (PGISPGHS) are those ~~impervioushard~~ surfaces considered to be a significant source of pollutants in stormwater runoff. PGHS includes pollution-generating impervious surfaces (PGIS) and pollution-generating permeable pavements. Permeable pavements subject to pollution-generating activities are also considered pollution-generating pervious surfaces (PGPS) because of their infiltration capability. The glossary in Volume I provides additional definitions and clarification of these terms.

- ~~Such surfaces~~PGHS, PGIS, and PGPS include those surfaces which are subject to: vehicular use; 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 rainfall runoff. 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 enamel coating). Roofs subject to venting significant amounts of dusts, mists or fumes from manufacturing, commercial, or other indoor activities are also PGIS.
- 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, bike lanes within the traveled lane of a roadway, driveways, parking lots, ~~unfenced~~unrestricted access firelanes, 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~~restricted access firelanes, and infrequently used maintenance access roads.
- Pollution-generating pervious surfaces (PGPS) are any non-impervious surface subject to vehicular use, industrial activities (as further defined in the glossary); or storage of erodible or leachable materials, wastes, or chemicals, and that receive direct rainfall or run-on or blow-in of rainfall, the use of pesticides and fertilizers or loss of soil. Typical PGPS include permeable pavement subject to vehicular use, lawns, ~~and~~ landscaped areas, including: golf courses, parks, cemeteries, and sports fields, ~~(natural and artificial turf).~~

Summary of Areas Needing Treatment

- All runoff from pollution-generating ~~impervious~~hard surfaces is to be treated through the water quality facilities specified in Chapter 2~~Chapter 2~~ and Chapter 3~~Chapter 3~~.
- Lawns and landscaped areas specified are pervious but also generate run-off into street drainage systems. In those cases the runoff from the pervious areas must be estimated and added to the runoff from ~~impervious~~hard surface areas to size treatment facilities.
- Runoff from backyards can drain into native vegetation in areas designated as open space or buffers. In these cases, the area in native vegetation may be used to provide the requisite water quality treatment, provided it meets the requirements in Chapter 5~~Chapter 5~~.

under the “Cleared Area Dispersion BMPs,” of [BMP T5.30 Full Dispersion](#).

- Drainage from ~~impervious~~hard surfaces that are not pollution-generating need not be treated and may bypass runoff treatment, if it is not mingled with runoff from pollution-generating surfaces.
- ~~Roof runoff~~Runoff from nonpollution-generating roofs is still subject to flow control per Minimum Requirement #7. The nonpollution-generating roof runoff that is directed to an infiltration trench or dry well must first pass through a catch basin as shown in BMP T5.10A. Note that metal roofs are considered pollution generating unless they are coated with an inert non-leachabale material. Roofs that are subject to venting of significant amounts of manufacturing, commercial, or other indoor pollutants is considered pollution-generating.
- Drainage from areas in native vegetation should not be mixed with untreated runoff from streets and driveways, if possible. It is best to infiltrate or disperse this relatively clean runoff to maximize recharge to shallow ground water, wetlands, and streams.
- If runoff from non-pollution generating surfaces reaches a runoff treatment BMP, flows from those areas must be included in the sizing calculations for the facility. Once runoff from non-pollution generating areas is mixed with runoff from pollution-generating areas, it cannot be separated before treatment.

4.2 Sequence of Facilities

The Enhanced Treatment and Phosphorus Removal Menus, described in [Chapter 3](#) ~~Chapter 3~~, include treatment options in which more than one type of treatment facility is used. In those options, the sequence of facilities is prescribed. This is because the specific pollutant removal role of the second or third facility in a treatment often assumes that significant solids' settling has already occurred. For example, phosphorus removal using a two-facility treatment relies on the second facility (sand filter) to remove a finer fraction of solids than those removed by the first facility.

There is also the question of whether treatment facilities should be placed upstream or downstream of detention facilities that are needed for flow control purposes. In general, all treatment facilities may be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. However, not all treatment facilities can function effectively if located downstream of detention facilities. Those facilities that treat unconcentrated flows, such as filter strips ~~and narrow-area biofilters~~, are usually not practical downstream of detention facilities. Other types of treatment facilities present special problems that must be considered before placement downstream is advisable.

For instance, prolonged flows discharged by a detention facility that is designed to meet the flow duration standard of Minimum Requirement No. 7 may interfere with proper functioning of basic biofiltration swales and sand filters. Grasses typically specified in the basic biofiltration swale design will not survive. A wet biofilter design would be a better choice.

For sand filters, the prolonged flows may cause extended saturation periods within the filter. Saturated sand can lose all oxygen and become anoxic. If that occurs, some amount of phosphorus captured within the filter may become soluble and released. To prevent long periods of sand saturation, adjustments may be necessary after the sand filter is in operation to bypass some areas of the filter. This bypassing will allow them to drain completely. It may also be possible to employ a different type of facility that is less sensitive to prolonged flows.

Oil control facilities must be located upstream of treatment facilities and as close to the source of oil-generating activity as possible. They should also be located upstream of detention facilities, if possible.

[Table 4.2.1](#) ~~Table 4.1~~ summarizes placement considerations of treatment facilities in relation to detention.

Table 4.2.1 Treatment Facility Placement in Relation to Detention		
Water Quality Facility	Preceding Detention	Following Detention
Basic biofiltration swale (Chapter 9)	OK	OK. Prolonged flows may reduce grass survival. Consider wet biofiltration swale
Wet biofiltration swale (Chapter 9)	OK	OK
Filter strip (Chapter 9)	OK	No—must be installed before flows concentrate.
Basic or large wetpond (Chapter 10)	OK	OK—less water level fluctuation in ponds downstream of detention may improve aesthetic qualities and performance.
Basic or large combined detention and wetpond (Chapter 10)	Not applicable	Not applicable
Wetvault (Chapter 10)	OK	OK
Basic or large sand filter or sand filter vault (Chapter 8)	OK, but presettling and control of floatables needed	OK—sand filters downstream of detention facilities may require field adjustments if prolonged flows cause sand saturation and interfere with phosphorus removal.
Stormwater treatment wetland/pond (Chapter 10)	OK	OK—less water level fluctuation and better plant diversity are possible if the stormwater wetland is located downstream of the detention facility.

Note: Emerging Technologies may be installed either upstream or downstream of detention facilities. The location depends on the type of technology and the level of treatment desired.

4.3 Setbacks, Slopes, and Embankments

The following guidelines for setbacks, slopes, and embankments are intended to provide for adequate maintenance accessibility to runoff treatment facilities. Setback requirements are generally required by local regulations, ~~uniform~~International building code requirements, or other state regulations. Local governments should require specific setback, slopes and embankment limitations to address public health and safety concerns.

4.3.1 Setbacks

Local governments may require specific setbacks in sites with steep slopes, land-slide areas, open water features, springs, wells, and septic tank drain fields. Setbacks from tract lines are necessary for maintenance access and equipment maneuverability. Adequate room for maintenance equipment should be considered during site design.

Examples of ~~setbacks~~text describing commonly used setbacks include the following:

- Stormwater infiltration systems shall be set back at least 100 feet from open water features and 200 feet from springs used for drinking water supply. Infiltration facilities upgradient of drinking water supplies must comply with Health Department requirements (Washington Wellhead Protection Program, Department of Health, 12/93).
- Stormwater infiltration systems, and unlined wetponds and detention ponds shall be located at least 100 feet from drinking water wells and septic tanks and drainfields.
- Wetvaults and tanks may be required to be set back from building foundations, structures, property lines, and vegetative buffers. A typical setback requirement is 20 feet, for maintenance access.
- All facilities shall be a minimum of 50 feet from any steep (greater than 15%) slope. A geotechnical report must address the potential impact of a wetpond on a steep slope

4.3.2 Side Slopes and Embankments

- Side slopes should preferably not exceed a slope of 3H:1V. Moderately undulating slopes are acceptable and can provide a more natural setting for the facility. In general, gentle side slopes improve the aesthetic attributes of the facility and enhance safety.
- Interior side slopes may be retaining walls, if the design is prepared and stamped by a licensed civil engineer. A fence should be provided along the top of the wall.

- Maintenance access should be provided through an access ramp or other adequate means.
- Embankments that impound water must comply with the Washington State Dam Safety Regulations ([Chapter 173-175 WAC](#) ~~(Chapter 173-175 WAC)~~). If the impoundment has a storage capacity, including both water and sediment storage volumes, greater than 10 acre-feet above natural ground level, then dam safety design and review are required by the Department of Ecology. See Chapter 3, Volume III, for more detail concerning Detention Ponds.

4.4 Facility Liners

Liners are intended to reduce the likelihood that pollutants in stormwater will reach ground water when runoff treatment facilities are constructed. In addition to ~~groundwater~~ ground water protection considerations, some facility types require permanent water for proper functioning. An example is the first cell of a wetpond.

Treatment liners amend the soil with materials that treat stormwater before it reaches more freely draining soils. They have slow rates of infiltration, generally less than 2.4 inches per hour (1.7×10^{-3} cm/s), but not as slow as low permeability liners. Treatment liners may use in-place native soils or imported soils.

Low permeability liners reduce infiltration to a very slow rate, generally less than 0.02 inches per hour (1.4×10^{-5} cm/s). These types of liners should be used for industrial or commercial sites with a potential for high pollutant loading in the stormwater runoff. Low permeability liners may be fashioned from compacted till, clay, geomembrane, or concrete. Till liners are preferred because of their general resilience and ease of maintenance.

4.4.1 General Design Criteria

- [Table 4.4.1](#) ~~Table 4.2~~ shows recommendations for the type of liner generally best suited for use with various runoff treatment facilities.
- Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in [Table 4.4.1](#) ~~Table 4.2~~. Areas above the treatment volume ~~that are~~ required to pass flows greater than the water quality treatment flow (or volume) need not be lined. However, the lining must be extended to the top of the interior side slope and anchored if it cannot be permanently secured by other means.
- For low permeability liners, the following criteria apply:
 1. Where the seasonal high ~~groundwater~~ ground water elevation is likely to contact a low permeability liner, liner buoyancy may be a

concern. A low permeability liner shall not be used in this situation unless evaluated and recommended by a geotechnical engineer.

2. Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or compost-amended native soil (2 inches compost tilled into 6 inches of native till soil) must be placed over the liner in the area to be planted. Twelve inches of cover is preferred.
- If a treatment liner will be below the seasonal high water level, the pollutant removal performance of the liner must be evaluated by a geotechnical or ~~groundwater~~ ~~ground water~~ specialist and found to be as protective as if the liner were above the level of the ~~groundwater~~ ~~ground water~~.

See [Sections 4.4.2](#) ~~Sections 4.4.2~~ and [4.4.3](#) ~~4.4.3~~ for more specific design criteria for treatment liners and low permeability liners.

Table 4.4.1
Lining Types Recommended for Runoff Treatment Facilities

WQ Facility	Area to be Lined	Type of Liner Recommended
Presetting basin	Bottom and sides	Low permeability liner or Treatment liner (If the basin will intercept the seasonal high ground water table, a treatment liner is recommended.)
Wetpond	First cell: bottom and sides to WQ design water surface	Low permeability liner or Treatment liner (If the wet pond will intercept the seasonal high ground water table, a treatment liner is recommended.)
	----- Second cell: bottom and sides to WQ design water surface	----- Treatment liner
Combined detention/WQ facility	First cell: bottom and sides to WQ design water surface	Low permeability liner or Treatment liner (If the facility will intercept the seasonal high ground water table a treatment liner is recommended.)
	----- Second cell: bottom and sides to WQ design water surface	----- Treatment liner
Stormwater wetland	Bottom and sides, both cells	Low permeability liner (If the facility will intercept the seasonal high ground water table, a treatment liner is recommended.)
Sand filtration basin	Basin sides only	Treatment liner
Sand filter vault	Not applicable	No liner needed
Linear sand filter	Not applicable if in vault Bottom and sides of presettling cell if not in vault	No liner needed Low permeability or treatment liner

Media filter (in vault)	Not applicable	No liner needed
Wet vault	Not applicable	No liner needed

4.4.2 Design Criteria for Treatment Liners

This section presents the design criteria for treatment liners.

- A two-foot thick layer of soil with a minimum organic content of ~~5~~**1.0**% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams can be used as a treatment layer beneath a water quality or detention facility.
- To demonstrate that in-place soils meet the above criteria, one sample per 1,000 square feet of facility area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer (usually two to six feet below the expected facility invert).
- Typically, side wall seepage is not a concern if the seepage flows through the same stratum as the bottom of the treatment BMP. However, if the treatment soil is an engineered soil or has very low permeability, the potential to bypass the treatment soil through the side walls may be significant. In those cases, the treatment BMP side walls may be lined with at least 18 inches of treatment soil, as described above, to prevent untreated seepage. This lesser soil thickness is based on unsaturated flow as a result of alternating wet-dry periods.
- Organic content shall be measured on a dry weight basis using ASTM D2974.
- Cation exchange capacity (CEC) shall be tested using EPA laboratory method 9081.
- Certification by a soils testing laboratory that imported soil meets the organic content and CEC criteria above shall be provided to the local approval authority.
- Animal manures used in treatment soil layers must be sterilized because of potential for bacterial contamination of the ~~groundwater~~**ground water**.

4.4.3 Design Criteria for Low Permeability Liner Options

This section presents the design criteria for each of the following four low permeability liner options: compacted till liners, clay liners, geomembrane liners, and concrete liners.

Compacted Till Liners

- Liner thickness shall be 18 inches after compaction.
- Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).

- A different depth and density sufficient to retard the infiltration rate to 2.4×10^{-5} inches per minute (1×10^{-6} cm/s) may also be used instead of Criteria 1 and 2.
- Soil should be placed in 6-inch lifts.
- Soils may be used that meet the following gradation:

Table 4.4.2 Compacted Till Liners	
Sieve Size	Percent Passing
6-inch	100
4-inch	90
#4	70 - 100
#200	20

Clay Liners

- Liner thickness shall be 12 inches.
- Clay shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4×10^{-5} inches per minute (1×10^{-6} cm/s) may also be used instead of the above criteria.
- The slope of clay liners must be restricted to 3H: 1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the facility does not occur. Any alternative soil stabilization method must take maintenance access into consideration.
- Where clay liners form the sides of ponds, the interior side slope should not be steeper than 3: 1, irrespective of fencing. This restriction is to ensure that anyone falling into the pond may safely climb out.

Geomembrane Liners

- Geomembrane liners shall be ultraviolet (UV) light resistant and have a minimum thickness of 30 mils. A thickness of 40 mils shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
- Geomembranes shall be bedded according to the manufacturer's recommendations.
- Liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the water quality facility, except for liner sand filters. Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to

mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic “safety fencing” or another highly-visible, continuous marker is embedded 6 inches above the membrane.

- If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.
- Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

Concrete Liners

- Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, specifications must be developed by a professional engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.
- Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.
- If grass is to be grown over a concrete liner, slopes must be no steeper than 5H: 1V to prevent the top dressing material from slipping.

4.5 Hydraulic Structures

4.5.1 Flow Splitter Designs

Many water quality (WQ) facilities can be designed as flow-through or on-line systems with flows above the WQ design flow or volume simply passing through the facility at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to WQ treatment facilities and bypass the remaining higher flows around them through off-line facilities. This can be accomplished by splitting flows in excess of the WQ design flow upstream of the facility and diverting higher flows to a bypass pipe or channel. The bypass typically enters a detention pond or the downstream receiving drainage system, depending on flow control requirements. In most cases, it is a designer’s choice whether WQ facilities are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

A crucial factor in designing flow splitters is to ensure that low flows are delivered to the treatment facility up to the WQ design flow rate. Above this rate, additional flows are diverted to the bypass system with minimal

increase in head at the flow splitter structure to avoid surcharging the WQ facility under high flow conditions.

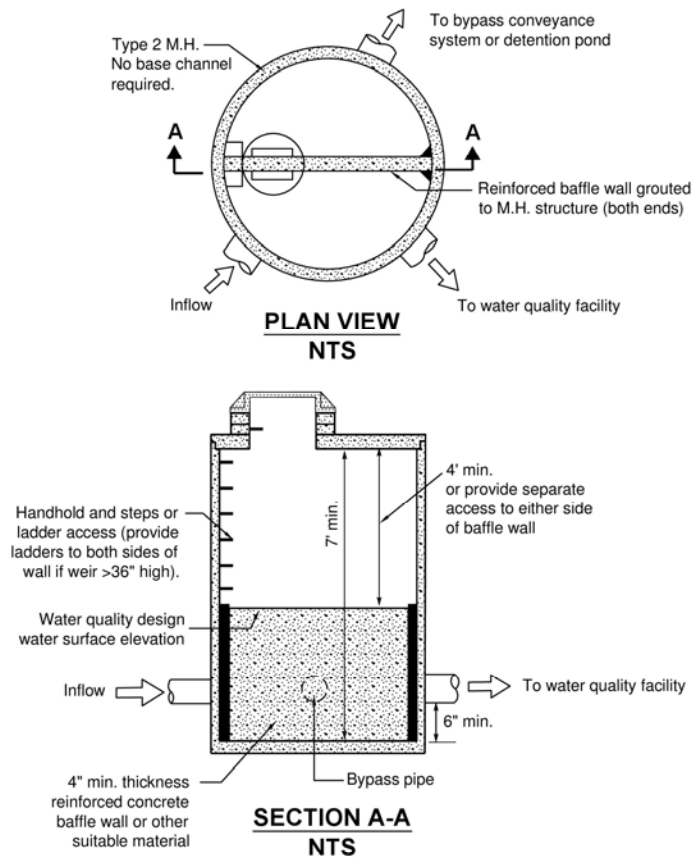
Flow splitters are typically manholes or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half tee section with a solid top and an orifice in the bottom of the tee section. A full tee option may also be used as described below in the “General Design Criteria.” We show two possible design options for flow splitters ~~are shown in~~ [Figure 4.5.1](#) ~~Figure 4.1~~ and [Figure 4.5.2](#) ~~Figure 4.2~~ (King County). Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the facility are also acceptable.

General Design Criteria

- A flow splitter must be designed to deliver the WQ design flow rate specified in this volume to the WQ treatment facility. For the basic size sand filter, which is sized based on volume, use the WQ design flow rate to design the splitter. For the large sand filter, use the 2-year flow rate or the flow rate that corresponds with treating 95 percent of the runoff volume of a long-term time series predicted by an approved continuous runoff model.
- The top of the weir must be located at the water surface for the design flow. Remaining flows enter the bypass line. Flows modeled using a continuous simulation model should use 15-minute time steps, if available. Otherwise use 1-hour time steps.
- The maximum head must be minimized for flow in excess of the WQ design flow. Specifically, flow to the WQ facility at the 100-year water surface must not increase the design WQ flow by more than 10%.
- Either design shown in [Figure 4.5.1](#) ~~Figure 4.1~~ or [Figure 4.5.2](#) ~~Figure 4.2~~ or an equivalent design may be used.
- As an alternative to using a solid top plate in [Figure 4.5.2](#) ~~Figure 4.2~~, a full tee section may be used with the top of the tee at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the WQ facility rather than back up from the manhole.
- Special applications, such as roads, may require the use of a modified flow splitter. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.
- For ponding facilities, back water effects must be included in designing the height of the standpipe in the manhole.
- Ladder or step and handhold access must be provided. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, must be used.

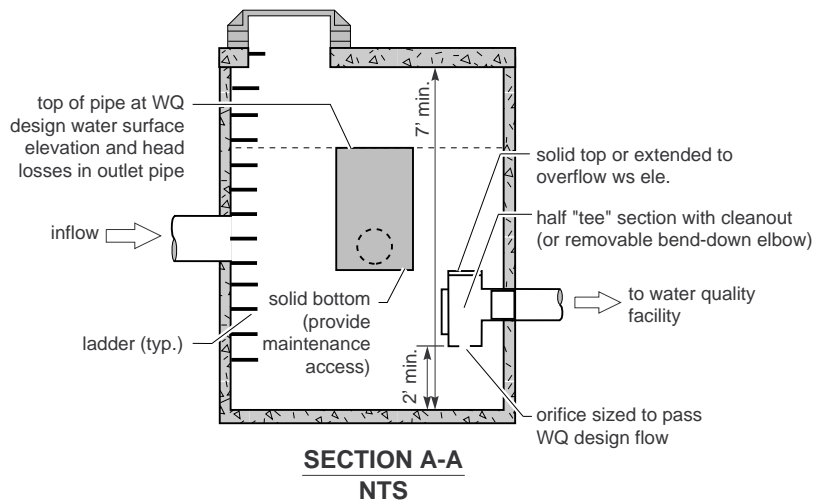
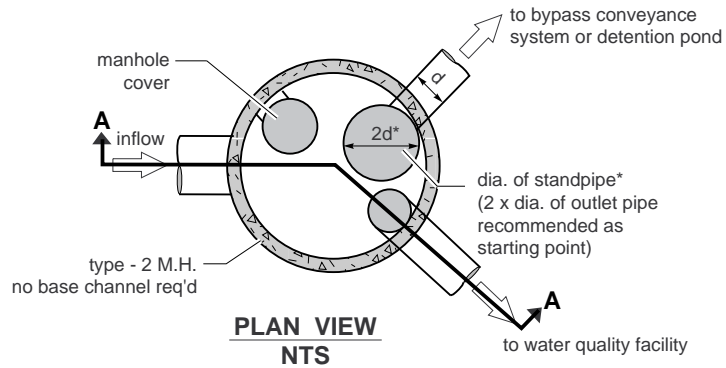
Materials

- The splitter baffle may be installed in a Type 2 manhole or vault.
- The baffle wall must be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness. The minimum clearance between the top of the baffle wall and the bottom of the manhole cover must be 4 feet; otherwise, dual access points should be provided.
- All metal parts must be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painted metal parts should not be used because of poor longevity.



Note: The water quality discharge pipe may require an orifice plate to be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

Figure 4.5.1 – Flow Splitter, Option A



*** NOTE:** Diameter (d) of standpipe should be large enough to minimize head above W.Q. design W.S. and to keep W.Q. design flows from increasing more than 10% during 100-year flows.

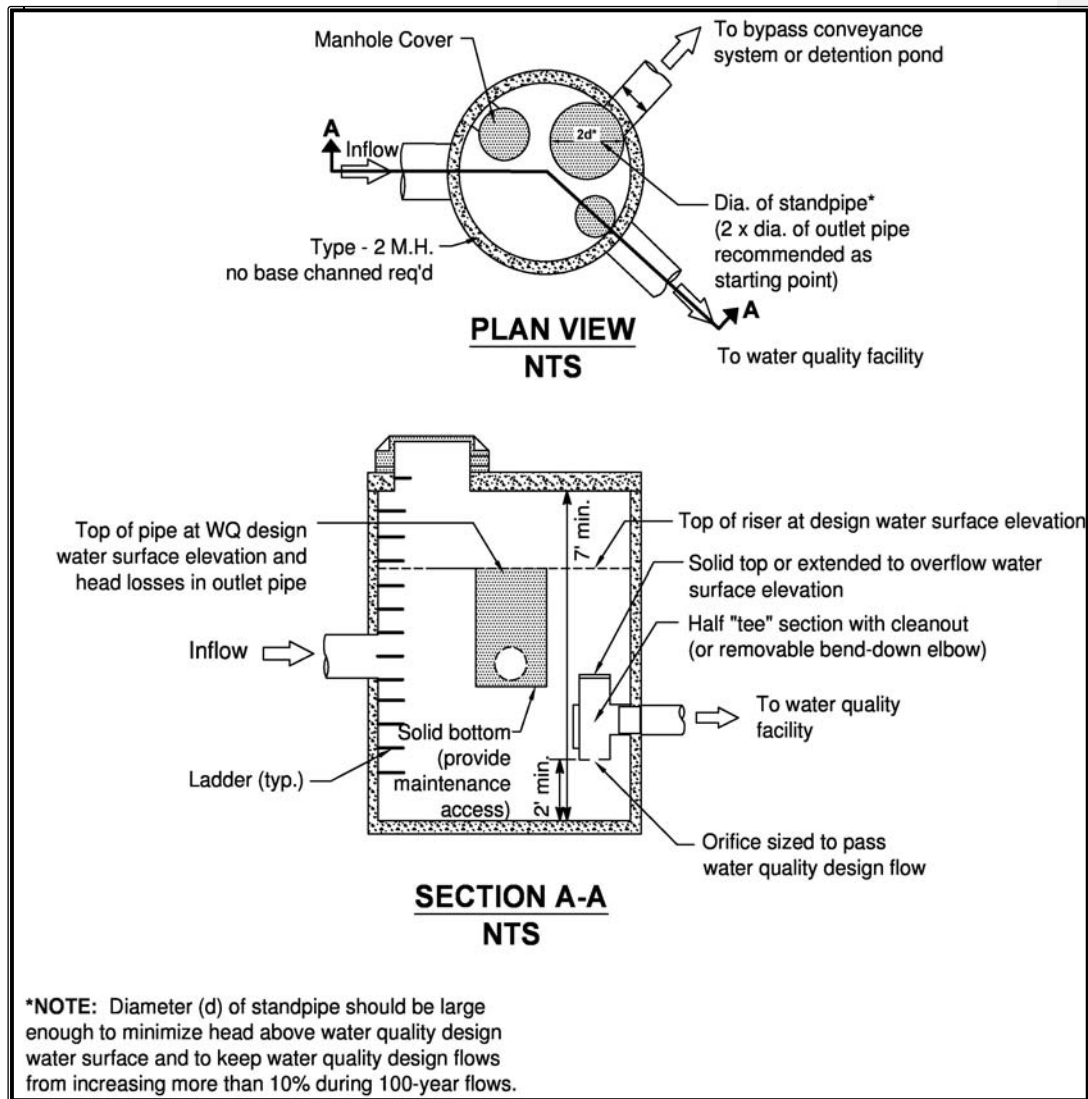


Figure 4.5.2 – Flow Splitter, Option B

4.5.2 Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inflow portion of water quality facilities (e.g., sand filter, biofiltration swale, or filter strip). There are five flow spreader options presented in this section:

Option A – Anchored plate

Option B – Concrete sump box

Option C – Notched curb spreader

Option D – Through-curb ports

Option E – Interrupted curb

Options A through C can be used for spreading flows that are concentrated. Any one of these options can be used when spreading is required by the facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a filter strip.

Options D and E are only for flows that are already unconcentrated and enter a filter strip or continuous inflow biofiltration swale. Other flow spreader options are possible with approval from the reviewing authority.

General Design Criteria

- Where flow enters the flow spreader through a pipe, it is recommended that the pipe be submerged to the extent practical to dissipate energy as much as possible.
- For higher inflows (greater than 5 cfs for the 100-yr storm), a Type 1 catch basin should be positioned in the spreader and the inflow pipe should enter the catch basin with flows exiting through the top grate. The top of the grate should be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.
- [Table 4.5.1](#) ~~Table 4.4~~ provides general guidance for rock protection at outfalls.

<p align="center">Table 4.5.1 Rock Protection at Outfalls</p>					
Discharge Velocity at Design Flow in feet per second (fps)	Required Protection Minimum Dimensions				
	Type	Thickness	Width	Length	Height
0 – 5	Rock lining ⁽¹⁾	1 foot	Diameter + 6 feet	8 feet <i>or</i> 4 x diameter, whichever is greater	Crown + 1 foot
5 ⁺ - 10	Riprap ⁽²⁾	2 feet	Diameter + 6 feet <i>or</i> 3 x diameter, whichever is greater	12 feet <i>or</i> 4 x diameter, whichever is greater	Crown + 1 foot
10 ⁺ - 20	Gabion outfall	As required	As required	As required	Crown + 1 foot
20 ⁺	Engineered energy dissipater required				

Footnotes:

(1) **Rock lining** shall be quarry spalls with gradation as follows:

Passing 8-inch square sieve: 100%
 Passing 3-inch square sieve: 40 to 60% maximum
 Passing ¾-inch square sieve: 0 to 10% maximum

(2) **Riprap** shall be reasonably well graded with gradation as follows:

Maximum stone size: 24 inches (nominal diameter)
 Median stone size: 16 inches
 Minimum stone size: 4 inches

Note: Riprap sizing governed by side slopes on outlet channel, assumed to be approximately 3:1 (H:V).

Option A -- Anchored Plate [\(Figure 4.5.3\(Figure 4.3\)\)](#)

- An anchored plate flow spreader must be preceded by a sump having a minimum depth of 8 inches and minimum width of 24 inches. If not otherwise stabilized, the sump area must be lined to reduce erosion and to provide energy dissipation.
- The top surface of the flow spreader plate must be level, projecting a minimum of 2 inches above the ground surface of the water quality facility, or V-notched with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs may also be used.
- A flow spreader plate must extend horizontally beyond the bottom width of the facility to prevent water from eroding the side slope. The horizontal extent should be such that the bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the Water Quality (WQ) facility.
- Flow spreader plates must be securely fixed in place.
- Flow spreader plates may be made of either wood, metal, fiberglass reinforced plastic, or other durable material. If wood, pressure treated 4 by 10-inch lumber or landscape timbers are acceptable.

- Anchor posts must be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

Option B -- Concrete Sump Box [\(Figure 4.5.4\)](#) ~~(Figure 4.4)~~

- The wall of the downstream side of a rectangular concrete sump box must extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.
- The downstream wall of a sump box must have “wing walls” at both ends. Side walls and returns must be slightly higher than the weir so that erosion of the side slope is minimized.
- Concrete for a sump box can be either cast-in-place or precast, but the bottom of the sump must be reinforced with wire mesh for cast-in-place sumps.
- Sump boxes must be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

Option C -- Notched Curb Spreader [\(Figure 4.5.5\)](#) ~~(Figure 4.5)~~

Notched curb spreader sections must be made of extruded concrete laid side-by-side and level. Typically five “teeth” per four-foot section provide good spacing. The space between adjacent “teeth” forms a v-notch.

Option D -- Through-Curb Ports [\(Figure 4.5.6\)](#) ~~(Figure 4.6)~~

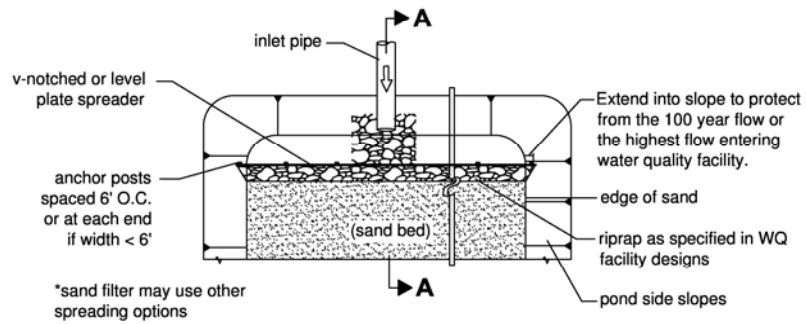
Unconcentrated flows from paved areas entering filter strips or continuous inflow biofiltration swales can use curb ports or interrupted curbs (Option E) to allow flows to enter the strip or swale. Curb ports use fabricated openings that allow concrete curbing to be poured or extruded while still providing an opening through the curb to admit water to the WQ facility.

Openings in the curb must be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening must be a minimum of 11 inches. Approximately 15 percent or more of the curb section length should be in open ports, and no port should discharge more than about 10 percent of the flow.

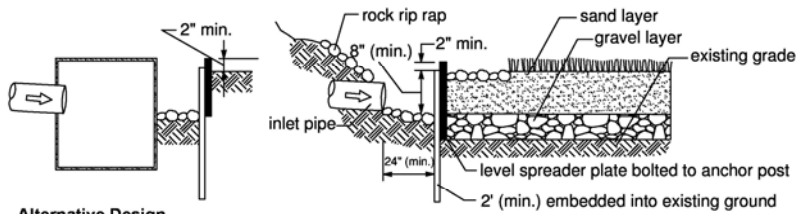
Option E -- Interrupted Curb (No Figure)

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, gaps must be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening must be a minimum of 11 inches. As a general rule, no opening should discharge more than 10 percent of the overall flow entering the facility.

Example of anchored plate used with a sand filter* (may also be used with other water quality facilities).



PLAN VIEW
NTS



SECTION A-A
NTS

Alternative Design

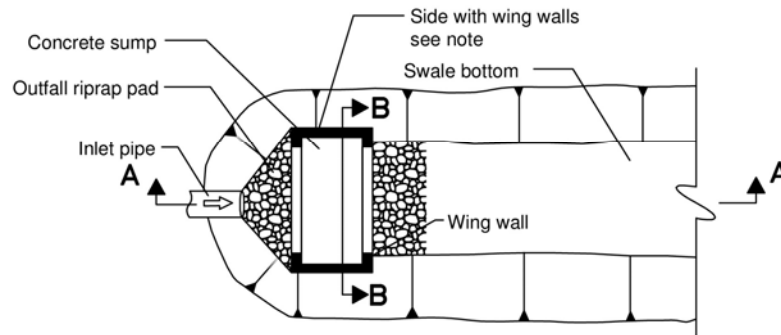
Catch basin recommended for higher flow situations (generally for inflow velocities of 5 fps or greater for 100 year storm).

Figure 4.5.3 – Flow Spreader Option A: Anchored Plate

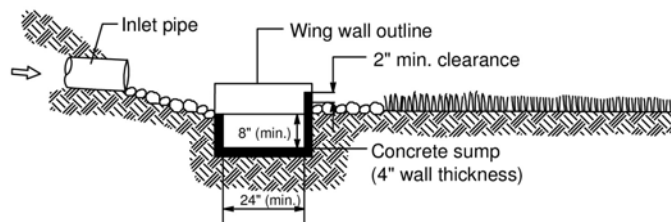
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Example of a concrete sump flow spreader used with a biofiltration swale (may be used with other WQ facilities).

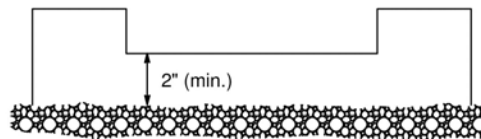


PLAN VIEW
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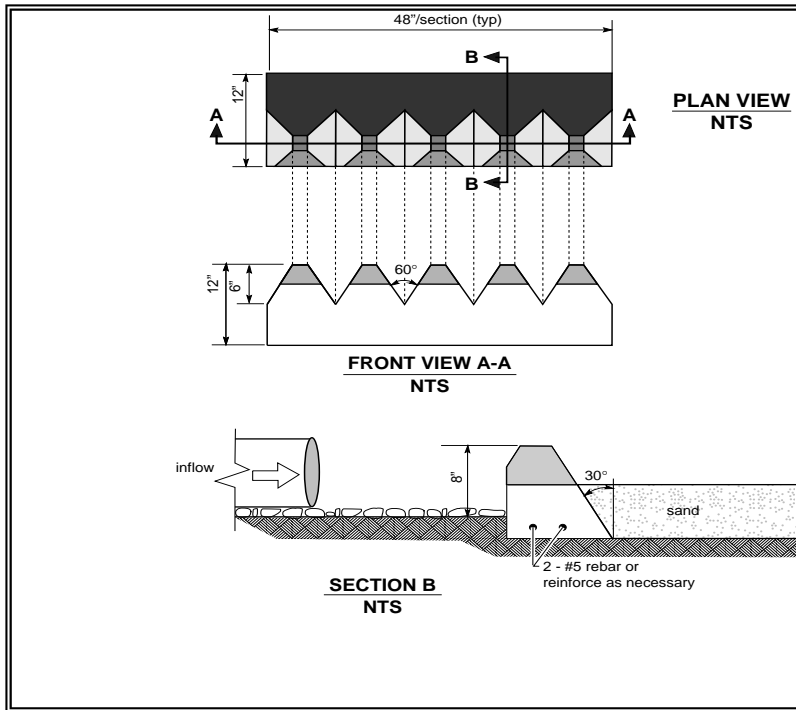
SECTION A-A
NTS

Note: Extend sides into slope. Height of side wall and wing walls must be sufficient to handle the 100-year flow or the highest flow entering the facility.



SECTION B-B
NTS

Figure 4.5.4 – Flow Spreader Option B: Concrete Sump Box



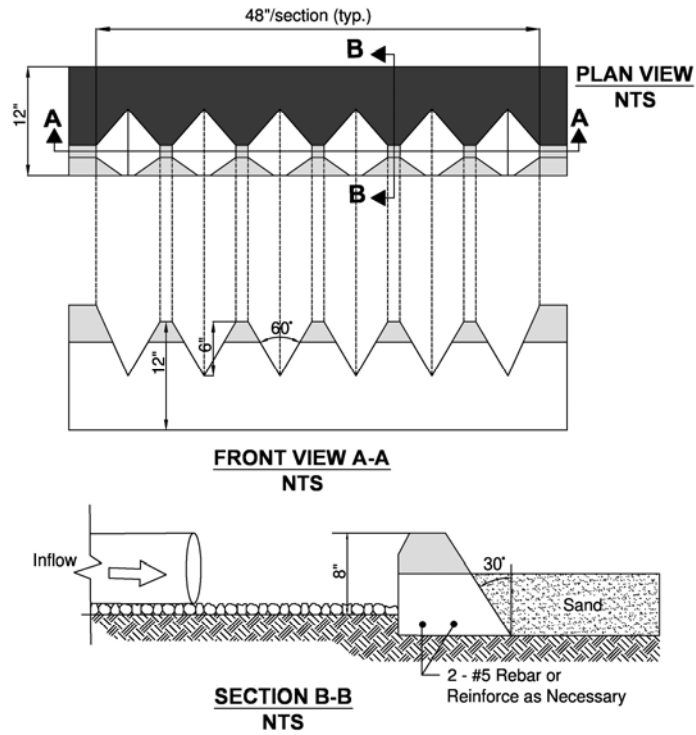


Figure 4.5.5 – Flow Spreader Option C: Notched Curb Spreader

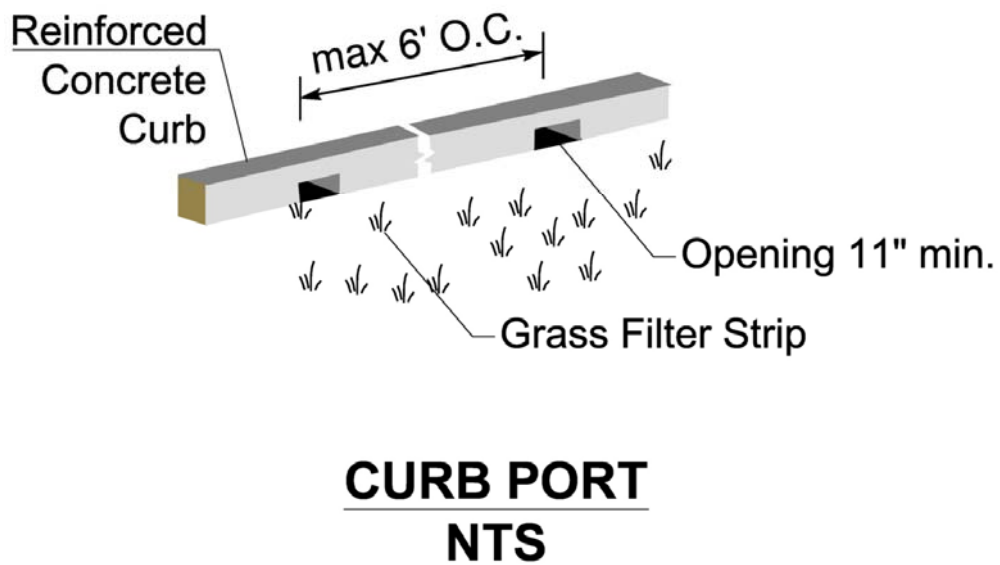
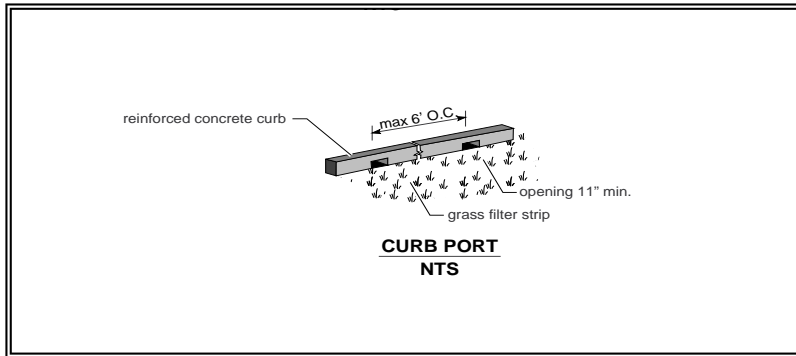


Figure 4.5.6 = Flow Spreader Option D: Through-Curb Port

4.5.3 Outfall Systems

Properly designed outfalls are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both ~~onsite~~on-site and downstream. Outfall systems include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

General Design Criteria

Provided below are general design criteria for both Outfall Features and Tightline Systems.

Outfall Features

At a minimum, all outfalls must be provided with a rock splash pad (see [Figure 4.5.7](#)~~Figure 4.7~~) except as specified below and in [Table 4.5.2](#)~~Table 4.5.2~~.

- The flow dispersal trenches shown in [Figures 4.5.8](#)~~Figures 4.8~~ and [4.5.9](#)~~4.9~~ should only be used when both criteria below are met:
 1. An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists and the natural (existing) discharge is unconcentrated; and
 2. The 100-year peak discharge rate is less than or equal to 0.5 cfs.
- For freshwater outfalls with a design velocity greater than 10 fps, a gabion dissipater or engineered energy dissipater may be required. There are many possible designs.

Note The gabion outfall detail shown in [Figure 4.5.10](#)~~Figure 4.10~~ is illustrative only. A design engineered to specific site conditions must be developed.

- Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem.
- In marine waters, rock splash pads and gabion structures are not recommended due to corrosion and destruction of the structure, particularly in high energy environments. Diffuser Tee structures, such as that depicted in [Figure 4.5.11](#)~~Figure 4.11~~, are also not generally recommended in or above the intertidal zone. They may be acceptable in low bank or rock shoreline locations. Stilling basins or bubble-up structures are acceptable. Generally, tightlines trenched to extreme low water or dissipation of the discharge energy above the ordinary high water line are preferred. Outfalls below extreme low water may still need an energy dissipation device (e.g., a tee structure) to prevent nearby erosion.

- Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with design velocity greater than 20 fps. These should be designed using published or commonly known techniques found in such references as *Hydraulic Design of Energy Dissipaters for Culverts and Channels*, published by the Federal Highway Administration of the United States Department of Transportation; *Open Channel Flow*, by V.T. Chow; *Hydraulic Design of Stilling Basins and Energy Dissipaters*, EM 25, Bureau of Reclamation (1978); and other publications, such as those prepared by the Soil Conservation Service (now Natural Resource Conservation Service).
- Alternate mechanisms may be used, such as bubble-up structures that eventually drain and structures fitted with reinforced concrete posts. If any alternate mechanisms are to be considered, they should be designed using sound hydraulic principles and consideration of ease of construction and maintenance.
- Mechanisms that reduce velocity prior to discharge from an outfall are encouraged. Some of these are drop manholes and rapid expansion into pipes of much larger size. Other discharge end features may be used to dissipate the discharge energy. An example of an end feature is the use of a Diffuser Tee with holes in the front half, as shown in [4.5.11 Figure 4.11](#).

Note: stormwater outfalls submerged in a marine environment can be subject to plugging due to biological growth and shifting debris and sediments. Therefore, unless intensive maintenance is regularly performed, they may not meet their designed function.

- New pipe outfalls can provide an opportunity for low-cost fish habitat improvements. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream (as shown in [Figure 4.5.12 Figure 4.12](#)). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with the Washington Department of Fish and Wildlife biologist prior to inclusion in design.
- Bank stabilization, bioengineering and habitat features may be required for disturbed areas.
- Outfall structures should be located where they minimize impacts to fish, shellfish, and their habitats.
- One caution to note is that the in-stream sample gabion mattress energy dissipater may not be acceptable within the ordinary high water mark of fish-bearing waters or where gabions will be subject to

abrasion from upstream channel sediments. A four-sided gabion basket located outside the ordinary high water mark should be considered for these applications.

Note: A Hydraulic Project Approval ([Chapter 77.55 RCW](#)~~(Chapter 77.55 RCW)~~) and an Army Corps of Engineers permit may be required for any work within the ordinary high water mark. Other provisions of the RCW or the Hydraulics Code - [Chapter 220-110 WAC](#)~~Chapter 220-110 WAC~~ may also apply. Contact the appropriate regional office of the State Department of Fish and Wildlife.

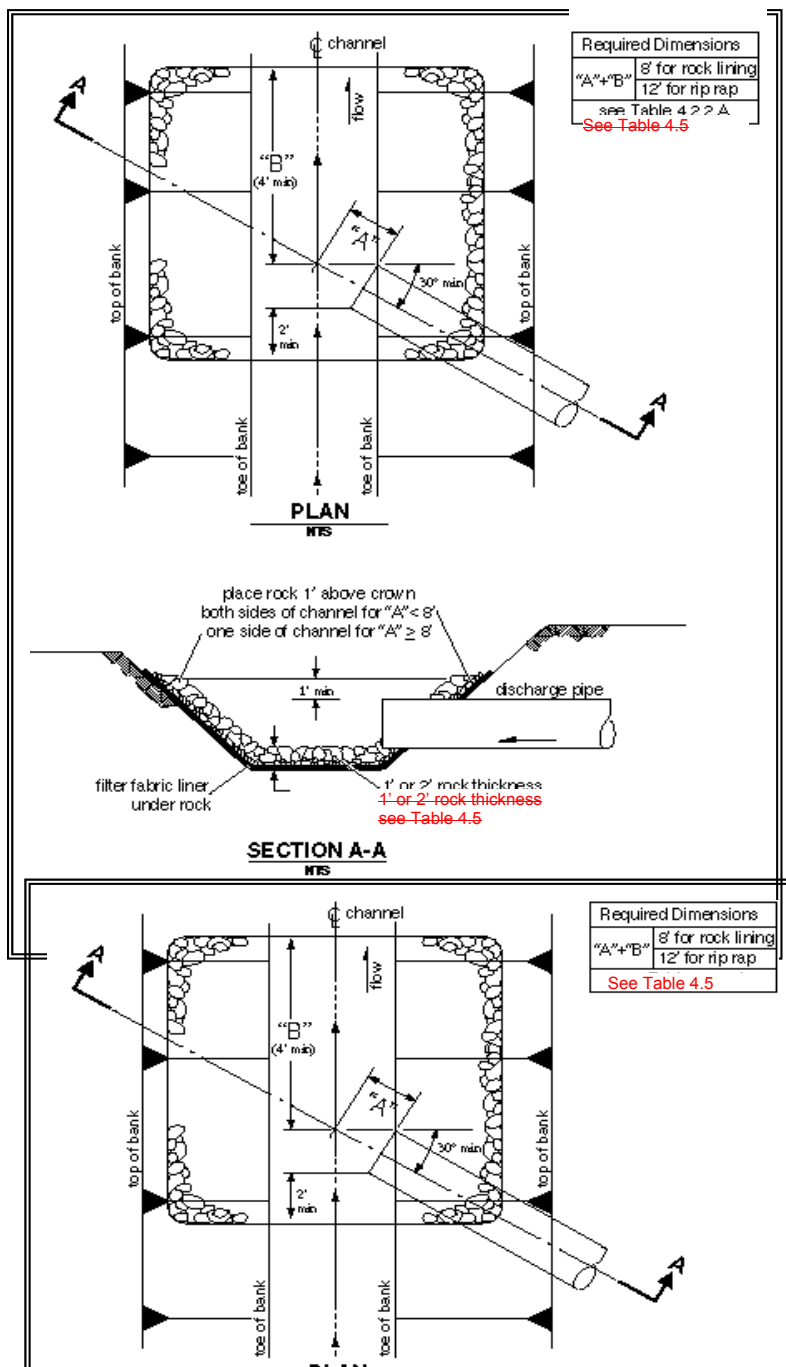
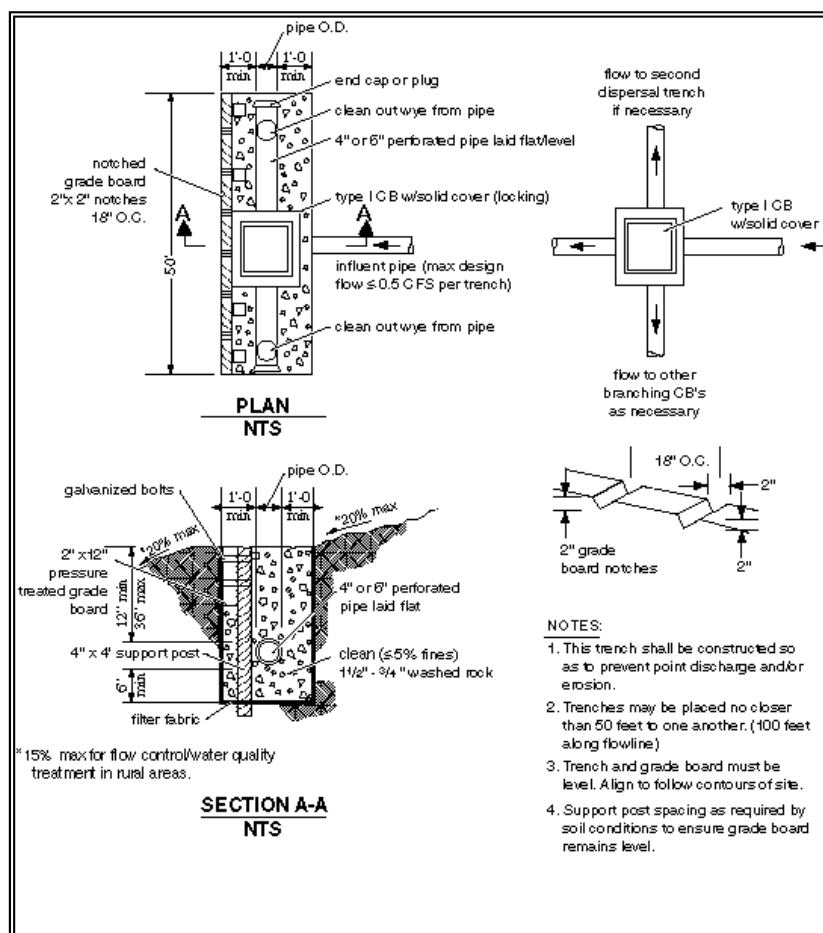
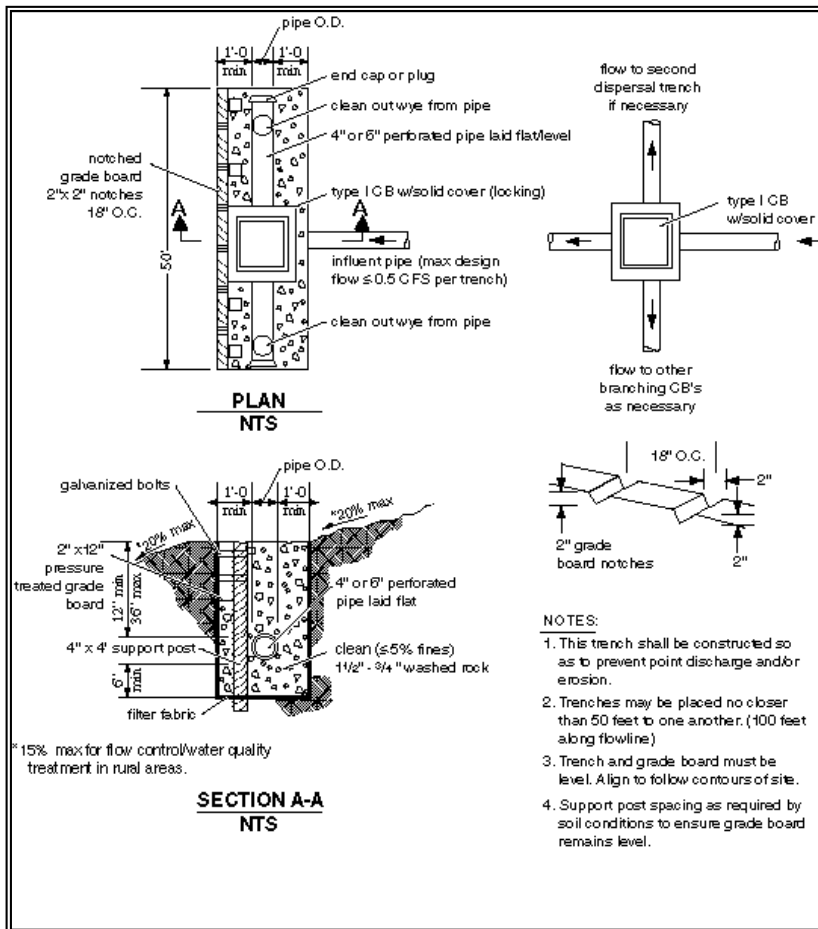




Figure 4.5.7 – Pipe/Culvert Outfall Discharge Protection





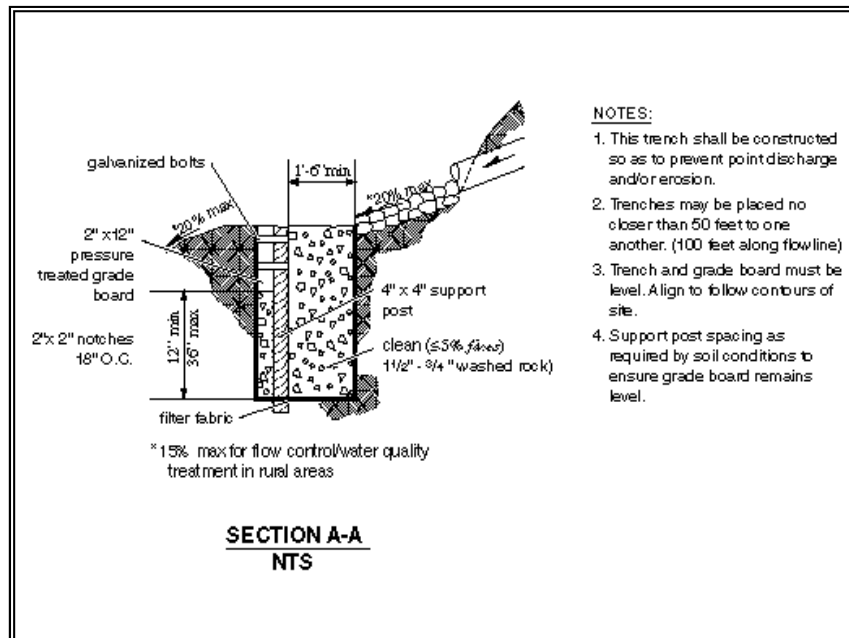


Figure 4.5.9 – Alternative Flow Dispersal Trench

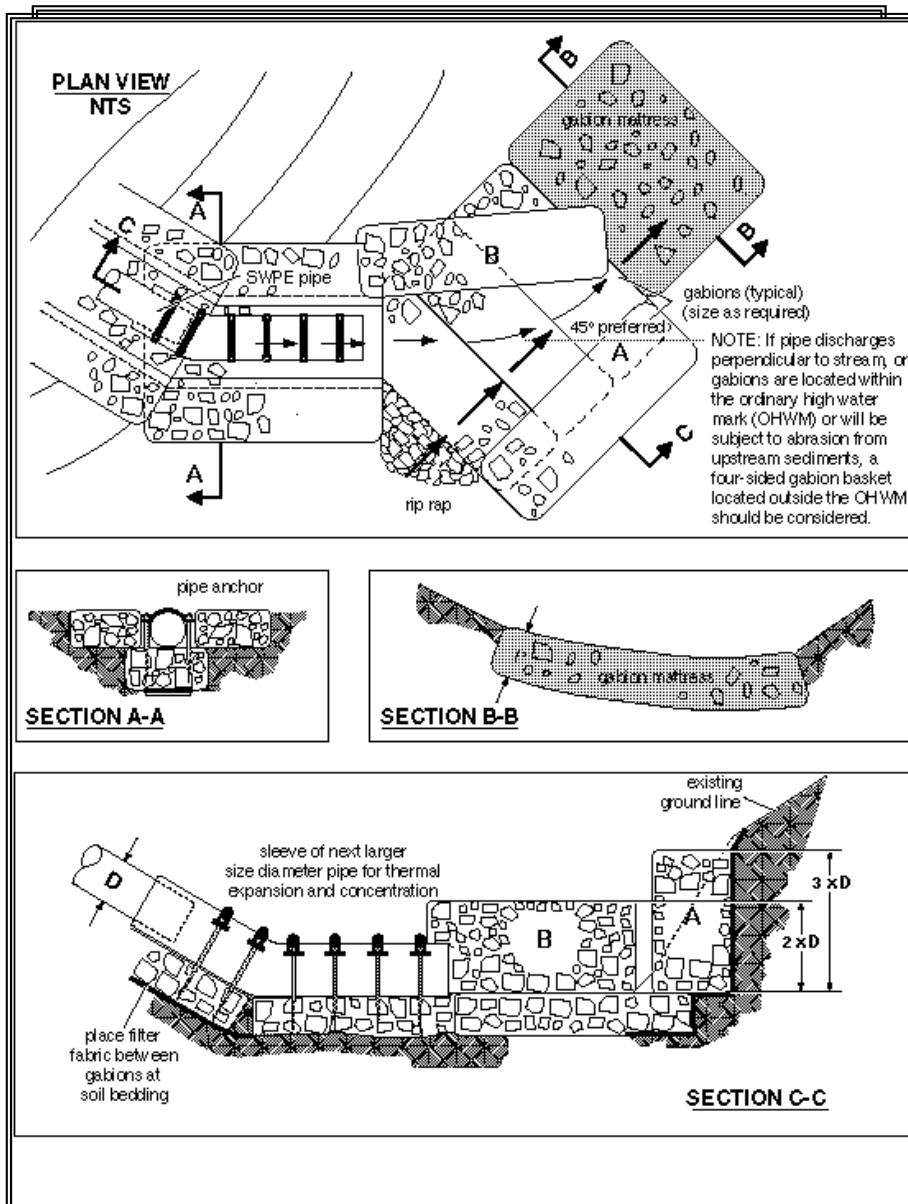
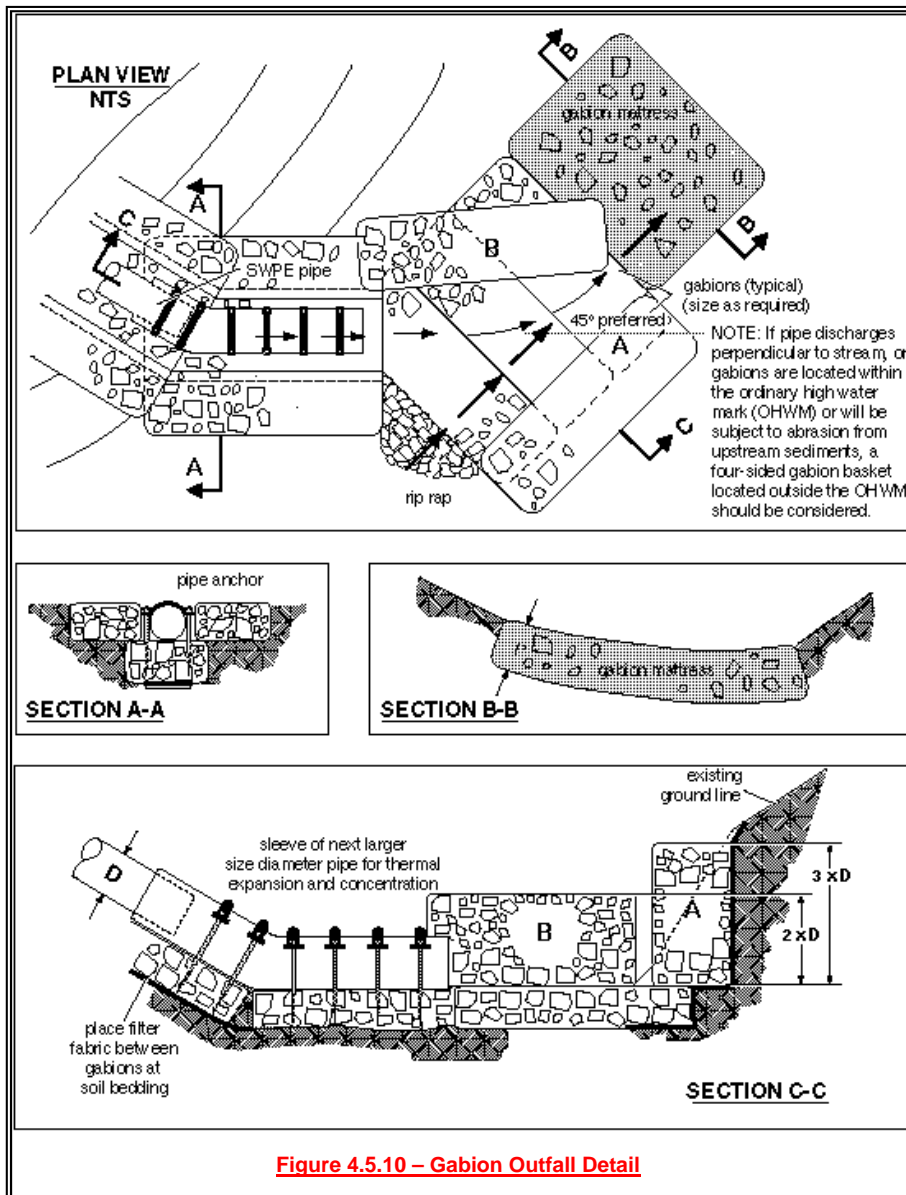


Figure 4.10—Gabion Outfall Detail



Tightline Systems

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20%. In order to minimize disturbance to slopes greater than 20%, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.
- Except as indicated above, tightlines or conveyances that traverse the marine intertidal zone and connect to outfalls must be buried to a depth sufficient to avoid exposure of the line during storm events or future changes in beach elevation. If non-native material is used to bed the tightline, such material shall be covered with at least 3 feet of native bed material or equivalent.
- High density polyethylene pipe (HDPP) tightlines must be designed to address the material limitations, particularly thermal expansion and contraction and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for solid wall polyethylene pipe (SWPE) is on the order of 0.001 inch per foot per Fahrenheit degree. Sliding sleeve connections must be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections must be located as close to the discharge end of the outfall system as is practical.
- Due to the ability of HDPP tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Details of a sample gabion mattress energy dissipater have been provided as [Figure 4.5.10](#) ~~Figure 4.10.~~ Flows of very high energy will require a specifically engineered energy dissipater structure.

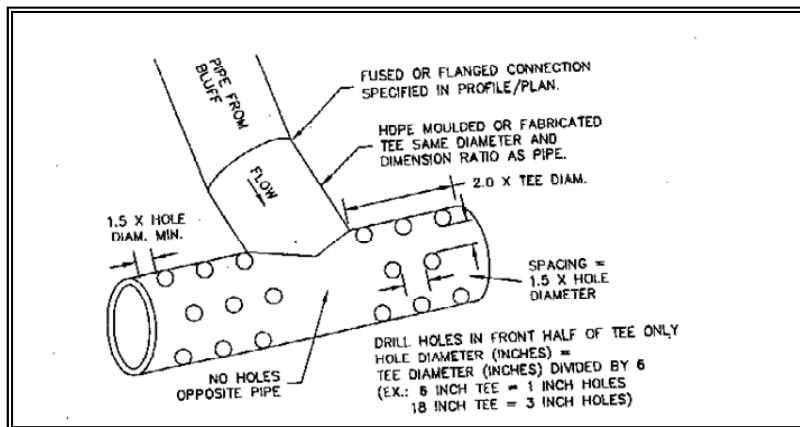


Figure 4.5.11 – Diffuser TEE (an example of energy dissipating end feature)

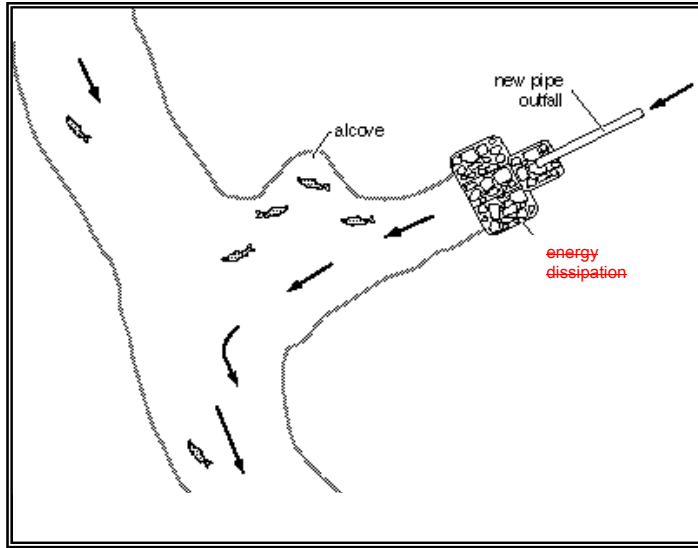


Figure 4.5.12 – Fish Habitat Improvement at New Outfalls

4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table 4.5—2 Maintenance Standards

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.)	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

No. 2 – Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Poisonous/Noxious Vegetation	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Contaminants and Pollution	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Rodent Holes	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Piping	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway	Rock Missing	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

No. 3 – Closed Detention Systems (Tanks/Vaults)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See "Catch Basins" (No. 5)	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 4 – Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).
Catch Basin	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 7 – Energy Dissipaters

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

No. 8 – Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits on grass treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

No. 9 – Wet Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation	Sediment depth exceeds 2-inches in 10% of the swale treatment area.	Remove sediment deposits in treatment area.
	Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
	Trash and Debris Accumulation	See "Detention Ponds" (No. 1).	Remove trash and debris from wet swale.
	Erosion/Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as <i>Juncus effusus</i> (soft rush) in wet areas or snowberry (<i>Symphoricarpos albus</i>) in dryer areas.

No. 10 – Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

No. 11 – Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as <i>Juncus effusus</i> (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.
	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

No. 12 – Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
	Access Ladder Damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned. Confined space warning sign missing.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.

No. 13 – Sand Filters (above ground/open)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground (open sand filter)	Sediment Accumulation on top layer	Sediment depth exceeds 1/2-inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
	Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
	Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short Circuiting	When flows become concentrated over one section of the sand filter rather than dispersed.	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.
	Erosion Damage to Slopes	Erosion over 2-inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes stabilized using proper erosion control measures.
	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.	Pipe repaired or replaced.

No. 14 –Sand Filters (below ground/enclosed)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault.	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2-inch.	No sediment deposits on sand filter section that which would impede permeability of the filter section.
	Sediment Accumulation in Pre-Settling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	No sediment deposits in first chamber of vault.
	Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.
	Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
	Short Circuiting	When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area.	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.
	Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles/Internal walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

No. 15 – Manufactured Media Filters)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault	Sediment Accumulation on Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits which would impede permeability of the compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
Below Ground Cartridge Type	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

No. 16 – Baffle Oil/Water Separators (API Type)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulations that exceed 1-inch, at the surface of the water.	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	See "Catch Basins" (No. 5)	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 17 – Coalescing Plate Oil/Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulation that exceeds 1-inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.
	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

No. 18 – Catchbasin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

No. 19 – MEDIA FILTER DRAIN (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow vegetation or remove nuisance vegetation to not impede flow. Mow grass to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

No. 20 – COMPOST AMENDED VEGETATED FILTER STRIP (CAVFS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with a 50/50 mixture of crushed gravel and compost. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

No. 21 – Bioretention Facilities

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
		Ecology has provided grant funding to develop detailed maintenance standards for Bioretention Facilities. Ecology anticipates a revision to this table by January 2013. Until that is available, refer to maintenance requirements listed in the <i>2012 Low Impact Development Technical Guidance Manual for Puget Sound</i> .	

No. 22 – Permeable Pavement

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
		Ecology has provided grant funding to develop detailed maintenance standards for Permeable Pavement. Ecology anticipates a revision to this table by January 2013. Until that is available, refer to maintenance requirements listed in the <i>2012 Low Impact Development Technical Guidance Manual for Puget Sound</i> .	

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Chapter 5. - On-Site Stormwater Management

Note: Figures 5.1 through 5.5 are courtesy of King County

5.1 Purpose

This Chapter presents the methods for analysis and design of on-site stormwater management Best Management Practices (BMPs). Many of these BMPs, although being used elsewhere, are new locally. Efforts ~~are have been~~ underway to further develop these “low impact development” concepts in Western Washington. Ecology ~~will update~~ has updated these BMPs ~~as local standards are established and added references to the Low Impact Development Technical Guidance Manual for Puget Sound, authored by the Washington State University Cooperative Extension and published by the Puget Sound Partnership. The document is available at the following website:~~ <http://www.psp.wa.gov/documents.php>

5.2 Application

The On-Site Stormwater Management BMPs presented in this Chapter ~~have application to treatment situations specified in Volume V, Chapter 3.~~

~~On-site BMPs focus on minimization of impervious surface area, the use of infiltration help achieve compliance with Minimum Requirement #5, and dispersion through on-site vegetation for stormwater runoff flow control can contribute toward compliance with Minimum Requirements #6 and treatment. #7.~~

Most of the BMPs serve to ~~control~~ reduce runoff flow ~~rates~~ as well as to provide runoff treatment. ~~Non-pollution generating surfaces, such as some~~ pollutant reduction benefits. The Department of Ecology accepts Full Dispersion as roofs meeting Minimum Requirements #6, and patios, may also use the infiltration BMPs contained in Volume 3, Section 3.1, which provide flow control only. Pollution-generating surfaces, such as driveways, small parking lots, #7. Bioretention and landscaping, must use on-site BMPs to provide some water quality treatment. Permeable Pavements can meet the same requirements for their tributary drainage areas depending upon site conditions and sizing.

5.3 Best Management Practices for On-Site Stormwater Management

~~The following~~ This chapter contains several On-Site Stormwater Management BMPs ~~are included in this Chapter.~~

Section 5.3.1 – Dispersion and Soil Quality BMPs (Required for Manual Equivalency)

~~BMP T5.10 Downspout Dispersion~~
~~BMP T5.11 Concentrated Flow Dispersion~~
~~BMP T5.12 Sheet Flow Dispersion~~
~~BMP T5.13 Post-Construction Soil Quality and Depth~~

Section 5.3.2 – Site Design BMPs

~~BMP T5.20 Preserving Natural Vegetation~~
~~BMP T5.21 Better Site Design~~

~~BMP T5.30 Full Dispersion~~

Projects shall employ these BMPs to infiltrate, disperse, and retain stormwater runoff on site to the maximum extent practicable without causing flooding or erosion impacts. Sites that are required to provide water quality treatment must provide treatment before infiltration or use infiltration as treatment. Sites that can fully infiltrate (see Volume III, Chapter 3, Section 3.3) or fully disperse (see ~~BMP T5.30~~BMP T5.30) are not required to provide additional runoff treatment or flow control facilities. Full dispersion ~~credit is limited~~applies to sites (or sub-areas of sites) with a maximum of 10% effective impervious area that is dispersed through 65% of the site maintained in natural vegetation. Full dispersion using substantially less area can also be utilized by roads through soils with high saturated hydraulic conductivity.

~~Impervious~~Hard surfaces that are not fully dispersed or infiltrated should be partially dispersed or infiltrated to the maximum extent practicable ~~and then hydrologically modeled.~~ For projects triggering minimum requirement #7, if the model predicts ~~that there will be a 0.4-1.0 cfs or greater increase in the 100-year return frequency flow;~~ (or a 1.5 cfs increase for 15-minute time steps), or if certain thresholds of impervious surfaces or converted pervious surfaces are exceeded within a threshold discharge area (see Volume 1, ~~Table~~Section 2.25.7), then at the project must comply with the flow control ~~facility is required standard.~~ Also, a treatment facility is required if projects that exceed the thresholds in TableSection 2.45.6 of Volume 1 ~~are exceeded~~must comply with treatment requirements.

Note:

~~Sections 5.3.3. and 5.3.4. have been deleted. The reader is directed to Low Impact Development Technical Guidance Manual for Puget Sound, authored by the Washington State University Cooperative Extension and published by the Puget~~

~~Sound Water Quality Action Team. The document is available at the following websites:~~

~~Also, the reader is directed to Appendix C in Volume III of this manual where directions are given concerning flow reduction credits for using low impact development BMP's.~~

5.3.1 ~~Dispersion and Soil Quality~~On-site Stormwater Management BMPs (Required for Manual Equivalency)

~~The following BMPs pertain to dispersion and soil quality applications:~~

~~BMP T5.10~~ Downspout Dispersion

~~Purpose and Definition:~~

~~The primary purpose of On-site (LID) Stormwater Management BMPs is to reduce the disruption of the natural site hydrology. Local governments under the Municipal Stormwater Permits can require projects to use these BMPs to gain compliance with Minimum Requirement #5. Municipal permittees that adopt different BMPs shall document how those BMPs will protect water quality, reduce the discharge of pollutants to the maximum extent practicable, and satisfy the state AKART requirements~~

Competing Needs:

~~The On-site Stormwater Management BMPs can be superseded or reduced where they are in conflict with:~~

~~Requirements of the following federal or state laws, rules, and standards: Historic Preservation Laws and Archaeology Laws as listed at <http://www.dahp.wa.gov/learn-and-research/preservation-laws>~~
~~Downspout dispersion BMPs are splashblocks or gravel-filled trenches that serve to spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits.~~

Applications and Limitations

- ~~• Downspout dispersion is required on all subdivision single family lots which meet one of the following criteria:~~
 - ~~1. Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Volume III, Chapter 3.~~
 - ~~2. Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration as determined in Volume III, Chapter 3 and where the design criteria below can be met.~~
- ~~• All other projects required to apply Roof Downspout BMPs must provide downspout dispersion if downspout infiltration is not feasible or applicable as determined in Volume III, Chapter 3, and if the design criteria below can be met.~~

Flow Credit for Roof Downspout Dispersion

~~If roof runoff is dispersed according to the requirements of this section on single family lots greater than 22,000 square feet, and the vegetative~~

~~flowpath^a—is 50 feet or larger through undisturbed native landscape or lawn/landscape area that meets BMP T5.13, the designer may click on the “Credits” button in the WWHM and enter the percent of roof area that is being dispersed.~~

General Design Guidelines

- ~~• Dispersion trenches designed as shown in the Figures 5.1 and 5.2 shall be used for all downspout dispersion applications except where splashblocks are allowed below. See Figure 5.3 for a typical splashblock.~~
- ~~• Splashblocks may be used for downspouts discharging to a vegetated flowpath at least 50 feet in length as measured from the downspout to the downstream property line, structure, sensitive steep slope, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flowpath lengths. The vegetated flowpath must be covered with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.~~
- ~~• If the vegetated flowpath (measured as defined above) is less than 25 feet on a subdivision single-family lot, a perforated stub-out connection may be used in lieu of downspout dispersion (See Volume III, Chapter 3). A perforated stub-out may also be used where implementation of downspout dispersion might cause erosion or flooding problems, either on site or on adjacent lots. This provision might be appropriate, for example, for lots constructed on steep hills where downspout discharge could be cumulative and might pose a potential hazard for lower-lying lots, or where dispersed flows could create problems for adjacent offsite lots. This provision does not apply to situations where lots are flat and onsite downspout dispersal would result in saturated yards.~~
- ~~• Note: For all other types, Federal Superfund or Washington State Model Toxics Control Act, Federal Aviation Administration requirements for airports, Americans with Disabilities Act.~~
- ~~• Where an LID requirement has been found to be in conflict with special zoning district design criteria adopted and being implemented pursuant to a community planning process, the existing local codes~~

^a ~~Vegetative flow path is measured from the downspout or dispersion system discharge point to the downstream property line, stream, wetland, or other impervious surface.~~

may supersede or reduce the LID requirement. This does not relieve municipal stormwater permittees of the requirement to review local design codes, standards, and rules to remove barriers and require use of LID principles and BMP's.

- Public health and safety standards.
- Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-projects, the use-way.
- A local Critical Area Ordinance that provides protection of tree species.

BMP T5.10A: Downspout Full Infiltration

Please refer to Section 3.1.1 in Volume III of this manual.

BMP T5.10B: Downspout Dispersion Systems

Please refer to Section 3.1.2 in Volume III of this manual.

BMP T5.10C: Perforated Stub-out Connections

Please refer to Section 3.1.3 in Volume III of this manual.

BMP T5.11: Concentrated Flow Dispersion

Purpose and Definition

Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of the runoff into the conveyance system, allowing for some infiltration, and providing some water quality benefits. See Figure 5.3.1.

Applications and Limitations

- Use this BMP in any situation where concentrated flow can be dispersed through vegetation.
- Figure 5.3.1 shows two possible ways of spreading flows from steep driveways.

Design Guidelines

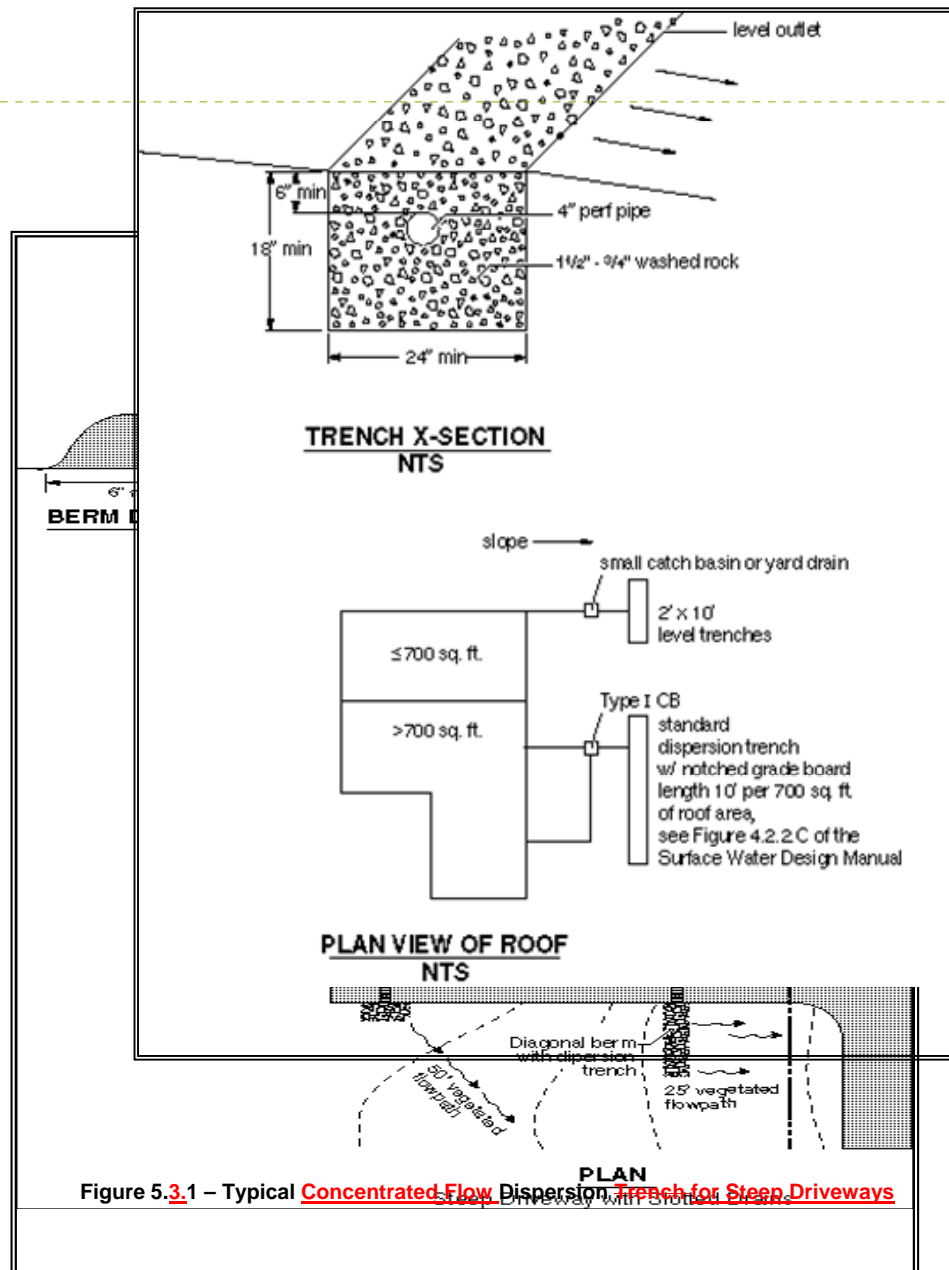
- Maintain a vegetated flowpath of at least 50 feet between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.
- in lieu of downspoutA maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion BMP.
- Provide a pad of crushed rock (a minimum of 2 feet wide by 3 feet long by 6 inches deep) at each discharge point.
- No erosion or flooding of downstream properties may result.
- Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. shall be as determinedDo not place the discharge point on or above slopes greater

than 20%, or above erosion hazard areas, without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.

- For sites with septic systems, the discharge point must be ten feet downgradient of the drainfield primary and reserve areas (WAC 246-272A-0210). A Local Plan Approval Authority may waive this requirement if site topography clearly prohibits flows from intersecting the drainfield.

Runoff Modeling

Where BMP T5.11 is used to disperse runoff into an undisturbed native landscape area or an area that meets [BMP T5.13](#), and the vegetated flow path is at least 50 feet, the impervious area may be modeled as landscaped area. This is done in the WWHM 3 on the Mitigated Scenario screen by entering the dispersed impervious area into one of the entry options for dispersal of impervious area runoff. For procedures in WWHM 2012, see Appendix III-C.



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Figure 5.3.1 – Typical Concentrated Flow Dispersion Trench for Steep Driveways

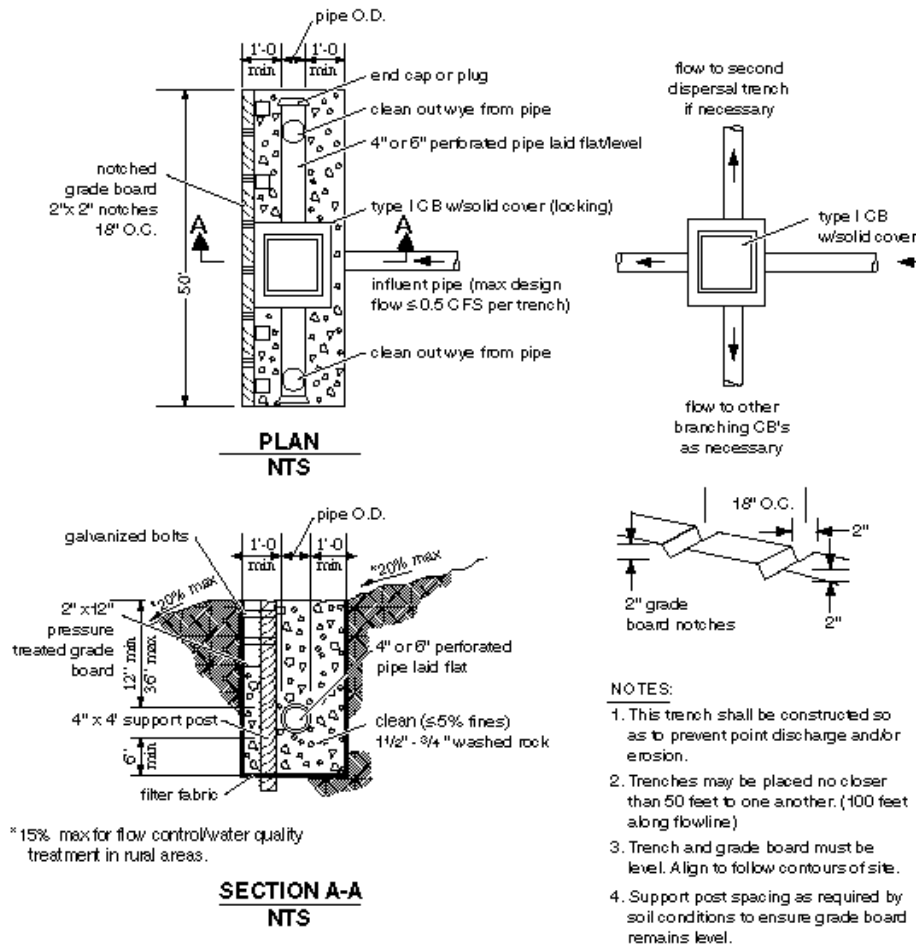


Figure 5.2—Standard

BMP T5.12: Sheet Flow Dispersion ~~Trench with Notched Grade Board~~

***Purpose and
Definition***

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded to avoid concentrating flows). Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

***Applications and
Limitations***

Use this BMP for flat or moderately sloping (< 15% slope) surfaces such as driveways, sports courts, patios, roofs without gutters, lawns, pastures; or any situation where concentration of flows can be avoided.

***Design
Guidelines***

- See [Figure 5.3.2](#) for details for driveways.
- Provide a 2-foot-wide transition zone to discourage channeling between the edge of the impervious surface (or building eaves) and the downslope vegetation. This transition zone may consist of an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the Local Plan Approval Authority.

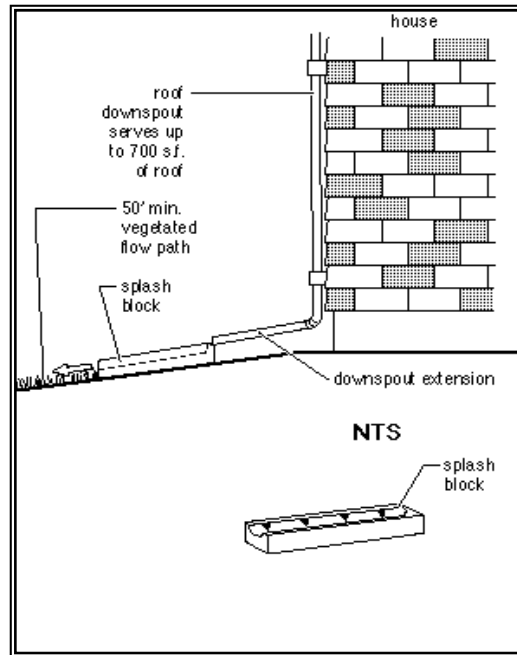


Figure 5.3—Typical Downspout Splashblock Dispersion

Additional Design Criteria for Dispersion Trenches

- A vegetated flowpath of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any steep slope. Sensitive area buffers may count towards flowpath lengths.
- Trenches serving up to 700 square feet of roof area may be simple 10-foot long by 2-foot wide gravel-filled trenches as shown on Figure 5-1. For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in Figure 5-2 may be used as approved by the Local Plan Approval Authority. The total length of this design must provide at least 10 feet of trench per 700 square feet of roof area and not exceed 50 feet.
- A setback of at least 5 feet must be maintained between any edge of the trench and any structure or property line.
- Provide a 10-foot-wide vegetated buffer for up to 20 feet of width of paved or impervious surface. Provide an additional 10 feet of

vegetated buffer width for each additional 20 feet of impervious surface width or fraction thereof. (For example, if a driveway is 30 feet wide and 60 feet long provide a 20-foot wide by 60-foot long vegetated buffer, with a 2-foot by 60-foot transition zone.)

- No erosion or flooding of downstream properties may result.
- ~~Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist. Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. The discharge point may~~ Do not be placed ~~allow sheet flow~~ on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and jurisdiction approval.
- ~~For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by the jurisdiction's permit review staff if site topography will clearly prohibit flows from intersecting the drainfield.~~

Additional Design Criteria for Splashblocks

~~In general, if the ground is sloped away from the foundation, and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.~~

~~The following conditions must be met to use splashblocks:~~

- ~~A vegetated flowpath of at least 50 feet must be maintained between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.~~
- ~~A maximum of 700 square feet of roof area may drain to each splashblock.~~
- ~~A splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each downspout discharge point.~~
- ~~No erosion or flooding of downstream properties may result.~~
- ~~Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist. Splashblocks may not be placed on or above slopes greater than 20% or above erosion hazard areas, without evaluation by a geotechnical engineer or~~

qualified geologist and approval by the Local Plan Approval Authority.

- For sites with septic systems, the discharge ~~point~~area must be ~~downslope~~ten feet downgradient of the drainfield primary and reserve ~~drainfield~~ areas (WAC 246-272A-0210). ~~This requirement can be waived by the~~ A Local Plan Approval Authority may waive this requirement if site topography clearly prohibits flows from intersecting the drainfield.

~~BMP T5.11 Concentrated Flow Dispersion~~

Purpose and Definition

~~Dispersion of concentrated flows from driveways or other pavement through a vegetated pervious area attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits. See Figure 5.4.~~

Applications and Limitations

- ~~• Any situation where concentrated flow can be dispersed through vegetation.~~
- ~~• Dispersion for driveways will generally only be effective for single-family residences on large lots and in rural short plats. Lots proposed by short plats in urban areas will generally be too small to provide effective dispersion of driveway runoff.~~
- ~~• Figure 5.4 shows two possible ways of spreading flows from steep driveways.~~

Design Guidelines

- ~~• A vegetated flowpath of at least 50 feet should be maintained between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake, or other impervious surface.~~
- ~~• A maximum of 700 square feet of impervious area may drain to each dispersion BMP.~~
- ~~• A pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.~~
- ~~• No erosion or flooding of downstream properties may result.~~

Where BMP T5.12 is used to disperse runoff into an undisturbed native landscape area or an area that meets [BMP T5.13](#), the impervious area may be modeled as landscaped area. This is done in the WWHM3 on the Mitigation Scenario screen by entering the dispersed impervious area into one of the entry options for dispersal of impervious area runoff. For procedures in WWHM 2012, see Appendix III-C in Volume III.

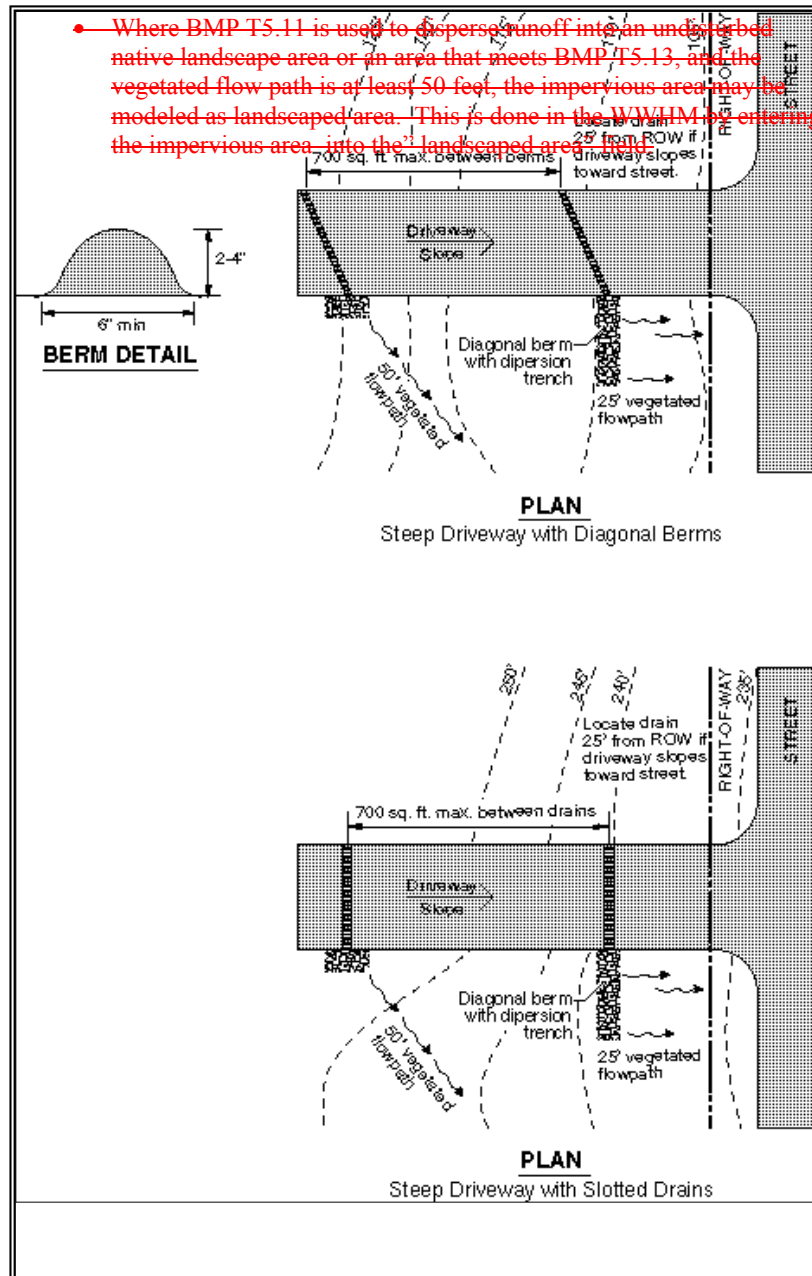
~~Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist.~~ **Runoff Modeling**

- ~~• The discharge point shall not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.~~
- ~~• For sites with septic systems, the discharge point should be downgradient of the drainfield primary and reserve areas. This~~

requirement may be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.

Flow Credits

- Where BMP T5.11 is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13, and the vegetated flow path is at least 50 feet, the impervious area may be modeled as landscaped area. This is done in the WQVIM by entering the impervious area into the "landscaped area" field.



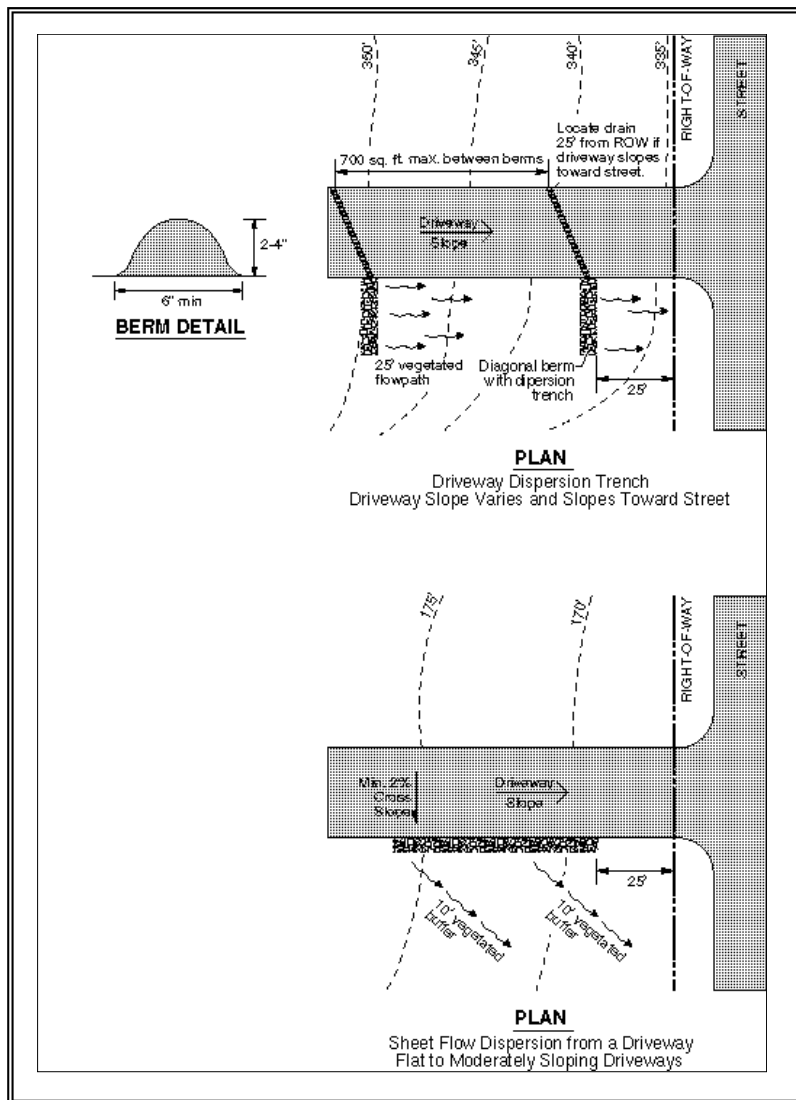


Figure 5.4—Typical Concentrated Flow Dispersion for Steep Driveways

BMP T5.12 3.2 – Sheet Flow Dispersion for Driveways

Purpose and Definition

Sheet flow dispersion is the simplest method of runoff control. This BMP can be used for any impervious or pervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

Applications and Limitations

Flat or moderately sloping (<15% slope) impervious surfaces such as driveways, sport courts, patios, and roofs without gutters; sloping cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture; or any situation where concentration of flows can be avoided.

Design Guidelines

- See Figure 5.5 for details for driveways.
- A 2-foot wide transition zone to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to the Local Plan Approval Authority.
- A vegetated buffer width of 10 feet of vegetation must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width or fraction thereof.
- A vegetated buffer width of 25 feet of vegetation must be provided for up to 150 feet of contributing cleared area (i.e., bare soil, non-native landscaping, lawn, and/or pasture). Slopes within the 25-foot minimum flowpath through vegetation should be no steeper than 8 percent. If this criterion cannot be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.
- No erosion or flooding of downstream properties may result.

Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist.

- ~~The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the Local Plan Approval Authority.~~
- ~~For sites with septic systems, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement may be waived by the Local Plan Approval Authority if site topography clearly prohibits flows from intersecting the drainfield.~~

Flow Credits

- ~~Where BMPT5.12 is used to disperse runoff into an undisturbed native landscape area or an area that meets BMP T5.13, the impervious area may be modeled as landscaped area. This is done in the WWHM by entering the impervious area into the "landscaped area" field.~~

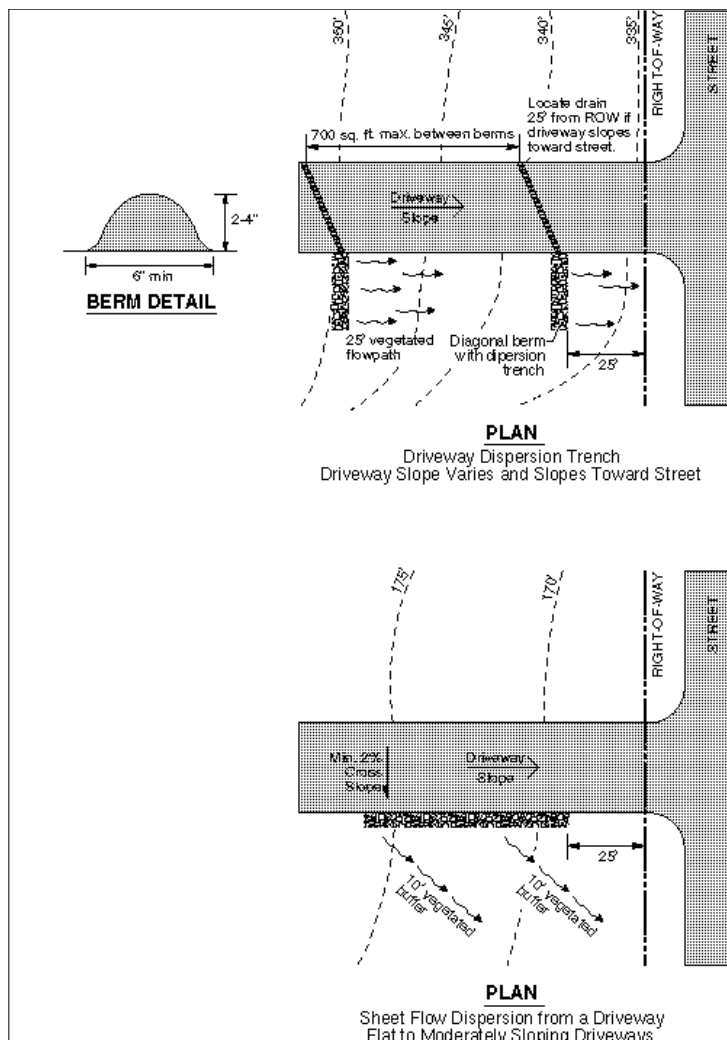


Figure 5.5—Sheet Flow Dispersion for Driveways

BMP T5.13: Post-Construction Soil Quality and Depth

Purpose and Definition

Naturally occurring (undisturbed) soil and vegetation provide important stormwater 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 development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Not only are these important stormwater functions lost, but such landscapes themselves become pollution generating pervious surfaces due to increased use of

pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.

Establishing soil quality and depth regains greater stormwater functions in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention.

Applications and Limitations

Establishing a minimum soil quality and depth is not the same as preservation of naturally occurring soil and vegetation. However, establishing a minimum soil quality and depth will provide improved on-site management of stormwater flow and water quality.

Soil organic matter can be attained through numerous materials such as compost, composted woody material, biosolids, and forest product residuals. It is important that the materials used to meet the soil quality and depth BMP be appropriate and beneficial to the plant cover to be established. Likewise, it is important that imported topsoils improve soil conditions and do not have an excessive percent of clay fines.

This BMP can be considered infeasible on till soil slopes greater than 33 percent.

Design Guidelines

- Soil retention. Retain, in an undisturbed state, the duff layer and native topsoil to the maximum extent practicable. In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.

Purpose and Definition

~~Naturally occurring (undisturbed) soil and vegetation provide important stormwater 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 development strips away native soil and vegetation and replaces it with minimal topsoil and sod. Not only are these important stormwater functions lost, but such landscapes themselves become pollution—generating pervious surfaces due to increased use of pesticides, fertilizers and other landscaping and household/industrial chemicals, the concentration of pet wastes, and pollutants that accompany roadside litter.~~

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Design Guidelines

- ~~Soil retention. The duff layer and native topsoil should be retained in an undisturbed state to the maximum extent practicable. In any areas requiring grading remove and stockpile the duff layer and topsoil on site in a designated, controlled area, not adjacent to public resources and critical areas, to be reapplied to other portions of the site where feasible.~~
- Soil quality. All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage facility or engineered as structural fill or slope shall, at project completion, demonstrate the following:
 1. A topsoil layer with a minimum organic matter content of ~~ten percent~~ 10% dry weight in planting beds, and 5% organic matter content in turf areas, and a pH from 6.0 to 8.0 or matching the pH of the ~~original~~ undisturbed soil. The topsoil layer shall have a minimum depth of eight inches except where tree roots limit the depth of incorporation of amendments needed to meet the criteria. Subsoils below the topsoil layer should be scarified at least 4 inches with some incorporation of the upper material to avoid stratified layers, where feasible.
 2. ~~Mulch~~ planting beds ~~must be mulched~~ with 2 inches of organic material
 3. ~~Quality of Use~~ compost and other materials ~~used to that~~ meet ~~the these~~ organic content requirements:
 - a. The organic content for “pre-approved” amendment rates can be met only using compost that meets the definition of “composted materials” in ~~WAC 173-350-100~~ ~~WAC 173-350-220~~. This code is available online at:
<http://apps.leg.wa.gov/wac/default.aspx?cite=173-350>
<http://www.ecy.wa.gov/programs/swfa/facilities/350.html>
The compost must also have an organic matter content of ~~35~~ 40% to 65%, and a carbon to nitrogen ratio below 25:1.

The carbon to nitrogen ratio may be as high as 35:1 for plantings composed entirely of plants native to the Puget Sound Lowlands region.

- b. ~~b.~~ Calculated amendment rates may be met through use of composted materials ~~as defined meeting (a.)~~ above; or other organic materials amended to meet the carbon to nitrogen ratio requirements, and meeting the contaminant standards of Grade A Compost.

The resulting soil should be conducive to the type of vegetation to be established.

- Implementation Options: The soil quality design guidelines listed above can be met by using one of the methods listed below:
 1. Leave undisturbed native vegetation and soil, and protect from compaction during construction.
 2. Amend existing site topsoil or subsoil either at default “pre-approved” rates, or at custom calculated rates based on ~~specifiers~~ tests of the soil and amendment.
 3. Stockpile existing topsoil during grading, and replace it prior to planting. Stockpiled topsoil must also be amended if needed to meet the organic matter or depth requirements, either at a default “pre-approved” rate or at a custom calculated rate.
 4. Import topsoil mix of sufficient organic content and depth to meet the requirements.

More than one method may be used on different portions of the same site. Soil that already meets the depth and organic matter quality standards, and is not compacted, does not need to be amended.

Planning/Permitting/Inspection/Verification Guidelines & Procedures

- Local governments are encouraged to adopt guidelines and procedures similar to those recommended in *Guidelines and Resources For Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington*. This document is available at:
http://www.soilsforsalmon.org/pdf/Soil_BMP_Manual.pdf

Maintenance

- Establish soil quality and depth toward the end of construction and once established, protect from compaction, such as from large machinery use, and from erosion.

~~Planning/Permitting/Inspection/Verification Guidelines & Procedures~~

- ~~Local governments are encouraged to adopt guidelines and procedures similar to those recommended in Guidelines and Resources For Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington. This document is available at:~~

Maintenance

- ~~Soil quality and depth should be established toward the end of construction and once established, should be protected from compaction, such as from large machinery use, and from erosion.~~
- ~~Soil should be planted~~ Plant vegetation and ~~mulched~~ mulch the amended soil area after installation.
- Leave plant debris or its equivalent ~~should be left~~ on the soil surface to replenish organic matter.
- ~~It should be~~ Reduce and adjust, where possible ~~to reduce, the~~ use of irrigation, fertilizers, herbicides and pesticides. ~~These activities should be adjusted where possible,~~ rather than continuing to implement formerly established practices.

Runoff Model Representation

Areas meeting the design guidelines may be entered into approved runoff models as “Pasture” rather than “Lawn.”

Flow Reduction Credits

Flow reduction credits can be taken in runoff modeling when BMP T5.13 is used as part of a dispersion design under the conditions described in:

[BMP T5.10B Downspout Dispersion](#)

[BMP T5.11 Concentrated Flow Dispersion](#)

[BMP T5.12 Sheet Flow Dispersion](#)

[BMP T5.18 Reverse Slope Sidewalks](#)

[BMP T5.30 Full Dispersion \(for public road projects\)](#)

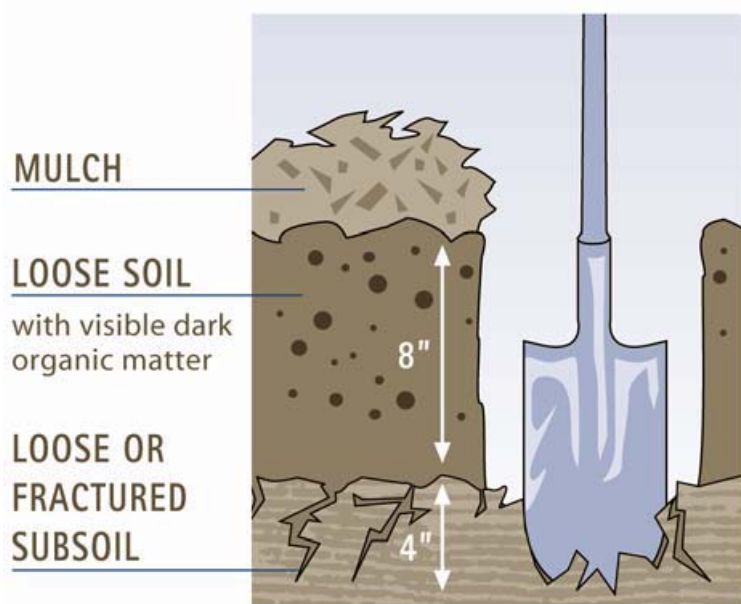


Figure 5.3.3 – Planting bed Cross-Section

(Reprinted from *Guidelines and Resources For Implementing Soil Quality and Depth BMP T5.13* in *WDOE Stormwater Management Manual for Western Washington*, 2010, Washington Organic Recycling Council)

BMP T5.14A: Rain Gardens

Purpose and Definition

Land development projects may not be of sufficient size such that it is practical to construct engineered stormwater facilities for flow reduction and pollutant removal. However, the cumulative impact of smaller development projects on the natural hydrology and water quality of local waters can be significant. To reduce that cumulative impact, small projects (see Section 2.4 in Volume I) must implement on-site stormwater management BMP's (See Minimum Requirement #5 in Section 2.5 of Volume I). Rain gardens are an on-site stormwater management BMP that can provide effective removal of many stormwater pollutants, and provide reductions in stormwater runoff quantity and surface runoff flow rates.

Rain gardens are non-engineered, shallow, landscaped depressions with compost-amended soils and adapted plants. The depression ponds and temporarily stores stormwater runoff from adjacent areas. A portion of the influent stormwater passes through the amended soil profile and into the native soil beneath. Stormwater that exceeds the storage capacity is designed to overflow to an adjacent drainage system.

Applications and Limitations

Rain gardens are an on-site stormwater management BMP option for projects that have to comply with Minimum Requirements #1 - #5, but not Minimum Requirements #6 - #9. For projects electing to use List #1 of Minimum Requirement #5, rain gardens are to be used to the extent feasible for runoff from roofs and other hard surfaces unless a higher priority BMP is feasible.

Infeasibility criteria for rain gardens are the same as for bioretention. Please see Bioretention infeasibility criteria in BMP T7.30 of this Volume.

Although not required, Ecology recommends installation by a landscaping company with experience in rain garden construction.

Rain gardens constructed with imported compost materials should not be used within one-quarter mile of phosphorus-sensitive waterbodies. Preliminary monitoring indicates that new rain gardens can add phosphorus to stormwater. Therefore, they should also not be used with an underdrain when the underdrain water would be routed to a phosphorus-sensitive receiving water.

Design Guidelines

Refer to the Rain Garden Handbook for Western Washington Homeowners (Pierce County Extension of Washington State University, 2007 or as revised) for rain garden specifications and construction guidance.

For design on projects subject to Minimum Requirement #5, and choosing to use List #1 of that requirement, rain gardens shall have a horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

<u>Maintenance</u>	<u>Until such time as Ecology publishes guidance in regard to maintenance of rain gardens, please refer to the Rain Garden Handbook for Western Washington Homeowners. That document provides tips on mulching, watering, weeding, pruning, and soil management.</u>
<u>BMP T5.14B: Bioretention</u>	
<u>Purpose and Definition</u>	<p><u>Bioretention areas are shallow landscaped depressions, with a designed soil mix and plants adapted to the local climate and soil moisture conditions, that receive stormwater from a contributing area.</u></p> <p><u>Bioretention provides effective removal of many stormwater pollutants by passing stormwater through a soil profile that meets specified characteristics. Bioretention can also reduce stormwater runoff quantity and surface runoff flow rates significantly where the exfiltrate from the design soil is allowed to infiltrate into the surrounding native soils.</u></p> <p><u>Bioretention can be used as a primary or supplemental detention/retention system. Where the native soils have low infiltration rates, under-drain systems can be installed and the facility used to filter pollutants and detain flows. However, designs utilizing under-drains provide less flow control benefits.</u></p>
<u>Applications and Limitations</u>	<p><u>Bioretention facilities are an On-site BMP option for projects that only have to comply with Minimum Requirements #1 - #5. For projects electing to use Mandatory List #2 of Minimum Requirement #5, bioretention facilities are to be used to the extent feasible for runoff from roofs and other hard surfaces unless a higher priority BMP is feasible.</u></p> <p><u>Use of bioretention can be restricted by site limitations. Please see Bioretention infeasibility criteria in BMP T7.30 of this Volume.</u></p>
<u>Design Guidelines</u>	<p><u>Refer to BMP T7.30 in Chapter 7 of this Volume for detailed design guidelines.</u></p> <p><u>For design on projects subject to Minimum Requirement #5, and choosing to use List #1 or List #2 of that requirement, a bioretention facility shall have a horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.</u></p>
<u>Maintenance</u>	<u>Refer to BMP T7.30 and Section 4.6 of this Volume for maintenance guidelines.</u>

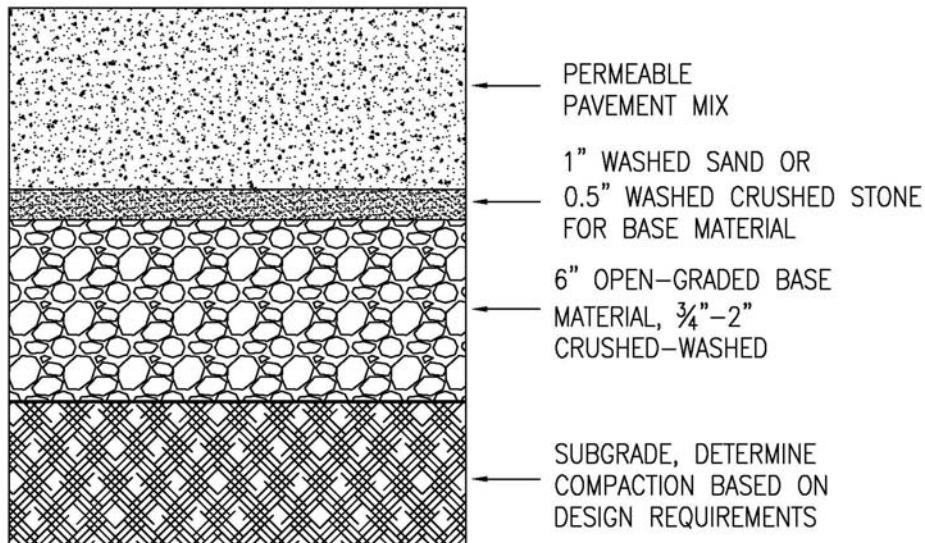
BMP T5.15: Permeable Pavements

Purpose and Definition

Pavement for vehicular and pedestrian travel occupies roughly twice the space of buildings. Stormwater from vehicular pavement can contain significant levels of solids, heavy metals, and hydrocarbon pollutants. Both pedestrian and vehicular pavements also contribute to increased peak flow durations and associated physical habitat degradation of streams and wetlands. Optimum management of stormwater quality and quantity from paved surfaces is, therefore, critical for improving fresh and marine water conditions in Puget Sound.

The general categories of permeable paving systems include:

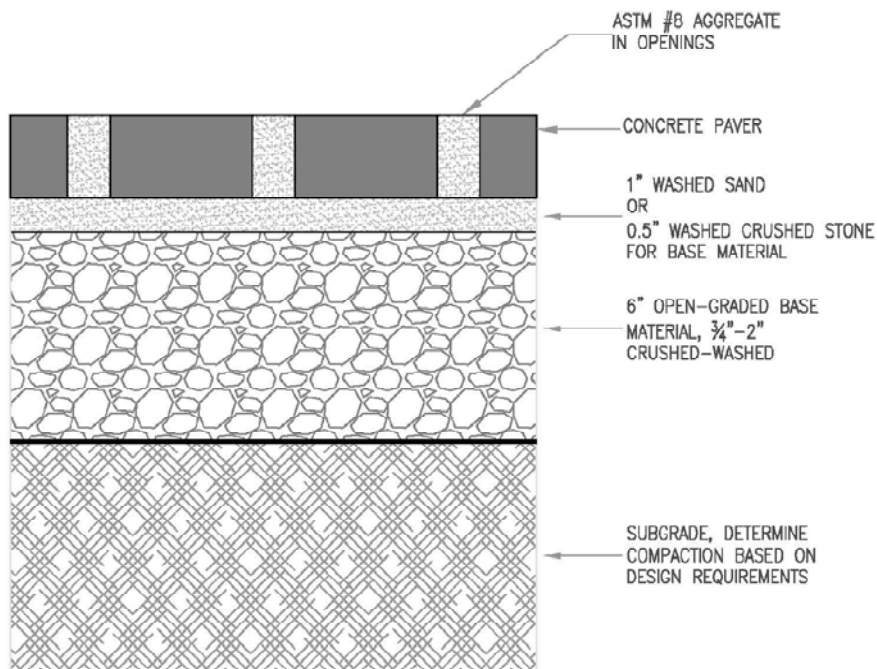
- **Porous hot or warm-mix asphalt pavement** (see [Figure 5.3.4](#)) is a flexible pavement similar to standard asphalt that uses a bituminous binder to adhere aggregate together. However, the fine material (sand and finer) is reduced or eliminated and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.
- **Pervious Portland cement concrete** (see [Figure 5.3.4](#)) is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. However, the fine aggregate (sand) component is reduced or eliminated in the gradation and, as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.



Modified from
City of Portland
Detail SW-110

Figure 5.3.4 – Example of a Permeable Pavement (concrete or asphalt) Section

- **Permeable interlocking concrete pavements (PICP) and aggregate pavers.** (see [Figure 5.3.5](#)) PICPs are solid, precast, manufactured modular units. The solid pavers are (impervious) high-strength Portland cement concrete manufactured with specialized production equipment. Pavements constructed with these units create joints that are filled with permeable aggregates and installed on an open-graded aggregate bedding course. Aggregate pavers (sometime called pervious pavers) are a different class of pavers from PICP. These include modular precast paving units made with similar sized aggregates bound together with Portland cement concrete with high-strength epoxy or other adhesives. Like PICP, the joints or openings in the units are filled with open-graded aggregate and placed on an open-graded aggregate bedding course. Aggregate pavers are intended for pedestrian use only.



Modified from
City of Portland
Detail SW-110

Figure 5.3.5 – Example of a Permeable Paver Section

- Grid systems include those made of concrete or plastic. Concrete units are precast in a manufacturing facility, packaged and shipped to the site for installation. Plastic grids typically are delivered to the site in rolls or sections. The openings in both grid types are filled with topsoil and grass or permeable aggregate. Plastic grid sections connect together and are pinned into a dense-graded base, or are eventually held in place by the grass root structure. Both systems can be installed on an open-graded aggregate base as well as a dense-graded aggregate base.

Applications and Limitations

Permeable paving surfaces are an important integrated management practice within the LID approach and can be designed to accommodate pedestrian, bicycle and auto traffic while allowing infiltration, treatment and storage of stormwater.

Permeable pavements are appropriate in many applications where traditionally impermeable pavements have been used. Typical applications for permeable paving include parking lots, sidewalks, pedestrian and bike trails, driveways, residential access roads, and emergency and facility maintenance roads.

Limitations:

- No run-on from pervious surfaces is preferred. If runoff comes from minor or incidental pervious areas, those areas must be fully stabilized.
- Unless the pavement, base course, and subgrade have been designed to accept runoff from adjacent impervious surfaces, slope impervious runoff away from the permeable pavement to the maximum extent practicable. Sheet flow from up-gradient impervious areas is not recommended, but permissible if porous surface flow path > impervious surface flow path.
- Soils must not be tracked onto the wear layer or the base course during construction.

Infeasibility Criteria:

These are conditions that make permeable pavement not required. If a project proponent wishes to use permeable pavement - though not required to because of these feasibility criteria - they may propose a functional design to the local government.

These criteria also apply to impervious pavements that would employ stormwater collection from the surface of impervious pavement with redistribution below the pavement.

Citation of any of the following infeasibility criteria must be based on an evaluation of site-specific conditions and a written recommendation from an appropriate licensed professional (e.g. engineer, geologist, hydrogeologist)

- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose ground water drains into an erosion hazard, or landslide hazard area.
- Where infiltrating and ponded water below new permeable pavement area would compromise adjacent impervious pavements.
- Where infiltrating water below a new permeable pavement area would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.

- Down slope of steep, erosion prone areas that are likely to deliver sediment.
- Where fill soils are used that can become unstable when saturated.
- Excessively steep slopes where water within the aggregate base layer or at the sub-grade surface cannot be controlled by detention structures and may cause erosion and structural failure, or where surface runoff velocities may preclude adequate infiltration at the pavement surface.
- Where permeable pavements can not provide sufficient strength to support heavy loads at industrial facilities such as ports.
- Where installation of permeable pavement would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, or pre-existing road sub-grades.

The following criteria can be cited as reasons for a finding of infeasibility without further justification (though some require professional services to make the observation):

- Within an area designated as an erosion hazard, or landslide hazard.
- Within 50 feet from the top of slopes that are greater than 20%.
- For properties with known soil or ground water contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)):
 - Within 100 feet of an area known to have deep soil contamination:
 - Where ground water modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the ground water;
 - Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
 - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under [Chapter 64.70 RCW](#).
- Within 100 feet of a closed or active landfill.
- Within 100 feet of a drinking water well, or a spring used for drinking water supply, if the pavement is a pollution-generating surface.
- Within 10 feet of a small on-site sewage disposal drainfield, including reserve areas, and grey water reuse systems. For setbacks from a “large on-site sewage disposal system”, see [Chapter 246-272B WAC](#).
- Within 10 feet of any underground storage tank and connecting underground pipes, regardless of tank size. As used in these criteria, an underground storage tank means any tank used to store petroleum

products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.

- At multi-level parking garages, and over culverts and bridges.
- Where the site design cannot avoid putting pavement in areas likely to have long-term excessive sediment deposition after construction (e.g., construction and landscaping material yards).
- Where the site cannot reasonably be designed to have a porous asphalt surface at less than 5 percent slope, or a pervious concrete surface at less than 10 percent slope, or a permeable interlocking concrete pavement surface (where appropriate) at less than 12 percent slope. Grid systems upper slope limit can range from 6 to 12 percent; check with manufacturer and local supplier.
- Where the native soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the soil suitability criteria for providing treatment. See SSC-6 in Section 3.3.7 of Volume III. Note: In these instances, the local government has the option of requiring a six-inch layer of media meeting the soil suitability criteria or the sand filter specification as a condition of construction.
- Where seasonal high ground water or an underlying impermeable/low permeable layer would create saturated conditions within one foot of the bottom of the lowest gravel base course.
- Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5% are considered suitable for residential access roads.
- Where appropriate field testing indicates soils have a measured (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.3 inches per hour. (Note: In these instances, unless other infeasibility restrictions apply, roads and parking lots may be built with an underdrain, preferably elevated within the base course, if flow control benefits are desired.)
- Where the road type is classified as arterial or collector rather than access. See [RCW 35.78.010](#), [RCW 36.86.070](#), and [RCW 47.05.021](#). Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces associated with the collector or arterial.
- Where replacing existing impervious surfaces unless the existing surface is a non-pollution generating surface over an outwash soil with a saturated hydraulic conductivity of four inches per hour or greater.
- At sites defined as “high use sites” in Volume V of the SMMWW.
- In areas with “industrial activity” as identified in 40 CFR 122.26(b)(14).

Design Guidelines

- Where the risk of concentrated pollutant spills is more likely such as gas stations, truck stops, and industrial chemical storage sites.
- Where routine, heavy applications of sand occur in frequent snow zones to maintain traction during weeks of snow and ice accumulation. Most lowland western Washington areas do not fit this criterion.

The design guidance from the [Low Impact Development Technical Guidance Manual for Puget Sound](#) should be used for design details. Local governments can adopt alternative design criteria. As long as those criteria do not conflict with the critical design criteria below, the permeable pavement may be entered into approved runoff models as indicated in Appendix III-C of Volume III, and as indicated in WWHM guidance due for publication in 2012.

BMP T5.10 Downspout Diversion

BMP T5.11 Concentrated Flow Dispersion

BMP T5.12 Sheet Flow Dispersion

Chapter III, Appendix III-C, Section 7.5: Reverse Slope Sidewalks

Chapter III, Appendix III-Subgrade

- Compact the subgrade to the minimum necessary for structural stability. Two guidelines currently used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90- 92% Standard Proctor (quantitative). Do not allow heavy compaction due to heavy equipment operation. The subgrade should not be subject to truck traffic.
- To prevent compaction when installing the aggregate base, the following steps (back-dumping) should be followed: 1) the aggregate base is dumped onto the subgrade from the edge of the installation and aggregate is then pushed out onto the subgrade; 2) trucks then dump subsequent loads from on top of the aggregate base as the installation progresses.
- Use on soil types A through C.

Separation or Bottom Filter Layer (recommended but optional)

- A layer of sand or crushed stone (0.5 inch or smaller) graded flat is recommended to promote infiltration across the surface, stabilize the base layer, protect underlying soil from compaction, and serve as a transition between the base course and the underlying geotextile material.

Base material

- Local governments should adopt their own minimum base material requirements as they see necessary for support of flexible pavements. Many design combinations are possible. The material must be free

draining. For more detailed specifications and options for different types of permeable pavement, see the [LID Technical Guidance Manual for the Puget Sound Basin](#). The municipality should determine and publish estimates of the void space for each standard base material allowed in their jurisdiction.

- To increase infiltration, improve flow attenuation and reduce structural problems associated with subgrade erosion on slopes, impermeable check dams may be placed on the subgrade and below the pavement surface (See [Figure 5.3.6](#)). Check dams should have an overflow drain invert placed at the maximum ponding depth. The distance between berms will vary depending on slope, flow control goals and cost.

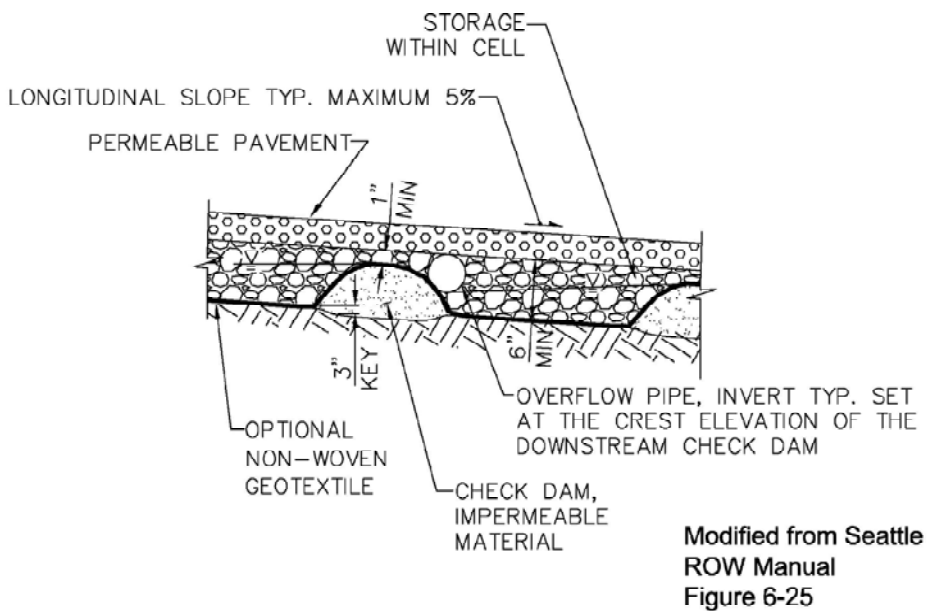


Figure 5.3.6 – Example of a check dam along a sloped section of permeable pavement

|

Wearing layer

- For all surface types, a minimum initial infiltration rate of 10 inches per hour is necessary. To improve the probability of long-term performance, significantly higher initial infiltration rates are desirable.
- **Porous Asphalt:** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 16 – 25% is typical. See the [LID Technical Guidance Manual for the Puget Sound Basin](#) for recommended specifications.
- **Pervious Concrete:** Products must have adequate void spaces through which water can infiltrate. A void space within the range of 15 – 35% is typical. See the [LID Technical Guidance Manual for the Puget Sound Basin](#) for recommended specifications. The aforementioned manual defers to the specifications in ACI 522.
- **Grid/lattice systems filled with gravel, sand, or a soil of finer particles with or without grass:** The fill material must be at least a minimum of 2 inches of sand, gravel, or soil.
- **Permeable Interlocking Concrete Pavement and Aggregate Pavers:** Pavement joints should be filled with No. 8, 89 or 9 stone. See the [LID Technical Guidance Manual for the Puget Sound Basin](#) for recommended specifications. The aforementioned manual defers to design specification and installation procedures published by the Interlocking Concrete Pavement Institute.

Drainage conveyance

Roads should still be designed with adequate drainage conveyance facilities as if the road surface was impermeable. Roads with base courses that extend below the surrounding grade should have a designed drainage flow path to safely move water away from the road prism and into the roadside drainage facilities. Use of perforated storm drains to collect and transport infiltrated water from under the road surface will result in less effective designs and less flow reduction benefit.

Acceptance test

- Driveways can be tested by simply throwing a bucket of water on the surface. If anything other than a scant amount puddles or runs off the surface, additional testing is necessary prior to accepting the construction.
- Roads may be initially tested with the bucket test. In addition, test the initial infiltration with a 6-inch ring, sealed at the base to the road surface, or with a sprinkler infiltrometer. Wet the road surface continuously for 10 minutes. Begin test to determine compliance with 20 inches per hour minimum rate. Use of ASTM C1701 is also recommended.

Stormwater-related Design Procedures

Runoff Model Representation

Maintenance

See Section 3.4 in Volume III of this manual for more specific guidance regarding required field testing, assignment of infiltration rate correction factors, project submission requirements, and modeling.

See Appendix III-C for runoff modeling guidance under WWHM3 and under WWHM 2012.

Maintenance recommendations for all facilities:

- Erosion and introduction of sediment from surrounding land uses should be strictly controlled after construction by amending exposed soil with compost and mulch, planting exposed areas as soon as possible, and armoring outfall areas.
- Surrounding landscaped areas should be inspected regularly and possible sediment sources controlled immediately.
- Installations can be monitored for adequate or designed minimum infiltration rates by observing drainage immediately after heavier rainstorms for standing water or infiltration tests using ASTM C1701.
- Clean permeable pavement surfaces to maintain infiltration capacity at least once or twice annually following recommendations below.
- Utility cuts should be backfilled with the same aggregate base used under the permeable paving to allow continued conveyance of stormwater through the base, and to prevent migration of fines from the standard base aggregate to the more open graded permeable base material (Diniz, 1980).
- Ice build up on permeable pavement is reduced and the surface becomes free and clear more rapidly compared to conventional pavement. For western Washington, deicing and sand application may be reduced or eliminated and the permeable pavement installation should be assessed during winter months and the winter traction program developed from those observations. Vacuum and sweeping frequency will likely be required more often if sand is applied.

Porous asphalt and pervious concrete

- Clean surfaces using suction, sweeping with suction or high-pressure wash and suction (sweeping alone is minimally effective). Hand held pressure washers are effective for cleaning void spaces and appropriate for smaller areas such as sidewalks.
- Small utility cuts can be repaired with conventional asphalt or concrete if small batches of permeable material are not available or are too expensive.

Permeable pavers

- ICPI recommends cleaning if the measured infiltration rate falls below 10 in/hr.

- Use sweeping with suction when surface and debris are dry 1-2 times annually (see next bullet for exception). Apply vacuum to a paver test section and adjust settings to remove all visible sediment without excess uptake of aggregate from paver openings or joints. If necessary replace No 8, 89 or 9 stone to specified depth within the paver openings. Washing or power washing should not be used to remove debris and sediment in the openings between the pavers (Smith, 2000).
- For badly clogged installations, wet the surface and vacuumed aggregate to a depth that removes all visible fine sediment and replace with clean aggregate.
- If necessary use No 8, 89 or 9 stone for winter traction rather than sand (sand will accelerate clogging).
- Pavers can be removed individually and replaced when utility work is complete.
- Replace broken pavers as necessary to prevent structural instability in the surface.
- The structure of the top edge of the paver blocks reduces chipping from snowplows. For additional protection, skids on the corner of plow blades are recommended.
- For a model maintenance agreement see Permeable Interlocking Concrete Pavements (Smith, 2011).

Plastic or Concrete grid systems

- Remove and replace top course aggregate if clogged with sediment or contaminated (vacuum trucks for stormwater collection basins can be used to remove aggregate).
- Remove and replace grid segments where three or more adjacent rings are broken or damaged.
- Replenish aggregate material in grid as needed.
- Snowplows should use skids to elevate blades slightly above the gravel surface to prevent loss of top course aggregate and damage to plastic grid.
- For grass installations, use normal turf maintenance procedures except do not aerate. Use very slow release fertilizers if needed.

BMP T5.16: Tree Retention and Tree Planting

Purpose and Definition

Trees provide flow control via interception, transpiration, and increased infiltration. Additional environmental benefits include improved air quality, carbon sequestration, reduced heat island effect, pollutant removal, and habitat preservation or formation.

When implemented in accordance with the criteria outlined below, retained and newly planted trees receive credits toward meeting flow control requirements.

The degree of flow control provided by a tree depends on the tree type (i.e., evergreen or deciduous), canopy area, and whether or not the tree canopy overhangs impervious surfaces. Flow control credits may be applied to project sites of all sizes.

Tree Retention Design Criteria

Setbacks of proposed infrastructure from existing trees are critical considerations. Tree protection requirements limit grading and other disturbances in proximity to the tree.

Existing tree species and location must be clearly shown on submittal drawings.

Trees must be viable for long-term retention (i.e., in good health and compatible with proposed construction).

Tree size: To receive flow control credit, retained trees shall have a minimum 6 inches diameter at breast height (DBH). DBH is defined as the outside bark diameter at 4.5 feet above the ground on the uphill side of a tree. For existing trees smaller than this, the newly planted tree credit may be applied.

The retained tree canopy area shall be measured as the area within the tree drip line. A drip line is the line encircling the base of a tree, which is delineated by a vertical line extending from the outer limit of a tree's branch tips down to the ground. If trees are clustered, overlapping canopies are not double counted.

Tree location: Flow control credit for retained trees depends upon proximity to ground level impervious or other hard surfaces. To receive a credit, the existing tree must be on the development site and within 20 feet of new and/or replaced ground level impervious or other hard surfaces (e.g., driveway or patio) on the development site. Distance from impervious or other hard surfaces is measured from the tree trunk center.

An arborist report may be required if impervious surface is proposed within the critical root zone of the existing tree. The critical root zone is defined as the line encircling the base of the tree with half the diameter of the dripline. If the arborist report concludes that impervious surface should not be placed within 20 feet of the tree and canopy overlap with impervious surface is still anticipated given a longer setback, the higher tree flow control credit may be approved.

Tree Retention
Flow Control
Credit

Protection during construction: The existing tree roots, trunk, and canopy shall be fenced and protected during construction activities.

Retention and protection: Trees shall be retained, maintained and protected on the site after construction and for the life of the development or until any approved redevelopment occurs in the future. Trees that are removed or die shall be replaced with like species during the next planting season (typically in fall). Trees shall be pruned according to industry standards (ANSI A 300 standards).

Flow control credits for retained trees are provided in Table 5.3.1 by tree type. These credits can be applied to reduce impervious or other hard surface area requiring flow control. Credits are given as a percentage of the existing tree canopy area. The minimum credit for existing trees ranges from 50 to 100 square feet.

Table 5.3.1 Flow Control Credits for Retained Trees.

<u>Tree Type</u>	<u>Credit</u>
<u>Evergreen</u>	<u>20% of canopy area (minimum of 100 sq. ft./tree)</u>
<u>Deciduous</u>	<u>10% of canopy area (minimum of 50 sq. ft./tree)</u>

Impervious/Hard Surface Area Mitigated =
(Σ Evergreen Canopy Area x .2) + (Σ Deciduous Canopy Area x 0.1)

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.

Newly Planted
Tree Design
Criteria

Tree Species: Each jurisdiction should adopt a list of approved tree species for stormwater credit. An example list of trees from the City of Seattle's tree list is included in Appendix V-E.

Tree Size: To receive flow control credit, new deciduous trees at the time of planting shall be at least 1.5 inches in diameter measured 6 inches above the ground. New evergreen trees shall be at least 4 feet tall.

Tree Location: Trees shall be sited according to sun, soil, and moisture requirements. Planting locations shall be selected to ensure that sight distances and appropriate setbacks are maintained given mature height, size, and rooting depths. Similar to retained trees, flow control credit for newly planted trees depends upon proximity to ground level impervious surfaces. To receive a credit, the tree must be planted on the development site and within 20 feet of new and/or replaced ground level impervious surfaces (e.g., driveway, patio, or parking lot). Distance from impervious

surfaces is measured from the edge of the surface to the center of the tree at ground level. To help ensure tree survival and canopy coverage, the minimum tree spacing for newly planted trees shall accommodate mature tree spread. In no circumstance shall flow control credit be given for new tree density exceeding 10 feet on center spacing.

Plant Material and Planting Specifications

Recommended guidelines for planting materials and methods are provided in City of Seattle Standard Specifications 8-02 and 9-14, and Standard Plans 100a, 100b, and 101.

Irrigation: Provisions shall be made for supplemental irrigation during the first three growing seasons after installation to help ensure tree survival.

Tree retention and protection: Trees shall be retained, maintained and protected on the site after construction and for the life of the development as required for retained trees.

Newly Planted Tree Flow Control Credits

Flow control credits for newly planted trees are provided in Table 5.3.2 by tree type. These credits can be applied to reduce the impervious or other hard surface area requiring flow control. Credits range from 20 to 50 square feet per tree.

Table 5.3.2. Flow Control Credits for Newly Planted Trees.

<u>Tree Type</u>	<u>Credit</u>
<u>Evergreen</u>	<u>50 sq. ft. per tree</u>
<u>Deciduous</u>	<u>20 sq. ft. per tree</u>

Impervious/Hard Surface Area Mitigated = Σ Number of Trees x Credit (sq. ft.)

Tree credits are not applicable to trees in native vegetation areas used for flow dispersion or other flow control credit. Credits are also not applicable to trees in planter boxes. The total tree credit for retained and newly planted trees shall not exceed 25 percent of impervious or other hard surface requiring mitigation.

BMP T5.17: Vegetated Roofs

Purpose and Definition

Vegetated roofs (also known as ecoroofs and green roofs) are thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs. Vegetated roofs can provide multiple benefits, including stormwater volume reduction and flow attenuation. The range of benefits for a green roof depends on a number of design factors such as plant selection, depth and composition of soil mix, location of the roof, orientation and slope, weather patterns, and the maintenance plan.

All vegetated roofs consist of four basic components: a waterproof membrane, a drainage layer, a light-weight growth medium, and vegetation (see Figure 5.3.7). In addition to these basic components, many systems may also incorporate a protection layer and root barrier to preserve the integrity of the waterproof membrane, a separation/filter layer to stabilize fine particles, capillary mats and mulch/mats to retain moisture and prevent surface erosion due to rain and wind scour.

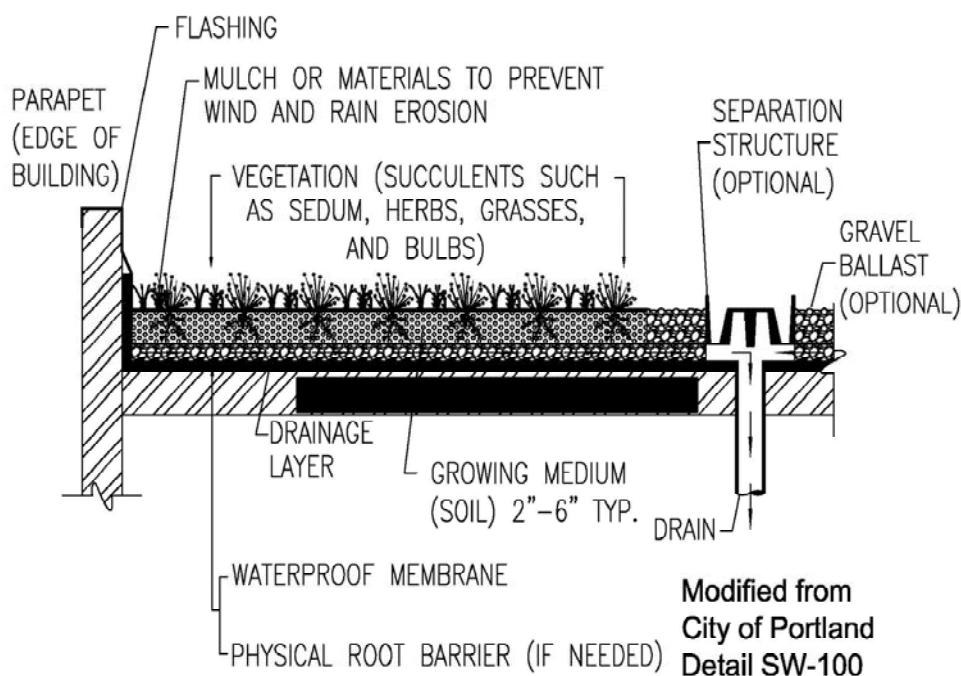


Figure 5.3.7 – Example of a Vegetated Roof Section

Applications and Limitations

While vegetated roofs can be installed on slopes up to 40 degrees, slopes between 5 and 20 degrees (1:12 and 5:12) are most suitable and can provide natural drainage by gravity. Roofs with slopes greater than 10 degrees (2:12) require an analysis of engineered slope stability.

Vegetated roofs are not included in the lists referenced under Minimum Requirement #5. However, they are an option available to project designers who want to use other methods to meet the LID Performance Standard option of Minimum Requirement #5.

Design Criteria

The reader is directed to the LID Technical Guidance Manual for the Puget Sound Basin, for a more detailed description of the components of and design criteria for vegetated roofs. It also includes references to other sources of information and design guidance.

Runoff Model Representation

See Appendix III-C in Volume III for a summary of how vegetated roofs may be entered into the approved continuous runoff models.

BMP T5.18: Reverse Slope Sidewalks

Purpose and Definition

Reverse slope sidewalks are sloped to drain away from the road and onto adjacent vegetated areas.

Design Criteria

- Greater than 10 feet of vegetated surface downslope that is not directly connected into the storm drainage system.
- Vegetated area receiving flow from sidewalk must be native soil or meet guidelines in BMP T5.13.

Runoff Model Representation

- In WWHM 3, enter sidewalk area as lawn/landscaped area over the underlying soil type. For WWHM 2012, see Appendix III-C in Volume III.

BMP T5.19: Minimal Excavation Foundations

Purpose and Definition

Low impact foundations are defined as those techniques that do not disturb, or minimally disturb the natural soil profile within the footprint of the structure. This preserves most of the hydrologic properties of the native soil. Pin foundations are an example of a minimal excavation foundation.

Applications and Limitations

- To minimize soil compaction, heavy equipment cannot be used within or immediately surrounding the building. Terracing of the foundation area may be accomplished by tracked, blading equipment not exceeding 650 psf.

Runoff Model Representation

- Where residential roof runoff is dispersed on the up gradient side of a structure in accordance with the design criteria and guidelines in BMP T5.10B, the tributary roof area may be modeled as pasture on the native soil.
- Where “step forming” is used on a slope, the square footage of roof

that can be modeled as pasture must be reduced to account for lost soils. In “step forming,” the building area is terraced in cuts of limited depth. This results in a series of level plateaus on which to erect the form boards. The following equation (suggested by Rick Gagliano of Pin Foundations, Inc.) can be used to reduce the roof area that can be modeled as pasture.

$$A_1 - \frac{dC(.5)}{dP} \times A_1 = A_2$$

A₁ = roof area draining to up gradient side of structure

dC = depth of cuts into the soil profile

dP = permeable depth of soil (The A horizon plus an additional few inches of the B horizon where roots permeate into ample pore space of soil).

A₂ = roof area that can be modeled as pasture on the native soil

- If roof runoff is dispersed down gradient of the structure in accordance with the design criteria and guidelines in [BMP T5.10B](#), AND there is at least 50 feet of vegetated flow path through native material or lawn/landscape area that meets the guidelines in [BMP T5.13](#), the tributary roof areas may be modeled as lawn/landscaped area.

BMP T5.20: Rainwater Harvesting

Purpose and Definition

Rainwater harvesting is the capture and storage of rainwater for beneficial use. Roof runoff may be routed to cisterns for storage and nonpotable uses such as irrigation, toilet flushing, and cold water laundry. Rainwater harvesting can help reduce peak stormwater flows, durations, and volumes. The amount of reduction achieved with cistern storage is a function of contributing area, storage volume, and rainwater use rate.

Design Criteria

- 100% reuse of the annual average runoff volume (use continuous runoff model to get annual average for drainage area).
- System designs involving interior uses must have a monthly water balance that demonstrates adequate capacity for each month and reuse of all stored water annually.

Runoff Model Representation

- Do not enter drainage area into the runoff model.

Other Criteria

- Restrict use to 4 homes/acre housing and lower densities when the captured water is solely for outdoor use.

BMP T5.30: Full Dispersion

Purpose and Definition

This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of development sites that protect at least 65% of the site (or a threshold discharge area on the site) in a forest or native condition.

Applications and Limitations for Residential Projects

- Rural single family residential developments should use these dispersion BMPs wherever possible to minimize effective impervious surface to less than 10% of the development site.
- Other types of development that retain 65% of the site (or a threshold discharge area on the site) in a forested or native condition may also use these BMPs to avoid triggering the flow control facility requirement.
- The preserved area may be a previously cleared area that has been replanted in accordance with native vegetation landscape specifications described within this BMP.
- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands (though the wetland area and any streams and lakes do not count toward the 65% forest or native condition area), and to buffer stream corridors.
- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
- All trees within the preserved area at the time of permit application shall be retained, aside from approved timber harvest activities regulated under WAC Title 222, except for Class IV General Forest Practices that are conversions from timberland to other uses, and the removal of dangerous or diseased trees.
- The preserved area may be used for passive recreation and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.
- The preserved area may contain utilities and utility easements, but not septic systems. Utilities are defined as potable and wastewater underground piping, underground wiring, and power and telephone poles.

Minimum Design Requirements for Residential Projects

Developments that preserve 65% of a site (or a threshold discharge area of a site) in a forested or native condition, can disperse runoff from the developed portion of the site into the native vegetation area as long as the developed areas draining to the native vegetation do not have impervious areas that exceed 10% of the entire site.

Where a development has less than 65% of a site available to maintain or create into a forested or native condition, that area may still be used for full dispersion of a portion of the developed area. The ratio of the native vegetation area to the impervious area, which is dispersed into the native vegetation, must not be less than 65 to 10. The lawn and landscaping areas associated with the impervious areas may also be dispersed into the native vegetation area. The lawn and landscaped area must comply with BMP T5.13. All design requirements listed also must be met.

The portion of the developed area which is not managed through full dispersion can be considered a separate project site. It must be evaluated against the thresholds in Figures 2.2 and 2.3 of Volume 1, whichever is appropriate, to determine the applicable minimum requirements.

Additional impervious and lawn/landscaped areas are allowed, but should not drain to the native vegetation area, and are subject to the thresholds, treatment and flow control requirements of this stormwater manual.

Within the context of this dispersion option, the only impervious surfaces that are ineffective are those that are routed into an appropriately sized dry well or into an infiltration basin that meets the flow control standard and does not overflow into the forested or native vegetation area.

Runoff must be dispersed into the native area in accordance with one or more of the dispersion devices, and in accordance with the design criteria and limits for those devices, cited in this BMP. A native vegetation flow path of at least 100 feet in length (25 feet for sheet flow from a non-native pervious surface) must be available along the flowpath that runoff would follow upon discharge from a dispersion device cited in this BMP. The native vegetated flowpath must meet all of the following criteria:

- The flow path must be over native vegetated surface
- The flow path must be on-site or in an off-site tract or easement area reserved for such dispersion
- The slope of the flowpath must be no steeper than 15% for any 20-foot reach of the flowpath. Slopes up to 33% are allowed where level spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
- The flowpath must be located between the dispersion device and any downstream drainage feature such as a pipe, ditch, stream, river, pond, lake, or wetland.

- The flowpaths for adjacent dispersion devices must be sufficiently spaced to prevent overlap of flows in the flowpath areas.

For sites with on-site sewage disposal systems, the discharge of runoff from dispersion devices must be located downslope of the primary and reserve drainfield areas. This requirement may be waived by the permitting jurisdiction if site topography clearly prevents discharged flows from intersecting the drainfield.

Dispersion devices are not allowed in critical area buffers or on slopes steeper than 20%. Dispersion devices proposed on slopes steeper than 15% or within 50 feet of a geologically hazardous area (RCW 36.70A.030(5)) must be approved by a geotechnical engineer or engineering geologist.

The dispersion of runoff must not create flooding or erosion impacts.

- **Roof Downspouts**

Roof surfaces that comply with the Downspout Full Infiltration BMP T5.10A, are considered to be "fully infiltrated" (i.e., zero percent effective imperviousness). All other roof surfaces are considered to be "fully dispersed" (i.e., at or approaching zero percent effective imperviousness) only if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they either: 1) comply with the Downspout Dispersion requirements of BMP T5.10B, but with vegetated flow paths of 100 feet or more through the native vegetation preserved area; or 2) disperse the roof runoff along with the road runoff in accordance with the roadway dispersion BMP section below.

- **Driveway Dispersion**

Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they either: 1) comply with BMP 5.11 for concentrated flow and BMP T5.12 for sheet flow- and have flow paths of 100 feet or more through native vegetation; or, 2) disperse driveway runoff along with the road runoff in accordance with the roadway dispersion BMP section below.

- **Roadway Dispersion BMPs**

Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the following dispersion requirements:

1. The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.
2. When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5-cfs limit would be in addition to the existing concentrated peak flows.
3. Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.
4. Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾-inch to 1½-inch washed rock, and provided with a level notched grade board (see Figure 5.3.2). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet between centerlines.
- 3-5. Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space.
Note: Runoff may be conveyed to an area meeting these flowpath criteria.
- 4-6. Ditch discharge points shall be located a minimum of 100 feet upgradient of steep slopes (i.e., slopes steeper than 40%), wetlands, and streams.
- 5-7. Where the Local Plan Approval Authority determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems),

dispersion of roadway runoff may not be allowed, or other measures may be required.

- **Cleared Area Dispersion BMPs**

, Section 7.2.4: The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture of up to 25 feet in flow path length can be considered to be "fully dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:

1. The topography of the non-native pervious surface must be such that runoff will not concentrate prior to discharge to the dispersal area.

2. Slopes within the dispersal area should be no steeper than 15%.

If the width of the non-native pervious surface is greater than 25 feet, the vegetated flowpath segment must be extended 1 foot for every 3 feet of width beyond 25 feet up to a maximum width of 250 feet.

Minimum Design Requirements for Public Road Projects

Applicability:

These criteria apply to the construction of public roads not within the context of residential, commercial, or industrial site development. They will likely only be implementable on roads outside of the urban growth management areas where roadside areas are not planned for urban density development.

- 1) Uncollected or natural dispersion into adjacent vegetated areas (i.e., sheet flow into the dispersion area)

Full dispersion credit (i.e. no other treatment or flow control required) for sites that meet the following criteria:

- a) Outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands) that have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on a Pilot Infiltration Test or the Soil Grain Size Analysis method as identified in Section 3 of Volume III, or another method as allowed by the local government.

- 20 feet of impervious flow path needs 10 feet of dispersion area width.

- Each additional foot of impervious flow path needs 0.25 feet of dispersion area width.

- b) Other soils: (Types C and D and some Type B not meeting the criterion in 1a above)

- Dispersion area must have 6.5 feet of width for every 1 foot width of impervious area draining to it. A minimum distance of 100 feet is necessary.

c) Criteria applicable to all soil types:

- Depth to the average annual maximum ground water elevation should be at least 3 feet.
- Impervious surface flow path must be < 75 ft. Pervious flow path must be < 150 ft. Pervious flow paths are up-gradient road side slopes that run onto the road and down-gradient road side slopes that precede the dispersion area.
- Lateral slope of impervious drainage area should be < 8%. Road side slopes must be < 25%. Road side slopes do not count as part of the dispersion area unless native vegetation is re-established and slopes are less than 15%. Road shoulders that are paved or graveled to withstand occasional vehicle loading count as impervious surface.
- Longitudinal slope of road should be < 5%.
- Length of dispersion area should be equivalent to length of road.
- Average longitudinal (parallel to road) slope of dispersion area should be < 15%.
- Average lateral slope of dispersion area should be < 15%.

2) Channelized (collected and re-dispersed) stormwater into areas with (a) native vegetation or (b) cleared land in areas outside of Urban Growth Areas that do not have a natural or man-made drainage system.

Full dispersion credit (i.e., no other treatment or flow control required) is given to projects that meet the following criteria:

- a) Outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands) that have an initial saturated hydraulic conductivity rate of 4 inches per hour or greater. The saturated hydraulic conductivity must be based on field results using procedures (Pilot Infiltration Test or Soil Grain Size Analysis Method) identified in Section 3 of Volume III, or another method approved by the local government.
- Dispersion area should be at least ½ of the impervious drainage area.
- b) Other soils: (Types C and D and some Type B not meeting the criterion in 2a above)
- Dispersion area must have 6.5 feet of width for every 1 foot width of impervious area draining to it. A minimum distance of 100 feet is necessary.
- c) Other criteria applicable to all soil types:
- Depth to the average annual maximum ground water elevation should be at least three feet.

- Channelized flow must be re-dispersed to produce longest possible flow path.
- Flows must be evenly dispersed across the dispersion area.
- Flows must be dispersed using rock pads and dispersion techniques as specified under Roadway Dispersion BMPs.
- Approved energy dissipation techniques may be used.
- Limited to on-site (associated with the road) flows.
- Length of dispersion area should be equivalent to length of the road.
- Average longitudinal and lateral slopes of the dispersion area should be < 8%.
- The slope of any flowpath segment must be no steeper than 15% for any 20-foot reach of the flowpath segment.

3) Engineered dispersion of stormwater runoff into an area with engineered soils

Full dispersion credit (i.e., no other treatment or flow control required) is given to projects that meet the following criteria:

- Stormwater can be dispersed via sheet flow or via collection and re-dispersion in accordance with the techniques specified under Roadway Dispersion BMPs.
- Depth to the average annual maximum ground water elevation should be at least three feet.
- Type C and D soils must be compost-amended following guidelines in [BMP T5.13](#). The guidance document *Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* can be used, or an approved equivalent soil quality and depth specification approved by the Department of Ecology. The guidance document is available at <http://www.soilsforsalmon.org>.
 - Dispersion area must meet the 65 to 10 ratio for full dispersion credit.
- Type A and B soils that meet or exceed the 4 inches per hour initial saturated hydraulic conductivity rate minimum must be compost amended in accordance with guidelines in [BMP T5.13](#). Compost must be tilled into the soil in accordance with the guidance document cited above.
 - 20 feet of impervious flow path needs 10 feet of dispersion area width.
 - Each additional foot of impervious flow path needs 0.25 feet of dispersion area width.

- Average longitudinal (parallel to road) slope of dispersion area should be < 15%.
- Average lateral slope of dispersion area should be < 15%.
- The dispersion area should be planted with native trees and shrubs.

4) Other Characteristics for Dispersal areas

- Dispersal areas must be outside of the urban growth area; or if inside the urban growth area, in legally protected areas (easements, conservation tracts, public parks).
- If outside urban growth areas, legal agreements should be reached with property owners of dispersal areas subject to stormwater that has been collected and is being re-dispersed.
- An agreement with the property owner is advised for uncollected natural dispersion via sheet flow that represents a continuation of past practice. If not a continuation of past practice, an agreement should be reached with the property owner.

Native Vegetation Landscape Specifications

These specifications may be used in situations where an applicant wishes to convert a previously developed surface to a native vegetation landscape for purposes of meeting full dispersion requirements or code requirements for forest retention. Native vegetation landscape is intended to have the soil, vegetation, and runoff characteristics approaching that of natural forestland.

Conversion of a developed surface to native vegetation landscape requires the removal of impervious surface, de-compaction of soils, and the planting of native trees, shrubs, and ground cover in compost-amended soil according to all of the following specifications:

1. Existing impervious surface and any underlying base course (e.g., crushed rock, gravel, etc.) must be completely removed from the conversion area(s).
2. Underlying soils must be broken up to a depth of 18 inches. This can be accomplished by excavation or ripping with either a backhoe equipped with a bucket with teeth, or a ripper towed behind a tractor.
3. At least 4 inches of well-decomposed compost must be tilled into the broken up soil as deeply as possible. The finished surface should be gently undulating and must be only lightly compacted.
4. The area of native vegetated landscape must be planted with native species trees, shrubs, and ground cover. Species must be selected as appropriate for site shade and moisture conditions, and in accordance with the following requirements:

- a) Trees: a minimum of two species of trees must be planted, one of which is a conifer. Conifer and other tree species must cover the entire landscape area at a spacing recommended by a professional landscaper or in accordance with local requirements.
- b) Shrubs: a minimum of two species of shrubs should be planted. Space plants to cover the entire landscape area, excluding points where trees are planted.
- c) Groundcover: a minimum of two species of ground cover should be planted. Space plants so as to cover the entire landscape area, excluding points where trees or shrubs are planted.

Note: for landscape areas larger than 10,000 square feet, planting a greater variety of species than the minimum suggested above is strongly encouraged. For example, an acre could easily accommodate three tree species, three species of shrubs, and two or three species of groundcover.

- 5. At least 4 inches of hog fuel or other suitable mulch must be placed between plants as mulch for weed control. It is also possible to mulch the entire area before planting; however, an 18-inch diameter circle must be cleared for each plant when it is planted in the underlying amended soil. Note: plants and their root systems that come in contact with hog fuel or raw bark have a poor chance of survival.
- 6. Plantings must be watered consistently once per week during the dry season for the first two years.
- 7. The plantings must be well established on at least 90% of the converted area. A minimum of 90% plant survival is required after 3 years.

Conversion of an area that was under cultivation to native vegetation landscape requires a different treatment. Elimination of cultivated plants, grasses and weeds is required before planting and will be required on an on-going basis until native plants are well-established. The soil should be tilled to a depth of 18 inches. A minimum of 8 inches of soil having an organic content of 6 to 12 percent is required, or a four inch layer of compost may be placed on the surface before planting, or 4 inches of clean wood chips may be tilled into the soil, as recommended by a landscape architect or forester. After soil preparation is complete, continue with steps 4 through 7 above. Placing 4 inches of compost on the surface may be substituted for the hog fuel or mulch. For large areas where frequent watering is not practical, bare-root stock may be substituted at a variable spacing from 10 to 12 feet o.c. (with an average of 360 trees per acre) to allow for natural groupings and 4 to 6 feet o.c. for shrubs. Allowable bare-root stock types are 1-1, 2-1, P-1 and P-2. Live stakes at 4 feet o.c. may be substituted for willow and red-osier dogwood in wet areas.

Runoff Model Representation

Areas that are fully dispersed do not use the WWHM or other approved continuous runoff models.

5.3.2 Site Design BMPs

The two BMPs in this section are general practices for design and maintenance ~~at the site. They are listed here as an encouragement to project designers. The extent to which the concepts within these BMPs must be followed depends upon changes in the site development codes, rules, and standards adopted by the local government.~~

BMP T5.2040: Preserving ~~Natural~~Native Vegetation

Purpose and Definition

Preserving native vegetation on-site to the maximum extent practicable will minimize the impacts of development on stormwater runoff. Preferably 65 percent or more of the development site should be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors.

Applications and Limitations

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. This responsibility is usually exercised by agents, the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which trees are so highly valued.

~~Purpose and Definition~~

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~~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. This responsibility is usually exercised by agents, the planners, designers and contractors. It takes 20 to 30 years for newly planted trees to provide the benefits for which trees are so highly valued.~~

Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging ground water for summer stream flows and reducing

surface water runoff that creates erosion and flooding. Conifers can hold up to about 50 percent of all rain that falls during a storm. Twenty to 30 percent of this rain may never reach the ground but evaporates or is taken up by the tree. Forested and native growth areas also may be effective as stormwater buffers around smaller developments.

On lots that are one acre or greater, preservation of 65 percent or more of the site in ~~natural~~native vegetation will allow the use of full dispersion techniques presented in BMP T5.30~~BMP T5.30~~. Sites that can fully disperse are not required to provide runoff treatment or flow control facilities.

Design Guidelines

- The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.

Design Guidelines

- ~~• The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.~~
- The preserved area should be placed in a separate tract or protected through recorded easements for individual lots.
- If feasible, the preserved area should be located downslope from the building sites, since flow control and water quality are enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
- The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
- Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous and diseased trees.

~~The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.~~

Maintenance

~~•~~

Maintenance

- ~~• Vegetation and trees should not be removed from the natural growth retention area, except for approved timber harvest activities and the removal of dangerous and diseased trees.~~

BMP T5.2441: Better Site Design

Purpose and Definition

Fundamental hydrological concepts and stormwater management concepts can be applied at the site design phase that are:

Purpose and Definition

~~Fundamental hydrological concepts and stormwater management concepts can be applied at the site design phase that are:~~

- more integrated with natural topography,
- reinforce the hydrologic cycle,
- more aesthetically pleasing, and
- often less expensive to build.

A few site planning principles help to locate development on the least sensitive portions of a site and accommodate residential land use while mitigating its impact on stormwater quality.

Design Guidelines

- **Define Development Envelope and Protected Areas** - The first step in site planning is to define the development envelope. This is done by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements. Site features to be protected may include important existing trees, steep slopes, erosive soils, riparian areas, or wetlands.

Design Guidelines

- ~~**Define Development Envelope and Protected Areas** - The first step in site planning is to define the development envelope. This is done by identifying protected areas, setbacks, easements and other site features, and by consulting applicable local standards and requirements. Site features to be protected may include important existing trees, steep slopes, erosive soils, riparian areas, or wetlands.~~

By keeping the development envelope compact, environmental impacts can be minimized, construction costs can be reduced, and many of the site's most attractive landscape features can be retained. In some cases, economics or other factors may not allow avoidance of all sensitive areas. In these cases, care can be taken to mitigate the impacts of development through site work and other landscape treatments.

- **Minimize Directly Connected Impervious Areas** - Impervious areas directly connected to the storm drain system are the greatest contributors to urban nonpoint source pollution. Any impervious surface that drains into a catch basin or other conveyance structure is a "directly connected impervious surface." As stormwater runoff flows across parking lots, roadways, and other paved areas, the oil, sediment,

metals, and other pollutants are collected and concentrated. If this runoff is collected by a drainage structure and carried directly along impervious gutters or in sealed underground pipes, it has no opportunity for filtering by plant material or infiltration into the soil. It also increases in velocity and amount, causing increased peak-flows in the winter and decreased base-flows in the summer.

A basic site design principle for stormwater management is to minimize these directly connected impervious areas. This can be done by limiting overall impervious land coverage or by infiltrating and/or dispersing runoff from these impervious areas.

- **Maximize Permeability** - Within the development envelope, many opportunities are available to maximize the permeability of new construction. These include minimizing impervious areas, paving with permeable materials, clustering buildings, and reducing the land coverage of buildings by smaller footprints. All of these strategies make more land available for infiltration and dispersion through natural vegetation.

Clustered driveways, small visitor parking bays and other strategies can also minimize the impact of transportation-related surfaces while still providing adequate access.

Once site coverage is minimized through clustering and careful planning, pavement surfaces can be selected for permeability. A patio of brick-on-sand, for example, is more permeable than a large concrete slab. Engineered soil/landscape systems are permeable ground covers suitable for a wide variety of uses. Permeable/porous pavements can be used in place of traditional concrete or asphalt pavements in many low traffic applications.

Maximizing permeability at every possible opportunity requires the integration of many small strategies. These strategies will be reflected at all levels of a project, from site planning to materials selection. In addition to the environmental and aesthetic benefits, a high-permeability site plan may allow the reduction or elimination of expensive runoff underground conveyance systems, flow control and treatment facilities, yielding significant savings in development costs.

- **Build Narrower Streets** - More than any other single element, street design has a powerful impact on stormwater quantity and quality. In residential development, streets and other transportation-related structures typically can comprise between 60 and 70 percent of the total impervious area, and, unlike rooftops, streets are almost always directly connected to the stormwater conveyance system.

The combination of large, directly connected impervious areas, together with the pollutants generated by automobiles, makes the street

network a principal contributor to stormwater pollution in residential areas.

Street design is usually mandated by local municipal standards. These standards have been developed to facilitate efficient automobile traffic and maximize parking. Most require large impervious land coverage. In recent years, new street standards have been gaining acceptance that meet the access requirements of local residential streets while reducing impervious land coverage. These standards generally create a new class of street that is narrower than the current local street standard, called an “access” street. An access street is intended only to provide access to a limited number of residences.

Because street design is the greatest factor in a residential development’s impact on stormwater quality, it is important that designers, municipalities and developers employ street standards that reduce impervious land coverage.

- **Maximize Choices for Mobility** - Given the costs of automobile use, both in land area consumed and pollutants generated, maximizing choices for mobility is a basic principle for environmentally responsible site design. By designing residential developments to promote alternatives to automobile use, a primary source of stormwater pollution can be mitigated.

Bicycle lanes and paths, secure bicycle parking at community centers and shops, direct, safe pedestrian connections, and transit facilities are all site-planning elements that maximize choices for mobility.

- **Use Drainage as a Design Element** - Unlike conveyance storm drain systems that hide water beneath the surface and work independently of surface topography, a drainage system for stormwater infiltration or dispersion can work with natural land forms and land uses to become a major design element of a site plan.

By applying stormwater management techniques early in the site plan development, the drainage system can suggest pathway alignments, optimum locations for parks and play areas, and potential building sites. In this way, the drainage system helps to generate urban form, giving the development an integral, more aesthetically pleasing relationship to the natural features of the site. Not only does the integrated site plan complement the land, it can also save on development costs by minimizing earthwork and expensive drainage features.

Resource Material

Start at the Source. Residential Site Planning & Design Guidance Manual for Stormwater Quality Protection. Bay Area Stormwater Management Agencies Association. January 1997.

Site Planning for Urban Stream Protection. Center for Watershed Protection. December, 1995.

Better Site Design: A Handbook for Changing Development Rules in Your Community. Center for Watershed Protection. August 1998.

<http://www.stormwatercenter.net>

5.3.3—Other Practices

The BMPs described in this section are other general practices for on-site treatment of stormwater.

BMP T5.30—Full Dispersion

Purpose and Definition

This BMP allows for "fully dispersing" runoff from impervious surfaces and cleared areas of development sites that protect at least 65% of the site (or a threshold discharge area on the site) in a forest or native condition.

Applications and Limitations

- Rural single-family residential developments should use these dispersion BMPs wherever possible to minimize effective impervious surface to less than 10% of the development site.
- ~~Other types of development that retain 65% of the site (or a threshold discharge area on the site) in a forested or native condition may also use these BMPs to avoid triggering the flow control facility requirement. The preserved area should be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands (though the wetland area and any streams and lakes do not count toward the 65% forest or native condition area), and to buffer stream corridors.~~
- ~~The preserved area should be placed in a separate tract or protected through recorded easements for individual lots. The preserved area should be shown on all property maps and should be clearly marked during clearing and construction on the site.~~
- ~~All trees within the preserved area at the time of permit application shall be retained, aside from approved timber harvest activities and the removal of dangerous or diseased trees.~~
- ~~The preserved area may be used for passive recreation and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the preserved area.~~

Design Guidelines

- Roof Downspouts**

Roof surfaces that comply with the downspout infiltration requirements in Volume III, Chapter 3, are considered to be "fully dispersed" (i.e., zero percent effective imperviousness). ~~All other roof surfaces are considered to be "fully dispersed" (i.e., at or approaching zero percent effective imperviousness) only if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the downspout dispersion requirements of BMP T5.10, and have vegetated flow paths through native vegetation exceeding 100 feet.~~

● **Driveway Dispersion**

~~Driveway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the driveway dispersion BMPs—BMP 5.11 and BMP T5.12—and have flow paths through native vegetation exceeding 100 feet. This also holds true for any driveway surfaces that comply with the roadway dispersion BMPs described below.~~

~~**Roadway Dispersion BMPs** Roadway surfaces are considered to be "fully dispersed" if they are within a threshold discharge area that is or will be more than 65% forested (or native vegetative cover) and less than 10% impervious (total), AND if they comply with the following dispersion requirements:~~

- ~~6. Roadway runoff dispersion is allowed only on rural neighborhood collectors and local access streets. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources.~~
- ~~7.8. The road section shall be designed to minimize collection and concentration of roadway runoff. Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right of way) should be used wherever possible to avoid concentration.~~
- ~~8.9. When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be incrementally discharged from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows shall not exceed 0.5 cfs at any one discharge point from a ditch for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5 cfs limit would be in addition to the existing concentrated peak flows.~~

- ~~9. Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use rock pads or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only dispersion trenches to disperse flows.~~
- ~~10. Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with ¾ inch to 1½ inch washed rock, and provided with a level notched grade board (see Figure 5.2). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.~~
- ~~11. After being dispersed with rock pads or trenches, flows from ditch discharge points must traverse a minimum of 100 feet of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment.~~
- Note: In order to provide the 100-foot flowpath length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed. Also note that water quality treatment may be waived for roadway runoff dispersed through 100 feet of undisturbed native vegetation.*
- ~~12.10. Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space.~~
- Note: Runoff may be conveyed to an area meeting these flowpath criteria.*
- ~~13.11. Ditch discharge points shall be located a minimum of 100 feet upgradient of steep slopes (i.e., slopes steeper than 40%), wetlands, and streams.~~
- ~~14.12. Where the Local Plan Approval Authority determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.~~

- **Cleared Area Dispersion BMPs**

~~The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is considered to be "fully~~

~~dispersed" if it is dispersed through at least 25 feet of native vegetation in accordance with the following criteria:~~

- ~~1. The contributing flowpath of cleared area being dispersed must be no more than 150 feet, AND~~
- ~~2. Slopes within the 25-foot minimum flowpath through native vegetation should be no steeper than 8%. If this criterion can not be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.~~

Chapter 6. - Pretreatment

6.1 Purpose

This chapter presents the methods that may be used to provide pretreatment prior to basic or enhanced runoff treatment facilities. Pretreatment must be provided in the following applications:

- For sand ~~and media filtration filters~~ and infiltration BMPs to protect them from excessive siltation and debris.
- Where the basic treatment facility or the receiving water may be adversely affected by non-targeted pollutants (e.g., oil), or may be overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids).

6.2 Application

Presettling basins are a typical pretreatment BMP used to remove suspended solids. All of the basic runoff treatment facilities may also be used for pretreatment to reduce suspended solids. Ecology has approved some emerging technologies for pretreatment through the TAPE process. See

www.ecy.wa.gov/programs/wq/stormwater/newtech/Pretreatment.html
~~Catchbasin inserts may be appropriate in some circumstances to provide oil or TSS control, depending on the type of insert. Some of the manufactured storm drain structures presented in Chapter 12 may also be used for pretreatment for oil or TSS reduction.~~ for a list of approved pretreatment technologies.

You may also use a detention pond sized to meet the flow control standard in Volume I ~~may also be used~~ to provide pretreatment for suspended solids removal.

6.3 Best Management Practices (BMPs) for Pretreatment

This Chapter has only one BMP ~~BMP T6.10~~ for presettling basins. Please use the Pretreatment link in Chapter 12 to access a listing and design criteria for various patented devices that have received a General Use Level Designation for Pretreatment through the TAPE program.

BMP T6.10: Presettling Basin

Purpose and Definition

A Presettling Basin provides pretreatment of runoff in order to remove suspended solids, which can impact other runoff treatment BMPs.

Application and Limitations

Runoff treated by a Presettling Basin may not be discharged directly to a receiving water; it must be further treated by a basic or enhanced runoff

treatment BMP.

Design Criteria

1. A presettling basin shall be designed with a wetpool. The treatment volume shall be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event.

Purpose and Definition

~~A Presettling Basin provides pretreatment of runoff in order to remove suspended solids, which can impact other runoff treatment BMPs.~~

Application and Limitations

~~Runoff treated by a Presettling Basin may not be discharged directly to a receiving water; it must be further treated by a basic or enhanced runoff treatment BMP.~~

Design Criteria

- ~~1. A presettling basin shall be designed with a wetpool. The treatment volume shall be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event.~~
- ~~2. 2. A presettling basin shall be designed with a wetpool. The treatment volume shall be at least 30 percent of the total volume of runoff from the 6-month, 24-hour storm event.~~
- ~~2.3.~~ If the runoff in the Presettling Basin will be in direct contact with the soil, it must be lined per the liner requirement in [Section 4.4](#)~~Section 4.4.~~
- ~~3.4.~~ 3. The Presettling Basin shall conform to the following:
 - a) The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flowpath.
 - b) The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
- ~~4.5.~~ 4. Inlets and outlets shall be designed to minimize velocity and reduce turbulence. Inlet and outlet structures should be located at extreme ends of the basin in order to maximize particle-settling opportunities.

Site Constraints and Setbacks

Site constraints are any manmade restrictions such as property lines, easements, structures, etc. that impose constraints on development. Constraints may also be imposed from natural features such as requirements of the local government's Sensitive Areas Ordinance and Rules. These should also be reviewed for specific application to the proposed development.

Site Constraints and Setbacks

~~Site constraints are any manmade restrictions such as property lines, easements, structures, etc. that impose constraints on development. Constraints may also be imposed from natural features such as requirements of the local government's Sensitive Areas Ordinance and Rules. These should also be reviewed for specific application to the proposed development.~~

All facilities shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government.

All facilities shall be 100 feet from any septic tank/drainfield (except wet vaults shall be a minimum of 20 feet).

All facilities shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical report must address the potential impact of a wet pond on a steep slope.

Embankments that impound water must comply with the Washington State Dam Safety Regulations ([Chapter 173-175 WAC](#)~~(Chapter 173-175 WAC)~~). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, then dam safety design and review are required by the Department of Ecology. See Volume III for more detail.

Chapter 7. - Infiltration and ~~Bio-infiltration~~Bioretention Treatment Facilities

7.1 Purpose

This Chapter provides site suitability, design, and maintenance criteria for infiltration treatment systems. Infiltration treatment Best Management Practices (BMPs) serve the dual purpose of removing pollutants (TSS, heavy metals, phosphates, and organics) ~~from stormwater~~ and recharging aquifers.

A stormwater infiltration treatment facility is an impoundment; typically a basin, trench, or ~~bio-infiltration~~bioretention swale whose ~~underlying~~ soil removes pollutants from stormwater. ~~The infiltration BMPs described in this chapter include:~~

~~BMP T7.10 – Infiltration basins~~

~~BMP T7.20 – Infiltration trenches~~

~~BMP T7.30 – Bio-infiltration swales~~

Infiltration treatment soils must contain sufficient organic matter and/or clays to sorb, decompose, and/or filter stormwater pollutants. Pollutant/soil contact time, soil sorptive capacity, and soil aerobic conditions are important design considerations.

~~This chapter contains design details regarding BMP T7.30. To reduce duplication of design guidance, information regarding site criteria, infiltration rates, site suitability, and guidance of a general nature for these infiltration treatment BMPs has been moved to Chapter 3 of Volume III. Also, design details for infiltration basins and trenches have been moved to Chapter 3 of Volume III. The text in Chapter 3 has been modified to indicate where design guidance applies only to infiltration treatment systems, not infiltration facilities serving only a flow control function. Design details regarding BMP T7.30, Bio-infiltration swales, is retained in this chapter as that BMP serves only an infiltration treatment function.~~

~~7.2~~ Application

~~, Bioretention cells, swales and planter boxes, since the imported soil for that BMP serves primarily a treatment function. If the exfiltrate of stormwater from the imported soil is allowed to infiltrate into the ground, the facility also serves a flow control function.~~

7.2 General Considerations

These infiltration and ~~bio-infiltration~~bioretention treatment measures are capable of achieving the performance objectives cited in Chapter 3~~Chapter~~

3 for specific treatment menus. In general, these treatment techniques can capture and remove or reduce the target pollutants to levels that ÷

will not adversely affect public health or beneficial uses of surface and ground water resources, and will not cause a violation of ground water quality standards.

- ~~Will not cause a violation of ground water quality standards~~

The terms bioretention and raingarden are sometimes used interchangeably. However, for Washington State, the term bioretention is used to describe an engineered facility that includes designed soil mixes and perhaps under-drains and control structures. The term, rain garden, is used to describe a landscape feature to capture stormwater on small project sites. Rain gardens have less restrictive design criteria for the soil mix and usually do not include under-drains and other control structures.

7.3 Applications

Infiltration treatment systems are typically installed:

- As off-line systems, or on-line for small drainages
- As a polishing treatment for street/highway runoff after pretreatment for TSS and oil
- As part of a treatment train
- As retrofits at sites with limited land areas, such as residential lots, commercial areas, parking lots, and open space areas.
- With appropriate pretreatment for oil and silt control to prevent clogging. Appropriate pretreatment devices include a pre-settling basin, wet pond/vault, ~~biofilter~~, constructed wetland, media filter, and oil/water separator.
- An infiltration basin is preferred, where applicable, and where over a trench or bio-infiltration swale cannot for ease of maintenance reasons.
- Rain gardens are an On-site BMP option for projects that only have to comply with Minimum Requirements #1 through #5.
- Bioretention facilities are an On-site BMP option for: 1) projects that only have to comply with Minimum Requirements #1 through #5, and 2) projects that trigger Minimum Requirements #1 through #9.
- Bioretention facilities and rain gardens are applications of the same LID concept and can be sufficiently maintained highly effective for reducing surface runoff and removing pollutants.

7.3—General Considerations

Please reference Section 3.3 of Volume III.

7.4 Best Management Practices (BMPs) for Infiltration and ~~Bio-infiltration~~Bioretention Treatment

The three BMPs discussed below are recognized currently as effective treatment techniques using infiltration and ~~bio-infiltration~~. bioretention.

Selection of a specific BMP should be coordinated with the Treatment Facility Menus provided in Chapter 3.

BMP T7.10: Infiltration Basins

~~See Section 3.3.10, Chapter 3, Volume III.~~

The design criteria and design procedures for infiltration basins for treatment are in Chapter 3, section 3.3 of Volume III. Sub-sections 3.3.1 through 3.3.9 provide information pertinent to all infiltration facilities. Sub-section 3.3.10 provides information specific to infiltration basins.

BMP T7.20: Infiltration Trenches

See section 3.3.11, Chapter 3, Volume III.

The design criteria and design procedures for infiltration trenches for treatment are in Chapter 3, Section 3.3 of Volume III. Sub-sections 3.3.1 through 3.3.9 provide information pertinent to all infiltration facilities. Sub-section 3.3.11 provides information specific to infiltration trenches.

BMP T7.30: Bioretention Cells, Swales, and Planter Boxes

Purpose

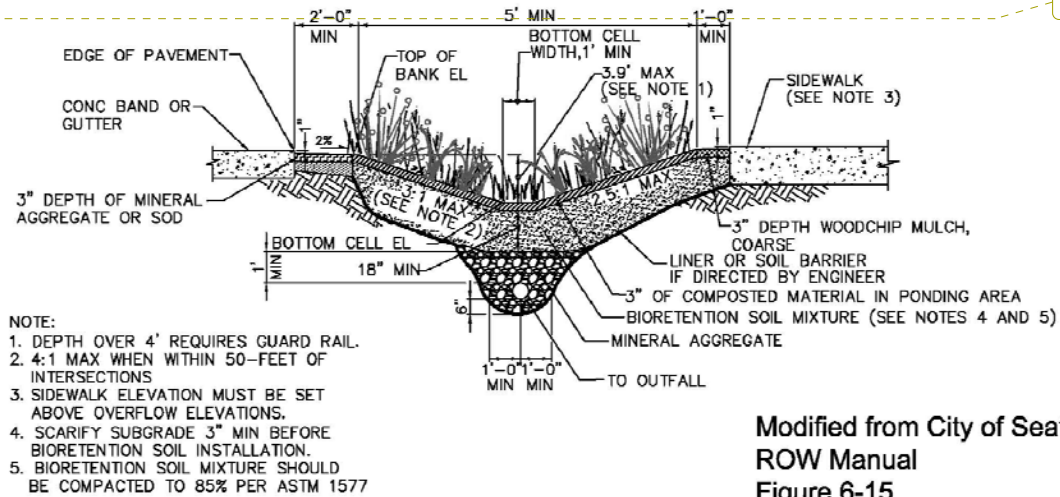
To provide effective removal of many stormwater pollutants, and provide reductions in stormwater runoff quantity and surface runoff flow rates. Where the surrounding native soils have adequate infiltration rates, bioretention can help comply with flow control and treatment requirements. Where the native soils have low infiltration rates, under-drain systems can be installed and the facility used to filter pollutants and detain flows that exceed infiltration capacity of the surrounding soil. However, designs utilizing under-drains provide less flow control benefits.

Description

Bioretention areas are shallow landscaped depressions, with a designed soil mix and plants adapted to the local climate and soil moisture conditions, that receive stormwater from a contributing area.

The term, bioretention, is used to describe various designs using soil and plant complexes to manage stormwater. The following terminology is used in this manual:

- Bioretention cells: Shallow depressions with a designed planting soil mix and a variety of plant material, including trees, shrubs, grasses, and/or other herbaceous plants. Bioretention cells may or may not have an under-drain and are not designed as a conveyance system. (See [Figure 7.4.1 – Bio-infiltration](#).)
- Bioretention swales: Incorporate the same design features as bioretention cells; however, bioretention swales are designed as part of a system that can convey stormwater when maximum ponding depth is exceeded. Bioretention swales have relatively gentle side slopes and ponding depths that are typically 6 to 12 inches.



Modified from City of Seattle
ROW Manual
Figure 6-15

Figure 7.4.1 Example of a Bioretention Swale

- Bioretention planters and planter boxes: Designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. Planter boxes are completely impervious and include a bottom (must include an under-drain). Planters have an open bottom and allow infiltration to the subgrade. These designs are often used in ultra-urban settings. (See [Figure 7.4.2](#))

Note: Ecology has approved use of certain patented treatment systems that use specific, high rate media for treatment. Such systems are not considered LID BMPs and are not options for meeting the requirements of Minimum Requirement #5. The Ecology approval is meant to be used for Minimum Requirement #6, where appropriate.

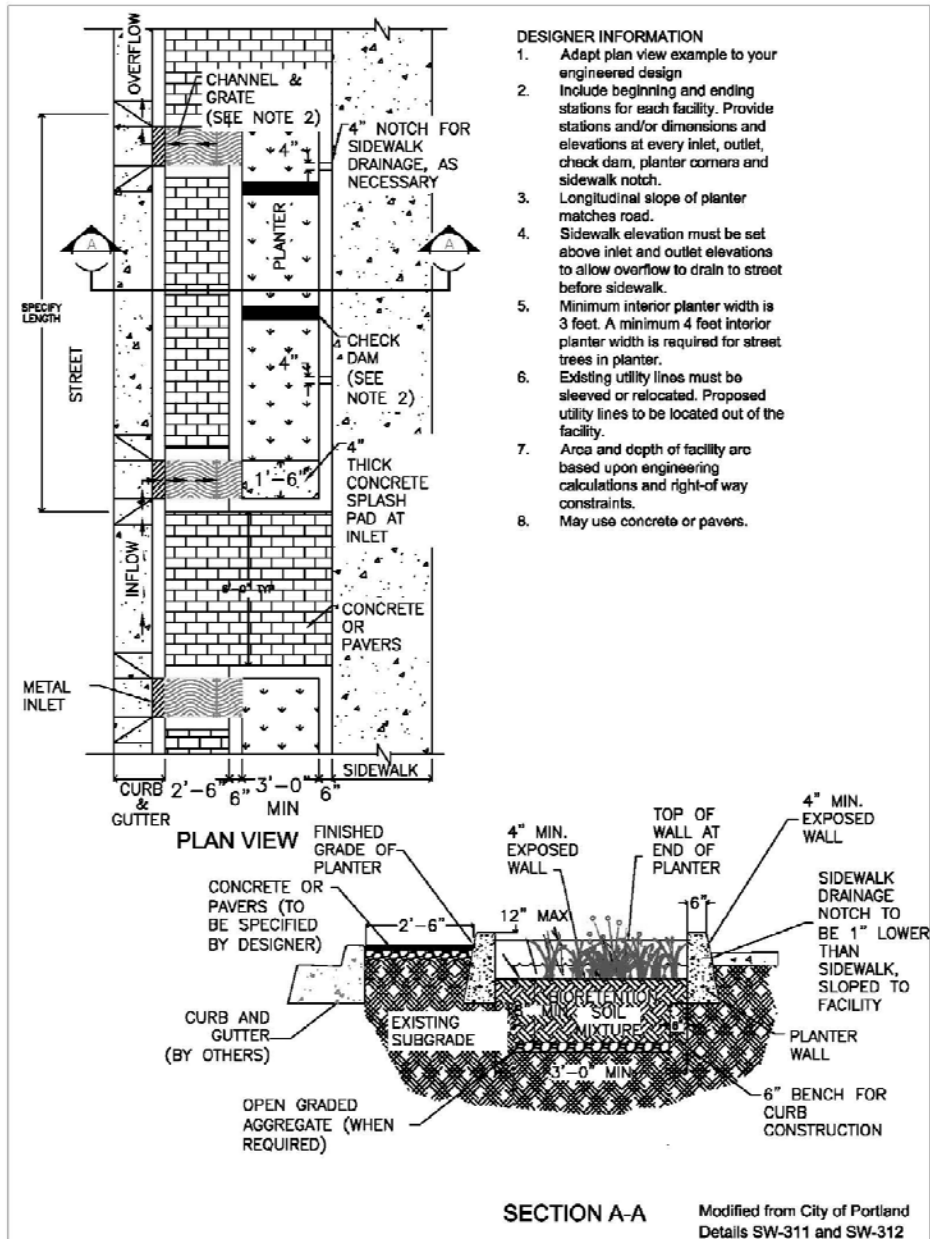


Figure 7.4.2 Example of a Bioretention Planter

Applications and Limitations

Because Bioretention facilities use an imported soil mix that has a moderate design infiltration rate, they are best applied for small drainages, and near the source of the stormwater. Cells may be scattered throughout a subdivision; a swale may run alongside the access road; or a series of planter boxes may serve the road. In these situations, they can but are not required to fully meet the requirement to treat 91% of the stormwater runoff from pollution-generating surfaces. But the amount of stormwater that is predicted to pass through the soil profile may be estimated and subtracted from the 91% volume that must be treated. Downstream treatment facilities may be significantly smaller as a result.

Description

~~Bio-infiltration swales, also known as Grass Percolation Areas, combine grassy vegetation and soils to remove stormwater pollutants by percolation into the ground. Their pollutant removal mechanisms include filtration, soil sorption, and uptake by vegetative root zones. Bio-infiltration swales have been used in Spokane County for many years to treat urban stormwater and recharge the ground water.~~

~~In general, bio-infiltration swales are used for treating stormwater runoff from roofs, roads and parking lots. Runoff volumes greater than water quality design volume are typically overflowed to the subsurface through an appropriate conveyance facility such as a dry well, or an overflow channel to surface water. Overflows that are directed to a surface water must meet Minimum Requirement #7 or #8 (whichever is applicable) unless the discharge is to a marine water, or qualifies for a flow control exemption in accordance with the criteria in Minimum Requirement #7.~~

~~**Additional Design** Bioretention facilities that infiltrate into the ground can also serve a significant flow reduction function. They can, but are not required to fully meet the flow control duration standard of Minimum Requirement #7. Because they typically do not have an orifice restricting overflow or underflow discharge rates, they typically don't fully meet Minimum Requirement #7. However, their performance contributes to meeting the standard, and that can result in much smaller flow control facilities at the bottom of the project site. When used in combination with other low impact development techniques, they can also help achieve compliance with the Performance Standard option of Minimum Requirement #5.~~

~~Bioretention constructed with imported compost materials should not be used within one-quarter mile of phosphorus-sensitive waterbodies if the underlying native soil does not meet the soil suitability criteria for treatment in Chapter 3 of Volume III. Preliminary monitoring indicates that new bioretention facilities can add phosphorus to stormwater. Therefore, they should also not be used with an underdrain when the~~

underdrain water would be routed to a phosphorus-sensitive receiving water.

Applications with or without under-drains vary extensively and can be applied in new development, redevelopment and retrofits. Typical applications include:

- Individual lots for rooftop, driveway, and other on-lot impervious surface.
- Shared facilities located in common areas for individual lots.
- Areas within loop roads or cul-de-sacs.
- Landscaped parking lot islands.
- Within right-of-ways along roads (often linear bioretention swales and cells).
- Common landscaped areas in apartment complexes or other multifamily housing designs.
- Planters on building roofs, patios, and as part of streetscapes.

Infeasibility Criteria-Specific for Bio-:

The following criteria describe conditions that make bioretention or rain gardens not required. If a project proponent wishes to use a bioretention or rain garden BMP though not required to because of these feasibility criteria, they may propose a functional design to the local government.

Note: Criteria with setback distances are as measured from the bottom edge of the bioretention soil mix.

Citation of any of the following infeasibility criteria must be based on an evaluation of site-specific conditions and a written recommendation from an appropriate licensed professional (e.g., engineer, geologist, hydrogeologist):

- Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or down gradient flooding.
- Within an area whose ground water drains into an erosion hazard, or landslide hazard area.
- Where the only area available for siting would threaten the safety or reliability of pre-existing underground utilities, pre-existing underground storage tanks, pre-existing structures, or pre-existing road or parking lot surfaces.
- Where the only area available for siting does not allow for a safe overflow pathway to the municipal separate storm sewer system or private storm sewer system.

- Where there is a lack of usable space for rain garden/bioretention facilities at re-development sites, or where there is insufficient space within the existing public right-of-way on public road projects.
- Where infiltrating water would threaten existing below grade basements.
- Where infiltrating water would threaten shoreline structures such as bulkheads.

The following criteria can be cited as reasons for a finding of infeasibility without further justification (though some require professional services):

- Within setbacks from structures as established by the local government with jurisdiction.
- Where they are not compatible with surrounding drainage system as determined by the local government with jurisdiction (e.g., project drains to an existing stormwater collection system whose elevation or location precludes connection to a properly functioning bioretention facility).
- Where land for bioretention is within area designated as an erosion hazard, or landslide hazard.
- Where the site cannot be reasonably designed to locate bioretention facilities on slopes less than 8%.
- Within 50 feet from the top of slopes that are greater than 20% and over 10 feet of vertical relief.
- For properties with known soil or ground water contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act (MTCA)):
 - Within 100 feet of an area known to have deep soil contamination;
 - Where ground water modeling indicates infiltration ~~Swales~~ will likely increase or change the direction of the migration of pollutants in the ground water;
 - Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area;
 - Any area where these facilities are prohibited by an approved cleanup plan under the state Model Toxics Control Act or Federal Superfund Law, or an environmental covenant under [Chapter 64.70 RCW](#).
- Within 100 feet of a closed or active landfill.

- Within 100 feet of a drinking water well, or a spring used for drinking water supply.
- Within 10 feet of small on-site sewage disposal drainfield, including reserve areas, and grey water reuse systems. For setbacks from a “large on-site sewage disposal system”, see [Chapter 246-272B WAC](#).
- Within 10 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is 1100 gallons or less. (As used in these criteria, an underground storage tank means any tank used to store petroleum products, chemicals, or liquid hazardous wastes of which 10% or more of the storage volume (including volume in the connecting piping system) is beneath the ground surface.
- Within 100 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is greater than 1100 gallons.
- Where the minimum vertical separation of 1 foot to the seasonal high water table, bedrock, or other impervious layer would not be achieved below bioretention or rain gardens that would serve a drainage area that is: 1) less than 5,000 sq. ft. of pollution-generating impervious surface, and 2) less than 10,000 sq. ft. of impervious surface; and, 3) less than ¾ acres of pervious surface.
- Where the a minimum vertical separation of 3 feet to the seasonal high water table, bedrock or other impervious layer would not be achieved below bioretention that: 1) would serve a drainage area that meets or exceeds: a) 5,000 square feet of pollution-generating impervious surface, or b) 10,000 square feet of impervious surface, or c) three-quarter (3/4) acres of pervious surfaces; and 2) cannot reasonably be broken down into amounts smaller than indicated in (1).
- Where the field testing indicates potential bioretention/rain garden sites have a measured (a.k.a., initial) native soil saturated hydraulic conductivity less than 0.30 inches per hour. If the measured native soil infiltration rate is less than 0.30 in/hour, this option should not be used to meet the requirements of MR#5. In these slow draining soils, a bioretention facility with an underdrain may be used to treat pollution- generating surfaces to help meet Minimum Requirement #6, Runoff Treatment. If the underdrain is elevated within a base course of gravel, it will also provide some modest flow reduction benefit that will help achieve Minimum Requirement #7.

Other Site Suitability Factors:

- Utility conflicts: Consult local jurisdiction requirements for horizontal and vertical separation required for publicly-owned utilities, such as water and sewer. Consult the appropriate franchise utility owners for separation requirements from their utilities, which may include communications and gas. When separation requirements cannot be met, designs should include appropriate mitigation measures, such as impermeable liners over the utility, sleeving utilities, fixing known leaky joints or cracked conduits, and/or adding an underdrain to the bioretention.
- Transportation safety: The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with local jurisdiction requirements.
- Ponding depth and surface water draw-down: Flow control needs, as well as location in the development, and mosquito breeding cycles will determine draw-down timing. For example, front yards and entrances to residential or commercial developments may require rapid surface dewatering for aesthetics.
- Impacts of surrounding activities: Human activity influences the location of the facility in the development. For example, locate bioretention areas away from traveled areas on individual lots to prevent soil compaction and damage to vegetation or provide elevated or bermed pathways in areas where foot traffic is inevitable, and provide barriers, such as wheel stops, to restrict vehicle access in roadside applications.
- Visual buffering: Bioretention facilities can be used to buffer structures from roads, enhance privacy among residences, and for an aesthetic site feature.
- Site growing characteristics and plant selection: Appropriate plants should be selected for sun exposure, soil moisture, and adjacent plant communities. Native species or hardy cultivars are recommended and can flourish in the properly designed and placed Bioretention Soil Mix with no nutrient or pesticide inputs and 2-3 years irrigation for establishment. Invasive species control may be necessary.

Field and Design Procedures

Geotechnical analysis is an important first step to develop an initial assessment of the variability of site soils, infiltration characteristics and the necessary frequency and depth of infiltration tests. See the Site Planning guidance in Chapter 3 of Volume 1.

See Section 3.4 in Volume III of this manual for more specific guidance regarding required field testing, assignment of infiltration rate correction factors, project submission requirements, and modeling.

Determining subgrade infiltration rates

Determining infiltration rates of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on-site. It is also necessary to estimate flow reduction benefits of such designs when using the Western Washington Hydrologic Model (WWHM) or MGS Flood.

The following provides recommended tests for the soils underlying bioretention areas. The test should be run at the anticipated elevation of the top of the native soil beneath the bioretention facility.

Method 1:

- Small bioretention cells (bioretention facilities receiving water from 1 or 2 individual lots or < 1/4 acre of pavement or other impervious surface): Small-Scale Pilot Infiltration Test (PIT). See Volume III, Section 3.3.6 for small-scale PIT method description. See Section 3.4 in Volume III for a discussion of the assignment of an appropriate infiltration correction factor.
- Large bioretention cells (bioretention facilities receiving water from several lots or 1/4 acre or more of pavement or other impervious surface): Multiple small or one large-scale PIT. If using the small-scale test, measurements should be taken at several locations within the area of interest. After completing the infiltration test, excavate the test site at least 3 feet if variable soil conditions or seasonal high water tables are suspected. Observe whether water is infiltrating vertically or only spreading horizontally because of ground water or a restrictive soil layer. See Section 3.4 in Volume III for a discussion of the assignment of an appropriate infiltration correction factor.
- Bioretention swales: approximately 1 small-scale PIT per 200 feet of swale, and within each length of road with significant differences in subsurface characteristics. However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high ground water conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional. See Section 3.4 in Volume III for a discussion of the assignment of an appropriate infiltration correction factor.

Method 2: Soil Grain Size Analysis Method:

This method is restricted to sites underlain with soils not consolidated by glacial advance (e.g., recessional outwash soils).

- Small bioretention cells: Use the grain size analysis method described in Section 3.3.6 of Volume III based on the layer(s) identified in results of one soil test pit or boring.
- Large bioretention cells: Use the grain size analysis method based on more than one soil test pit or boring. The more test pits/borings

used, and the more evidence of consistency in the soils, the less of a correction factor may be used.

- Bioretention swales: Approximately 1 soil test pit/boring per 200 feet of swale and within each length of road with significant differences in subsurface characteristics. However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high ground water conditions, the number of test locations may be reduced to the minimum frequency indicated above.

Determining Bioretention soil mix infiltration rate:

Option 1: If using the Bioretention Soil Mix recommended herein, the default infiltration rate of 1.5 inches per hour or 3 inches per hour may be used. 1.5 inches per hour is used where the drainage area to the bioretention device exceeds any of the following:

10,000 sq. ft. of impervious surface

5,000 sq. ft. of pollution-generating impervious surface

¾ acres of native vegetation converted to lawn/landscaping

2.5 acres of native vegetation converted to pasture.

Use 3 inches per hour if the drainage area does not exceed any of the above-listed areas.

Option 2: If creating a custom bioretention soil mix, Use ASTM D 2434 Standard Test Method for Permeability of granular Soils (Constant Head) with a compaction rate of 85 percent using ASTM D1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. See [Appendix V-B](#) for specific procedures for conducting ASTM D 2434.

If the contributing area of the bioretention cell or swale is equal to or exceeds any of the following limitations: 5,000 square feet of pollution-generating impervious surface; or 10,000 square feet of impervious surface; or ¾ acre of lawn and landscape, use 0.25 as the infiltration rate correction factor. If the contributing area is less than all of the above areas, use 0.5 as the infiltration correction factor.

Design Criteria for Bioretention

Note: These design criteria are from the *Low Impact Development Technical Guidance Manual for the Puget Sound Basin (2012)*. Refer to that document for additional explanations and background.

Flow entrance and presettling

Flow entrance design will depend on topography, flow velocities and volume entering the pretreatment and bioretention area, adjacent land use and site constraints. Flow velocities entering bioretention should be less

than 1.0 ft/second to minimize erosion potential. Five primary types of flow entrances can be used for bioretention:

- *Dispersed, low velocity flow across a landscape area:* Landscape areas and vegetated buffer strips slow incoming flows and provide an initial settling of particulates and are the preferred method of delivering flows to the bioretention cell.. Dispersed flow may not be possible given space limitations or if the facility is controlling roadway or parking lot flows where curbs are mandatory.
- *Dispersed or sheet flow across pavement or gravel and past wheel stops for parking areas.*
- *Curb cuts for roadside, driveway or parking lot areas:* Curb cuts should include a rock pad, concrete or other erosion protection material in the channel entrance to dissipate energy. Minimum curb cut width should be 12 inches; however, 18 inches is recommended. Avoid the use of angular rock or quarry spalls and instead use round (river) rock if needed. Removing sediment from angular rock is difficult. Flow entrance should drop 2 to 3 inches from curb line (see figure in the *Low Impact Development Technical Guidance Manual for the Puget Sound Basin*) and provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the cell.
- Curb cuts used for bioretention areas in high use parking lots or roadways require increased level of maintenance due to high coarse particulates and trash accumulation in the flow entrance and associated bypass of flows. The following are methods recommended for areas where heavy trash and coarse particulates are anticipated:
 - Curb cut width: 18 inches.
 - At a minimum the flow entrance should drop 2 to 3 inches from gutter line into the bioretention area and provide an area for settling and periodic removal of debris.
 - Anticipate relatively more frequent inspection and maintenance for areas with large impervious areas, high traffic loads and larger debris loads.
 - Catch basins or forebays may be necessary at the flow entrance to adequately capture debris and sediment load from large contributing areas and high use areas. Piped flow entrance in this setting can easily clog and catch basins with regular maintenance are necessary to capture coarse and fine debris and sediment.
- *Pipe flow entrance:* Piped entrances should include rock or other erosion protection material in the channel entrance to dissipate energy and disperse flow.

- Catch basin: In some locations where road sanding or higher than usual sediment inputs are anticipated, catch basins can be used to settle sediment and release water to the bioretention area through a grate for filtering coarse material.
- Trench drains: can be used to cross sidewalks or driveways where a deeper pipe conveyance creates elevation problems. Trench drains tend to clog and may require additional maintenance.

Woody plants can restrict or concentrate flows and can be damaged by erosion around the root ball and should not be placed directly in the entrance flow path.

Bottom area and side slopes

Bioretention areas are highly adaptable and can fit various settings such as rural and urban roadsides, ultra urban streetscapes and parking lots by adjusting bottom area and side slope configuration. Recommended maximum and minimum dimensions include:

- Maximum planted side slope if total cell depth is greater than 3 feet: 3H:1V. If steeper side slopes are necessary rockeries, concrete walls or soil wraps may be effective design options. Local jurisdictions may require bike and/or pedestrian safety features, such as railings or curbs with curb cuts, when steep side slopes are adjacent to sidewalks, walkways, or bike lanes.
- Minimum bottom width for bioretention swales: 2 feet recommended and 1 foot minimum. Carefully consider flow depths and velocities, flow velocity control (check dams) and appropriate vegetation or rock mulch to prevent erosion and channelization at bottom widths less than 2 feet.

Bioretention areas should have a minimum shoulder of 12 inches (30.5 cm) between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should 90 percent proctor.

Ponding area

Ponding depth recommendations:

- Maximum ponding depth: 12 inches (30.5 cm).
- Surface pool drawdown time: 24 hours

The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the cell. Pool depth and draw-down rate are recommended to provide surface storage, adequate infiltration capability, and soil moisture conditions that allow for a range of appropriate plant species. Soils must be allowed to dry out periodically in order to: restore hydraulic capacity to receive flows from subsequent storms; maintain infiltration rates; maintain adequate soil

oxygen levels for healthy soil biota and vegetation; provide proper soil conditions for biodegradation and retention of pollutants. Maximum designed depth of ponding (before surface overflow to a pipe or ditch) must be considered in light of drawdown time.

For bioretention areas with under-drains, elevating the drain to create a temporary saturated zone beneath the drain is advised to promote denitrification (conversion of nitrate to nitrogen gas) and prolong moist soil conditions for plant survival during dry periods (see Under-drain section below for details).

Surface overflow

Surface overflow can be provided by vertical stand pipes that are connected to under-drain systems, by horizontal drainage pipes or armored overflow channels installed at the designed maximum ponding elevations. Overflow can also be provided by a curb cut at the down-gradient end of the bioretention area to direct overflows back to the street. Overflow conveyance structures are necessary for all bioretention facilities to safely convey flows that exceed the capacity of the facility and to protect downstream natural resources and property.

The minimum freeboard from the invert of the overflow stand pipe, horizontal drainage pipe or earthen channel should be 6 inches unless otherwise specified by the local jurisdiction's design standards.

Default Bioretention Soil Media (BSM)

Projects which use the following requirements for the bioretention soil media do not have to test the media for its saturated hydraulic conductivity (aka. Infiltration rate). They may assume the rates specified in the subsection titled "Determining Bioretention Soil Mix Infiltration Rate."

Mineral Aggregate

Percent Fines: A range of 2 to 4 percent passing the #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to ASTM D422.

Aggregate Gradation

The aggregate portion of the BSM should be well-graded. According to ASTM D 2487-98 (Classification of Soils for Engineering Purposes (Unified Soil Classification System)), well-graded sand should have the following gradation coefficients:

- Coefficient of Uniformity ($C_u = D_{60}/D_{10}$) equal to or greater than 4, and
- Coefficient of Curve ($C_c = (D_{30})^2/D_{60} \times D_{10}$) greater than or equal to 1 and less than or equal to 3.

Table 7.4.1 provides a gradation guideline for the aggregate component of a Bioretention Soil Mix specification in western Washington (Hinman,

Robertson, 2007). The sand gradation below is often supplied as a well-graded utility or screened. With compost this blend provides enough fines for adequate water retention, hydraulic conductivity within recommended range (see below), pollutant removal capability, and plant growth characteristics for meeting design guidelines and objectives.

Table 7.4.1
General Guideline for Mineral Aggregate Gradation

<u>Sieve Size</u>	<u>Percent Passing</u>
<u>3/8"</u>	<u>100</u>
<u>#4</u>	<u>95-100</u>
<u>#10</u>	<u>75-90</u>
<u>#40</u>	<u>25-40</u>
<u>#100</u>	<u>4-10</u>
<u>#200</u>	<u>2-5</u>

Where existing soils meet the above aggregate gradation, those soils may be amended rather than importing mineral aggregate.

Compost to Aggregate Ratio, Organic Matter Content, Cation Exchange Capacity

- Compost to aggregate ratio: 60-65 percent mineral aggregate, 35 – 40 percent compost.
- Organic matter content: 5 – 8 percent by weight.
- Cation Exchange Capacity (CEC) must be > 5 milliequivalents/100 g dry soil Note: Soil mixes meeting the above specifications do not have to be tested for CEC. They will readily meet the minimum CEC.

Compost

To ensure that the BSM will support healthy plant growth and root development, contribute to biofiltration of pollutants, and not restrict infiltration when used in the proportions cited herein, the following compost standards are required.

- Meets the definition of “composted materials” in [WAC 173-350-220](#) (including contaminant levels and other standards), available online at <http://www.ecy.wa.gov/programs/swfa/organics/soil.html>
- Produced at a composting facility permitted by the WA Department of Ecology. A current list of permitted facilities is available at <http://www.ecy.wa.gov/programs/swfa/compost/>
- The compost product must originate a minimum of 65 percent by volume from recycled plant waste as defined in [WAC 173-350-100](#) as “Type I Feedstocks.” A maximum of 35 percent by volume of other approved organic waste as defined in [WAC 173-350-100](#) as “Type III”, including postconsumer food waste, but not including biosolids.

may be substituted for recycled plant waste. Type II and IV feedstocks shall not be used for the compost going into bioretention facilities or rain gardens.

- Stable (low oxygen use and CO₂ generation) and mature (capable of supporting plant growth) by tests shown below. This is critical to plant success in a bioretention soil mixes.
- Moisture content range: no visible free water or dust produced when handling the material.
- Tested in accordance with the U.S. Composting Council “Testing Methods for the Examination of Compost and Composting” (TMECC), as established in the Composting Council’s “Seal of Testing Assurance” (STA) program. Most Washington compost facilities now use these tests.
- Screened to the size gradations for Fine Compost under TMECC test method 02.02-B (gradations are shown in the specification in an appendix of the *Low Impact Development Technical Guidance Manual for Puget Sound*)
- pH between 6.0 and 8.5 (TMECC 04.11-A). If the pH falls outside of the acceptable range, it may be modified with lime to increase the pH or iron sulfate plus sulfur to lower the pH. The lime or iron sulfate must be mixed uniformly into the soil prior to use in the bioretention area.
- Manufactured inert content less than 1% by weight (TMECC 03.08-A)
- Minimum organic matter content of 40% (TMECC 05.07-A)
- Soluble salt content less than 4.0 mmhos/cm (TMECC 04.10-A)
- Maturity greater than 80% (TMECC 05.05-A “Germination and Vigor”)
- Stability of 7 or below (TMECC 05.08-B “Carbon Dioxide Evolution Rate”)
- Carbon to nitrogen ratio (TMECC 04.01 “Total Carbon” and 04.02D “Total Kjeldahl Nitrogen”) of less than 25:1. The C:N ratio may be up to 35:1 for plantings composed entirely of Puget Sound Lowland native species and up to 40:1 for coarse compost to be used as a surface mulch (not in a soil mix).

Design Criteria for Custom Bioretention Soil Mixes

Projects which prefer to create a custom Bioretention Soil Mix rather than using the default requirements above must demonstrate compliance with the following criteria using the specified test method:

- CEC ≥ 5 meq/100 grams of dry soil; USEPA 9081
- pH between 5.5 and 7.0

- 5 - 8 percent organic matter content before and after the saturated hydraulic conductivity test; ASTM D2974(Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils)
- 2-5 percent fines passing the 200 sieve; TMECC 04.11-A
- Measured (Initial) saturated hydraulic conductivity of less than 12 inches per hour; ASTM D 2434 (Standard Test Method for Permeability of Granular Soils (Constant Head)) at 85% compaction per ASTM D 1557 (Standard Test Method s for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use [Appendix V-B, Recommended Procedures for ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes.](#)
- Design (long-term) saturated hydraulic conductivity of more than 1 inch per hour. Note: Design saturated hydraulic conductivity is determined by applying the appropriate infiltration correction factors as explained above under “Determining Bioretention soil mix infiltration rate.”
- If compost is used in creating the custom mix, it must meet all of the specifications listed above for compost.

Soil Depth:

- Soil depth must be a minimum of 18 inches to provide water quality treatment and good growing conditions for selected plants
- A minimum depth of 24 inches should be selected for improved phosphorus and nitrogen (TKN) removal where under-drains are used.

Filter Fabrics:

Do not use filter fabrics between the subgrade and the Bioretention Soil Mix. The gradation between existing soils and Bioretention Soil Mix is not great enough to allow significant migration of fines into the Bioretention Soil Mix. Additionally, filter fabrics may clog with downward migration of fines from the Bioretention Soil Mix.

Underdrain (optional):

The area above an under-drain pipe in a bioretention area provides detention and pollutant filtering; however, only the area below the under-drain invert and above the bottom of the bioretention facility (subgrade) can be used in the WWHM or MGSFlood for dead storage volume that provides flow control benefit

Under-drain systems should only be installed when the bioretention facility is:

- Located near sensitive infrastructure (e.g., unsealed basements) and potential for flooding is likely.

- Used for filtering storm flows from gas stations or other pollutant hotspots (requires impermeable liner).
- Located above native soils with infiltration rates that are not adequate to meet maximum pool and system dewater rates, or are below a minimum rate allowed by the local government.
- In an area that does not provide the minimum depth to a hydraulic restriction layer, e.g., high seasonal ground water.

The under-drain can be connected to a downstream open conveyance (bioretention swale), to another bioretention cell as part of a connected treatment system, daylight to a dispersion area using an effective flow dispersion practice, or to a storm drain.

Under-drain pipe:

Under-drains shall be slotted, thick-walled plastic pipe. The slot opening should be smaller than the smallest aggregate gradation for the gravel filter bed (see under-drain filter bed below) to prevent migration of material into the drain. This configuration allows for pressurized water cleaning and root cutting if necessary.

Under-drain pipe recommendations:

- Minimum pipe diameter: 4 inches (pipe diameter will depend on hydraulic capacity required, 4 to 8 inches is common).
- Slotted subsurface drain PVC per ASTM D1785 SCH 40.
- Slots should be cut perpendicular to the long axis of the pipe and be 0.04 to 0.069 inches by 1 inch long and be spaced 0.25 inches apart (spaced longitudinally). Slots should be arranged in four rows spaced on 45-degree centers and cover ½ of the circumference of the pipe. See Filter Materials section for aggregate gradation appropriate for this slot size.
- Under-drains should be sloped at a minimum of 0.5 percent unless otherwise specified by an engineer.

Perforated PVC or flexible slotted HDPE pipe cannot be cleaned with pressurized water or root cutting equipment, are less durable and are not recommended. Wrapping the under-drain pipe in filter fabric increases chances of clogging and is not recommended. A 6-inch rigid non-perforated observation pipe or other maintenance access should be connected to the under-drain every 250 to 300 feet to provide a clean-out port, as well as an observation well to monitor dewatering rates.

Under-drain aggregate filter and bedding layer.

Aggregate filter and bedding layers buffer the under-drain system from sediment input and clogging. When properly selected for the soil gradation, geosynthetic filter fabrics can provide adequate protection from the migration of fines. However, aggregate filter and bedding layers, with

proper gradations, provide a larger surface area for protecting under-drains and are preferred.

- Guideline for under-drain aggregate filter and bedding layers with heavy walled slotted pipe (see under-drain pipe guideline above):

Sieve size Percent Passing

¾ inch 100

¼ inch 30-60

US No. 8 20-50

US No. 50 3-12

US No. 200 0-1

The above gradation is a Type 26 mineral aggregate (gravel backfill for drains, City of Seattle).

- Place under-drain on a bed of the Type 26 aggregate with a minimum thickness of 6 inches and cover with Type 26 aggregate to provide a 1-foot minimum depth around the top and sides of the slotted pipe. See the *Low Impact Development Technical Guidance Manual for Puget Sound* for a related figure.

Orifice and other flow control structures:

- The minimum orifice diameter should be 0.5 inches to minimize clogging and maintenance requirements.

Check dams and weirs

Check dams are necessary for reducing flow velocity and potential erosion, as well as increasing detention time and infiltration capability on sloped sites. Typical materials include concrete, wood, rock, compacted dense soil covered with vegetation, and vegetated hedge rows. Design depends on flow control goals, local regulations for structures within road right-of-ways and aesthetics. Optimum spacing is determined by flow control benefit (modeling) in relation to cost consideration. See the *Low Impact Development Technical Guidance Manual for Puget Sound* for displays of typical designs.

UIC discharge

Stormwater that has passed through the bioretention soil mix may also discharge to a gravel-filled dug or drilled drain. Underground Injection Control (UIC) regulations are applicable and must be followed ([Chapter 173-218 WAC](#)).

Hydraulic restriction layers:

Adjacent roads, foundations or other infrastructure may require that infiltration pathways are restricted to prevent excessive hydrologic

loading. Two types of restricting layers can be incorporated into bioretention designs:

- Clay (bentonite) liners are low permeability liners. Where clay liners are used under-drain systems are necessary. See Volume V [section 4.4.3](#) for guidelines.
- Geomembrane liners completely block infiltration to subgrade soils and are used for ground water protection when bioretention facilities are installed to filter storm flows from pollutant hotspots or on sidewalls of bioretention areas to restrict lateral flows to roadbeds or other sensitive infrastructure. Where geomembrane liners are used to line the entire facility under-drain systems are necessary. The liner should have a minimum thickness of 30 mils and be ultraviolet (UV) resistant.

Plant materials

In general, the predominant plant material utilized in bioretention areas are facultative species adapted to stresses associated with wet and dry conditions. Soil moisture conditions will vary within the facility from saturated (bottom of cell) to relatively dry (rim of cell). Accordingly, wetland plants may be used in the lower areas, if saturated soil conditions exist for appropriate periods, and drought-tolerant species planted on the perimeter of the facility or on mounded areas. See *Low Impact Development Technical Guidance Manual for the Puget Sound Basin* for additional guidance and recommended plant species.

Mulch layer

You can design Bioretention areas with or without a mulch layer. When used, mulch shall be:

- Coarse compost in the bottom of the facilities (compost is less likely to float during cell inundation).
- Shredded or chipped hardwood or softwood on side slopes above ponding elevation and rim area. Arborist mulch is mostly woody trimmings from trees and shrubs and is a good source of mulch material. Wood chip operations are a good source for mulch material that has more control of size distribution and consistency. Do not use shredded construction wood debris or any shredded wood to which preservatives have been added.
- Free of weed seeds, soil, roots and other material that is not **bole** or branch wood and bark.
- A maximum of 2 to 3 inches thick.

Mulch shall **not** be:

- Grass clippings (decomposing grass clippings are a source of nitrogen and are not recommended for mulch in bioretention areas).
- Pure bark (bark is essentially sterile and inhibits plant establishment).

In bioretention areas where higher flow velocities are anticipated an aggregate mulch may be used to dissipate flow energy and protect underlying Bioretention Soil Mix. Aggregate mulch varies in size and type, but 1 to 1 1/2 inch gravel (rounded) decorative rock is typical.

Installation

Excavation

Soil compaction can lead to facility failure; accordingly, minimizing compaction of the base and sidewalls of the bioretention area is critical. Excavation should never be allowed during wet or saturated conditions (compaction can reach depths of 2-3 feet during wet conditions and mitigation is likely not be possible). Excavation should be performed by

machinery operating adjacent to the bioretention facility and no heavy equipment with narrow tracks, narrow tires, or large lugged, high pressure tires should be allowed on the bottom of the bioretention facility. If machinery must operate in the bioretention cell for excavation, use light weight, low ground-contact pressure equipment and rip the base at completion to refracture soil to a minimum of 12 inches. If machinery operates in the facility, subgrade infiltration rates must be field tested and compared to design rates. Failure to meet or exceed the design infiltration rate will require revised engineering designs to verify achievement of treatment and flow control benefits that were estimated in the Stormwater Site Plan.

Prior to placement of the BSM, the finished subgrade shall:

- Be scarified to a minimum depth of 3 inches.
- Have any sediment deposited from construction runoff removed. To remove all introduced sediment, subgrade soil should be removed to a depth of 3-6 inches and replaced with BSM.
- Be inspected by the responsible engineer to verify required subgrade condition.

Sidewalls of the facility, beneath the surface of the BSM, can be vertical if soil stability is adequate. Exposed sidewalls of the completed bioretention area with BSM in place should be no steeper than 3H:1V. The bottom of the facility should be flat.

Soil Placement

On-site soil mixing or placement shall not be performed if Bioretention Soil Mix or subgrade soil is saturated. The bioretention soil mixture should be placed and graded by machinery operating adjacent to the bioretention facility. If machinery must operate in the bioretention cell for soil placement, use light weight equipment with low ground-contact pressure. If machinery operates in the facility, subgrade infiltration rates must be field tested and compared to design rates. Failure to meet or exceed the design infiltration rate will require revised engineering designs to verify achievement of treatment and flow control benefits that were estimated in the Stormwater Site Plan.

The soil mixture shall be placed in horizontal layers not to exceed 12 inches per lift for the entire area of the bioretention facility.

Compact the Bioretention Soil Mix to a relative compaction of 85 percent of modified maximum dry density (ASTM D 1557). Compaction can be achieved by boot packing (simply walking over all areas of each lift), and then apply 0.2 inches (0.5 cm) of water per 1 inch (2.5 cm) of Bioretention Soil Mix depth. Water for settling should be applied by spraying or sprinkling.

Temporary Erosion and Sediment Control (TESC)

Controlling erosion and sediment are most difficult during clearing, grading, and construction; accordingly, minimizing site disturbance to the greatest extent practicable is the most effective sediment management.

During construction:

- Bioretention facilities should not be used as sediment control facilities and all drainage should be directed away from bioretention facilities after initial rough grading. Flow can be directed away from the facility with temporary diversion swales or other approved protection. If introduction of construction runoff cannot be avoided see below for guidelines.
- Construction on Bioretention facilities should not begin until all contributing drainage areas are stabilized according to erosion and sediment control BMPs and to the satisfaction of the engineer.
- If the design includes curb and gutter, the curb cuts and inlets should be blocked until Bioretention Soil Mix and mulch have been placed and planting completed (when possible), and dispersion pads are in place.

Every effort during design, construction sequencing and construction should be made to prevent sediment from entering bioretention facilities. However, bioretention areas are often distributed throughout the project area and can present unique challenges during construction. See the *Low Impact Technical Guidance Manual for the Puget Sound Basin* for guidelines if no other options exist and runoff during construction must be directed through the bioretention facilities.

Erosion and sediment control practices must be inspected and maintained on a regular basis.

Verification

If using the default bioretention soil media, pre-placement laboratory analysis for saturated hydraulic conductivity of the bioretention soil media is not required. Verification of the mineral aggregate gradation, compliance with the compost specifications, and the mix ratio must be provided.

If using a custom bioretention soil media, verification of compliance with the minimum design criteria cited above for such custom mixes must be provided. This will require laboratory testing of the material that will be used in the installation. Testing shall be performed by a Seal of Testing Assurance, AASHTO, ASTM or other standards organization accredited laboratory with current and maintained certification. Samples for testing must be supplied from the BSM that will be placed in the bioretention areas.

If testing infiltration rates is necessary for post-construction verification use the Pilot Infiltration Test (PIT) method or a double ring infiltrometer test (or other small-scale testing allowed by the local government with

jurisdiction). If using the PIT method, do not excavate Bioretention Soil Mix (conduct test at level of finished Bioretention Soil Mix elevation), use a maximum of 6 inch ponding depth and conduct test before plants are installed.

Maintenance

Bioretention areas require annual plant, soil, and mulch layer maintenance to ensure optimum infiltration, storage, and pollutant removal capabilities. In general, bioretention maintenance requirements are typical landscape care procedures and include:

- Watering: Plants should be selected to be drought tolerant and not require watering after establishment (2 to 3 years). Watering may be required during prolonged dry periods after plants are established.
- Erosion control: Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred. Properly designed facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems occur the following should be reassessed: (1) flow volumes from contributing areas and bioretention cell sizing; (2) flow velocities and gradients within the cell; and (3) flow dissipation and erosion protection strategies in the pretreatment area and flow entrance. If sediment is deposited in the bioretention area, immediately determine the source within the contributing area, stabilize, and remove excess surface deposits.
- Sediment removal: Follow the maintenance plan schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Plant material: Depending on aesthetic requirements, occasional pruning and removing dead plant material may be necessary. Replace all dead plants and if specific plants have a high mortality rate, assess the cause and replace with appropriate species. Periodic weeding is necessary until plants are established.
- Weeding: Invasive or nuisance plants should be removed regularly and not allowed to accumulate and exclude planted species. At a minimum, schedule weeding with inspections to coincide with important horticultural cycles (e.g., prior to major weed varieties dispersing seeds). Weeding should be done manually and without herbicide applications. The weeding schedule should become less frequent if the appropriate plant species and planting density are used and the selected plants grow to capture the site and exclude undesirable weeds.
- Nutrient and pesticides: The soil mix and plants are selected for optimum fertility, plant establishment, and growth. Nutrient and pesticide inputs should not be required and may degrade the pollutant processing capability of the bioretention area, as well as contribute pollutant loads to receiving waters. By design, bioretention facilities

are located in areas where phosphorous and nitrogen levels may be elevated and these should not be limiting nutrients. If in question, have soil analyzed for fertility.

- Mulch: Replace mulch annually in bioretention facilities where heavy metal deposition is high (e.g., contributing areas that include gas stations, ports and roads with high traffic loads). In residential settings or other areas where metals or other pollutant loads are not anticipated to be high, replace or add mulch as needed (likely 3 to 5 years) to maintain a 2 to 3 inch depth.

Soil: Soil mixes for bioretention facilities are designed to maintain long-term fertility and pollutant processing capability. Estimates from metal attenuation research suggest that metal accumulation should not present an environmental concern for at least 20 years in bioretention systems, but this will vary according to pollutant load. Replacing mulch media in bioretention facilities where heavy metal deposition is likely provides an additional level of protection for prolonged performance. If in question, have soil analyzed for fertility and pollutant levels.

BMP T7.40: Compost-amended Vegetated Filter Strips (CAVFS)

Description

The CAVFS is a variation of the basic vegetated filter strip that adds soil amendments to the roadside embankment (See Figure 7.4.3). The soil amendments improve infiltration characteristics, increase surface roughness, and improve plant sustainability. Once permanent vegetation is established, the advantages of the CAVFS are higher surface roughness; greater retention and infiltration capacity; improved removal of soluble cationic contaminants through sorption; improved overall vegetative health; and a reduction of invasive weeds. Compost-amended systems have somewhat higher construction costs due to more expensive materials, but require less land area for runoff treatment, which can reduce overall costs.

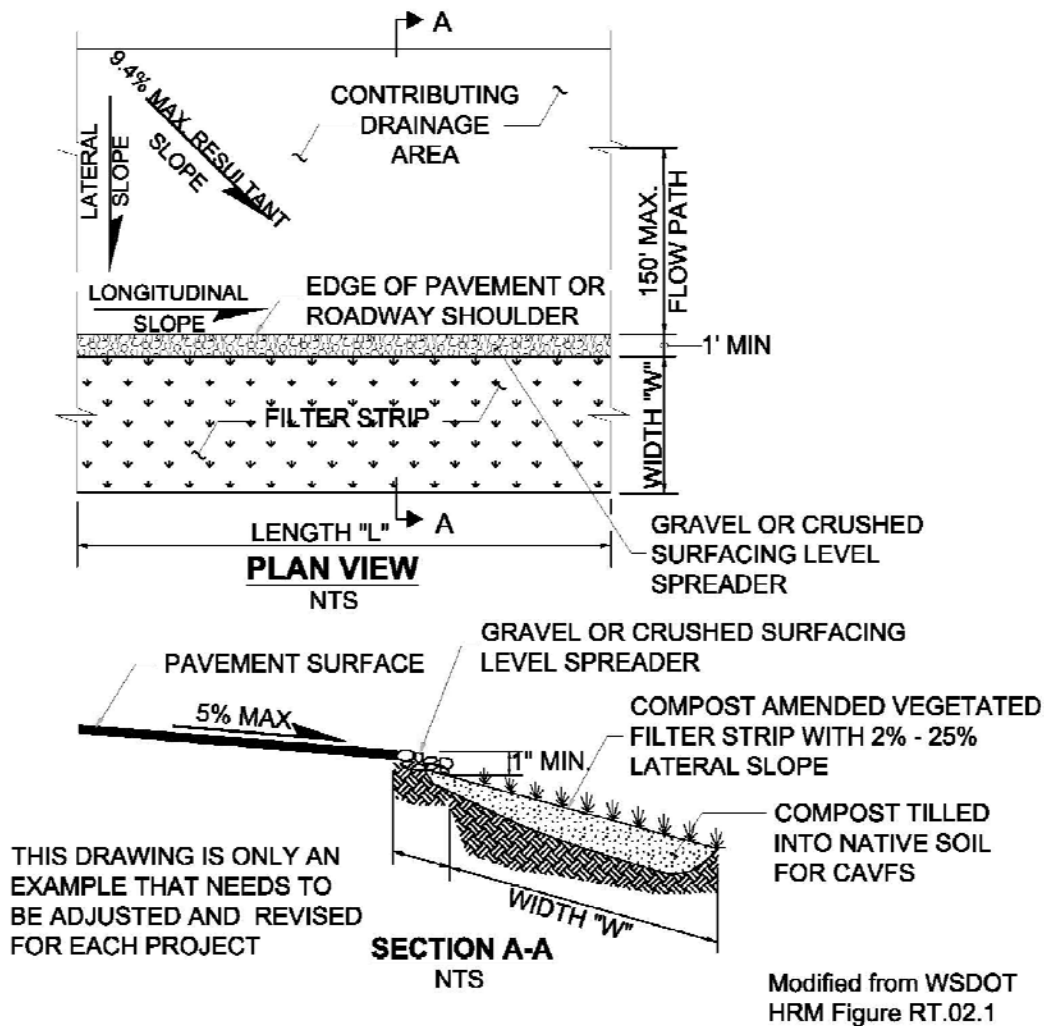


Figure 7.4.3 – Example of a Compost Amended Vegetated Filter Strip (CAVFS)

Applications

CAVFS can be used to meet basic runoff treatment and enhanced runoff treatment objectives. It has practical application in areas where there is space for roadside embankments that can be built to the CAVFS specifications.

Soil Design Criteria

The CAVFS design incorporates compost into the native soils per the criteria in BMP T5.13 for turf areas. The goal is to create a healthy soil environment for a lush growth of turf.

Soil/Compost Mix:

- Presumptive approach: Place and rototill 1.75 inches of composted material into 6.25 inches of soil (a total amended depth of about 9.5 inches), for a settled depth of 8 inches. Water or roll to compact soil to 85% maximum. Plant grass.
- Custom approach: Place and rototill the calculated amount of composted material into a depth of soil needed to achieve 8 inches of settled soil at 5% organic content. Water or roll to compact soil to 85% maximum. Plant grass. The amount of compost or other soil amendments used varies by soil type and organic matter content. If there is a good possibility that site conditions may already contain a relatively high organic content, then it may be possible to modify the pre-approved rate described above and still be able to achieve the 5% organic content target.
- The final soil mix (including compost and soil) should have an initial saturated hydraulic conductivity less than 12 inches per hour, and a minimum long-term hydraulic conductivity of 1.0 inch/hour per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 85% compaction per ASTM Designation D 1557 (Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort. Infiltration rate and hydraulic conductivity are assumed to be approximately the same in a uniform mix soil. Note: Long term saturated hydraulic conductivity is determined by applying the appropriate infiltration correction factors as explained under “Determining Bioretention soil mix infiltration rate” under [BMP T7.30](#).
- The final soil mixture should have a minimum organic content of 5% by dry weight per ASTM Designation D 2974 (Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils) (Tackett, 2004).
- Achieving the above recommendations will depend on the specific soil and compost characteristics. In general, the recommendation can be achieved with 60% to 65% loamy sand mixed with 25% to 30% compost or 30% sandy loam, 30% coarse sand, and 30% compost.
- The final soil mixture should be tested prior to installation for fertility, micronutrient analysis, and organic material content.
- Clay content for the final soil mix should be less than 5%.
- Compost must not contain biosolids, any street or highway sweepings, or any catch basin solids.

- The pH for the soil mix should be between 5.5 and 7.0 (Stenn, 2003). If the pH falls outside the acceptable range, it may be modified with lime to increase the pH or iron sulfate plus sulfur to lower the pH. The lime or iron sulfate must be mixed uniformly into the soil prior to use in LID areas (Low-Impact Development Center, 2004).
- The soil mix should be uniform and free of stones, stumps, roots, or other similar material larger than 2 inches.
- When placing topsoil, it is important that the first lift of topsoil is mixed into the top of the existing soil. This allows the roots to penetrate the underlying soil easier and helps prevent the formation of a slip plane between the two soil layers.

Soil Component:

The texture for the soil component of the LID BMP soil mix should be loamy sand (USDA Soil Textural Classification).

Compost Component:

Follow the specifications for compost in BMP T7.30 – Bioretention

***Design Modeling
Method***

The CAVFS will have an “Element” in the approved continuous runoff models that must be used for determining the amount of water that is treated by the CAVFS. To fully meet treatment requirements, Ninety-one percent of the influent runoff file must pass through the soil profile of the CAVFS. Water that merely flows over the surface is not considered treated. Approved continuous runoff models should be able to report the amount of water that it estimates will pass through the soil profile.

Maintenance

Compost, as with sand filters or other filter mediums, can become plugged with fines and sediment, which may require removal and replacement. Including vegetation with compost helps prevent the medium from becoming plugged with sediment by breaking up the sediment and creating root pathways for stormwater to penetrate into the compost. It is expected that soil amendments will have a removal and replacement cycle; however, this time frame has not yet been established.

- The space available for ponding water within a Bio-infiltration swale can be sized by either:
 - Completely retaining the water quality design volume, i.e., the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model (or, the runoff volume from a 6-month 24-hour storm). No reduction in volume is taken for any infiltration. Under this option, the overflow to a dry well or to a surface water must be above the elevation corresponding to the water quality design volume.
 - Using the same design sizing procedures outlined in Chapter 3 of Volume III for infiltration facilities designed as treatment facilities.

- Drawdown time for the water quality design volume: 48 hours max. See Site Suitability Criterion (SSC 4) in Section 3.3.7, Chapter 3, Volume III.
- Swale bottom: flat with a longitudinal slope less than 1%.
- The maximum ponded level: 6 inches.
- Treatment soil to be at least 18 inches thick with a CEC of at least 5 meq/100 gm dry soil, organic content of at least 1%, and sufficient target pollutant loading capacity. The design soil thickness may be reduced to as low as 6 inches if appropriate performance data demonstrates that the vegetated root zone and the natural soil can be expected to provide adequate removal and loading capacities for the target pollutants. The design professional should calculate the pollutant loading capacity of the treatment soil to estimate if there is sufficient treatment soil volume for an acceptable design period. (See Criteria for Assessing the Trace Element Removal Capacity of Bio-filtration Systems, Stan Miller, Spokane County, June 2000).
- Other combinations of treatment soil thickness, CEC, and organic content design factors can be considered if it is demonstrated that the soil and vegetation will provide a target pollutant loading capacity and performance level acceptable to the local jurisdiction.
- The treatment zone depth of 6 inches or more should contain sufficient organics and texture to ensure good growth of the vegetation.
- The treatment soil infiltration rate should not exceed 1-inch per hour for a treatment zone depth of 6 inches relying on the root zone to enhance pollutant removal. The Site Suitability Criteria in Section 3.3.7 of Chapter 3, Volume III must also be applied, if a design soil depth of 18 inches is used then a maximum infiltration rate of 2.4 inches per hour is applicable.
- Use native or adapted grass should be used.
- Pretreatment of debris, gross TSS, and oil & grease to prevent the clogging of the treatment soil and/or growth of the vegetation, where necessary.
- Identify pollutants, particularly in industrial and commercial area runoff, that could cause a violation of Ecology's ground water quality Standards ([Chapter 173-200 WAC](#)~~(Chapter 173-200 WAC)~~). Include appropriate mitigation measures (pretreatment, source control, etc.) for those pollutants.

Sand

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Chapter 8. - Filtration Treatment Facilities

Note: Figures in Chapter 8 are courtesy of King County, except as noted.

This Chapter presents criteria for the design, construction and maintenance of runoff treatment sand filters including basin, vault, and linear filters.

~~Two Best Management Practices (BMPs) are discussed in this Chapter:~~

~~BMP T8.10 Sand Filter Vault~~

~~BMP T8.20 Linear Sand Filter~~

8.1 Purpose

~~To~~ Filtration treatment facilities collect and treat ~~the~~ design runoff ~~volumes~~ to remove total suspended solids (TSS), phosphorous, and insoluble organics (including oils) from stormwater.

8.2 Description

A typical sand filtration system consists of a ~~a~~ pretreatment system, flow spreader(s), ~~a~~ sand bed, and ~~the~~ underdrain piping. The sand filter bed includes a geotextile fabric between the sand bed and the bottom underdrain system.

Provide an impermeable liner under the facility ~~may also be needed~~ if the filtered runoff requires additional treatment to remove soluble ground water pollutants; ~~or in cases~~ where additional ground water protection ~~was~~ mandated.

The variations of a sand filter include a basic ~~or~~ sand filter basin, large sand filter, ~~sand filter with level spreader~~ basin, sand filter vault, and linear sand filter. (Figures ~~8.1 through 8.7~~ throughout this chapter provide examples of various sand filter configurations).)

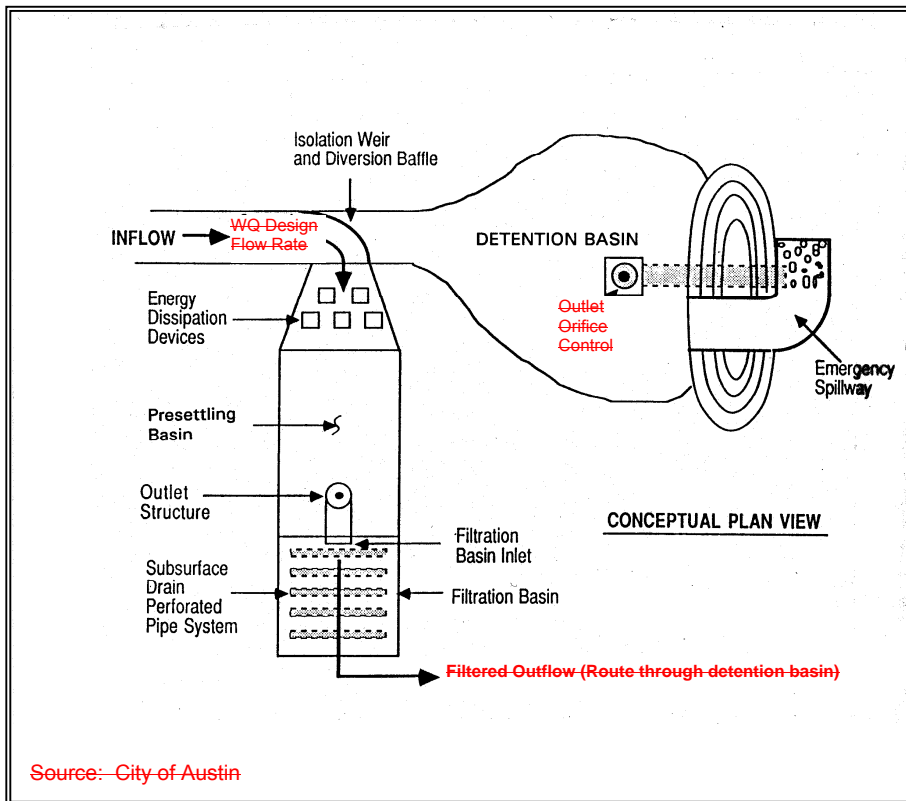


Figure 8.1— Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)

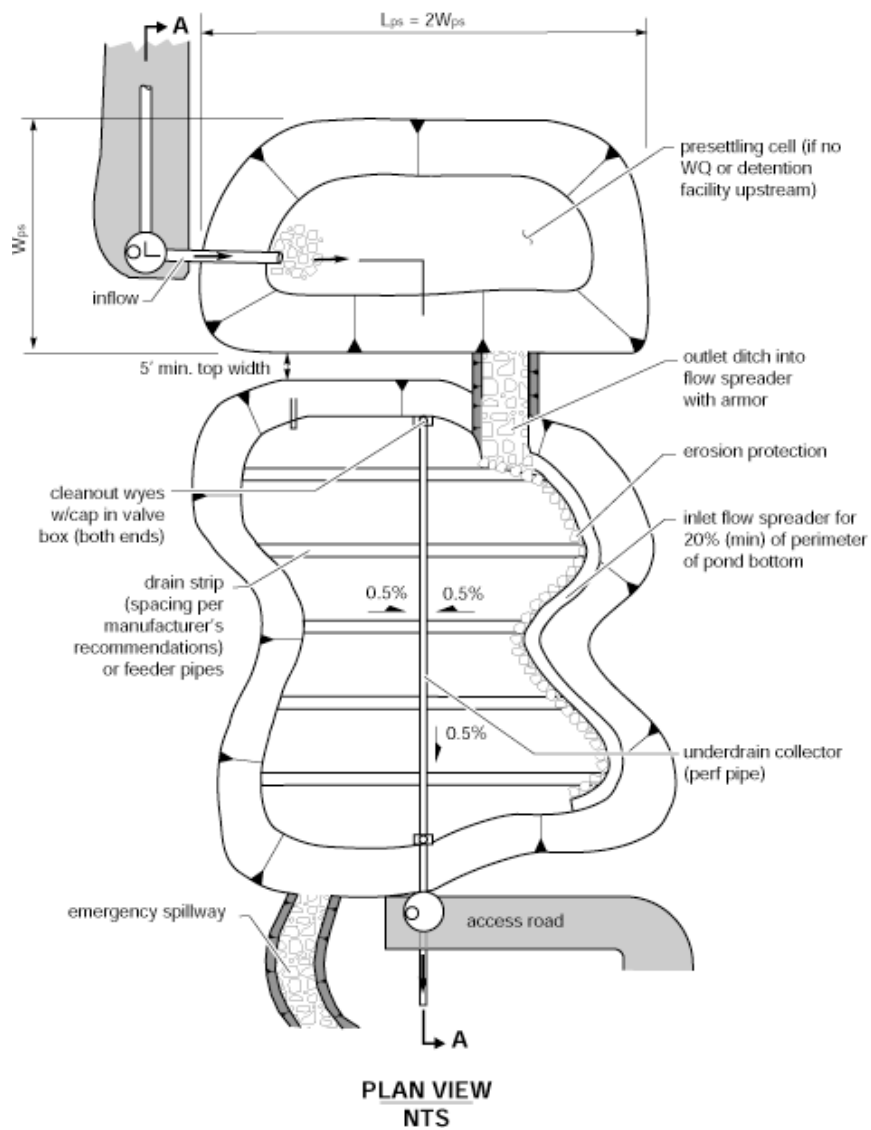


Figure 8.2 — Sand Filter with Pretreatment Cell

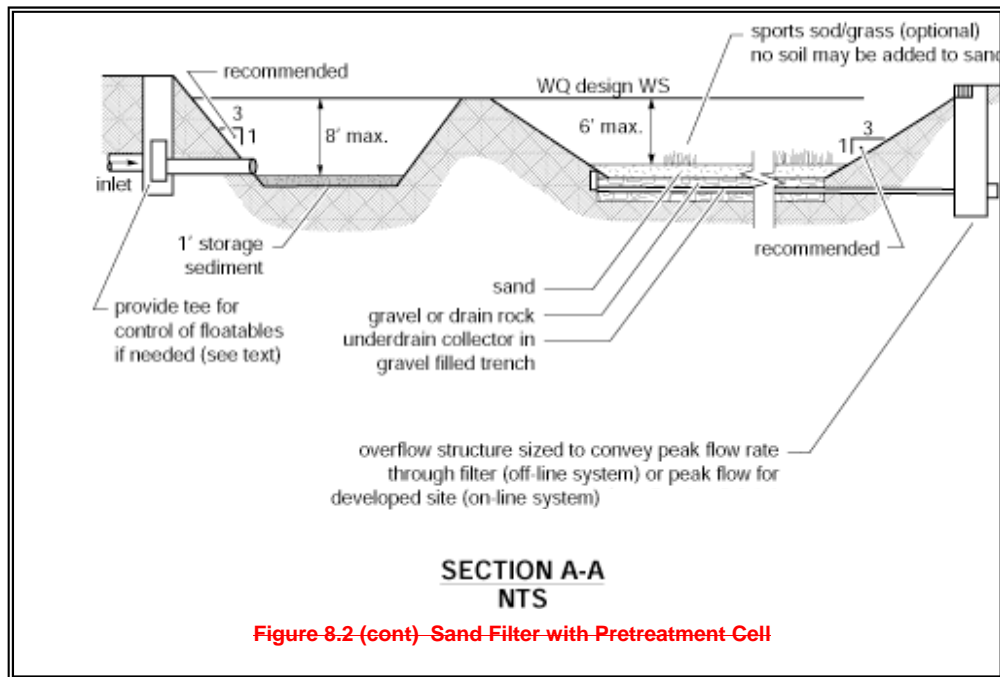


Figure 8.3 Sand Filter with Level Spreader

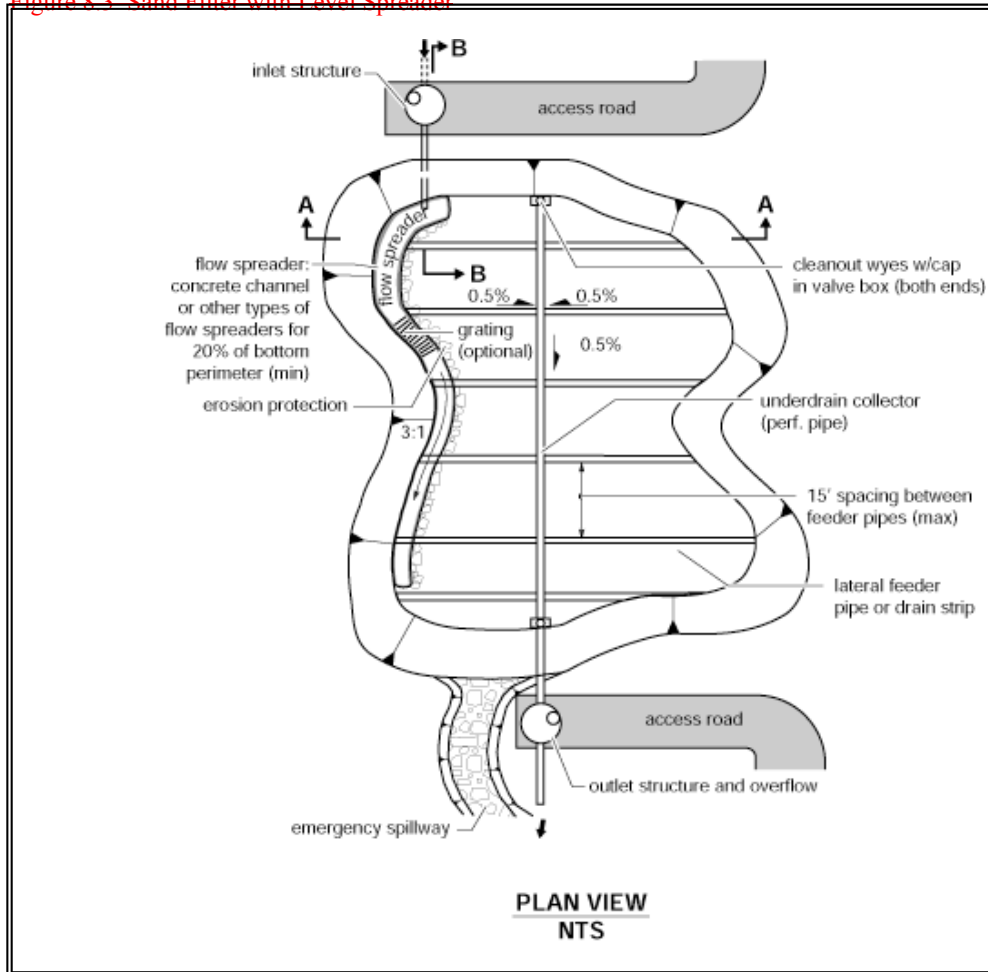


Figure 8.3 – Sand Filter with Level Spreader

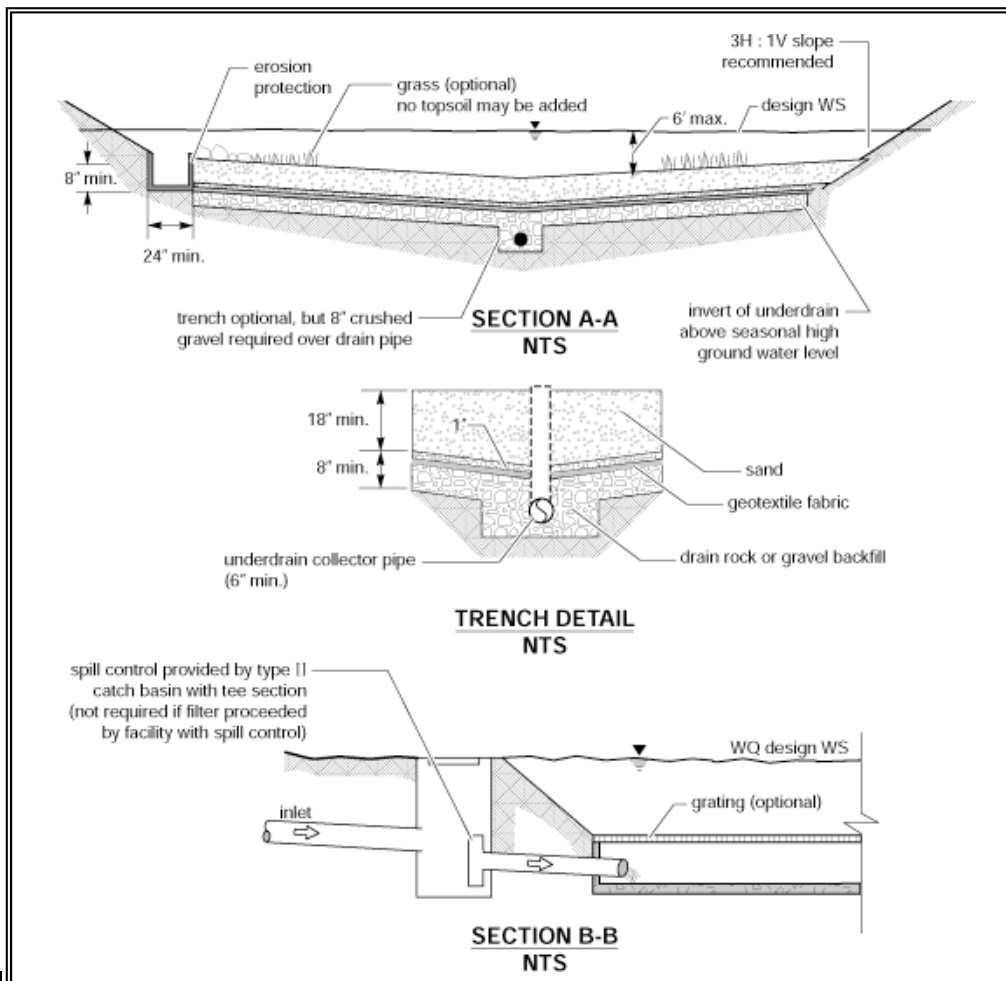
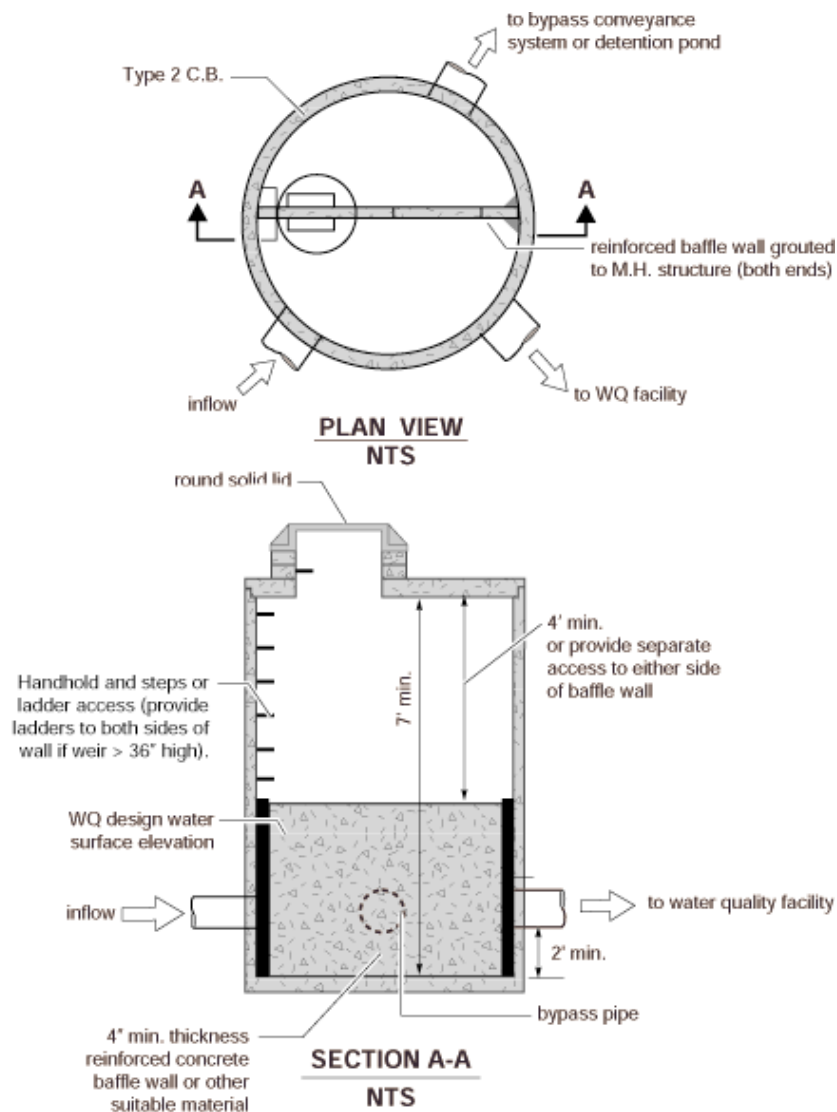
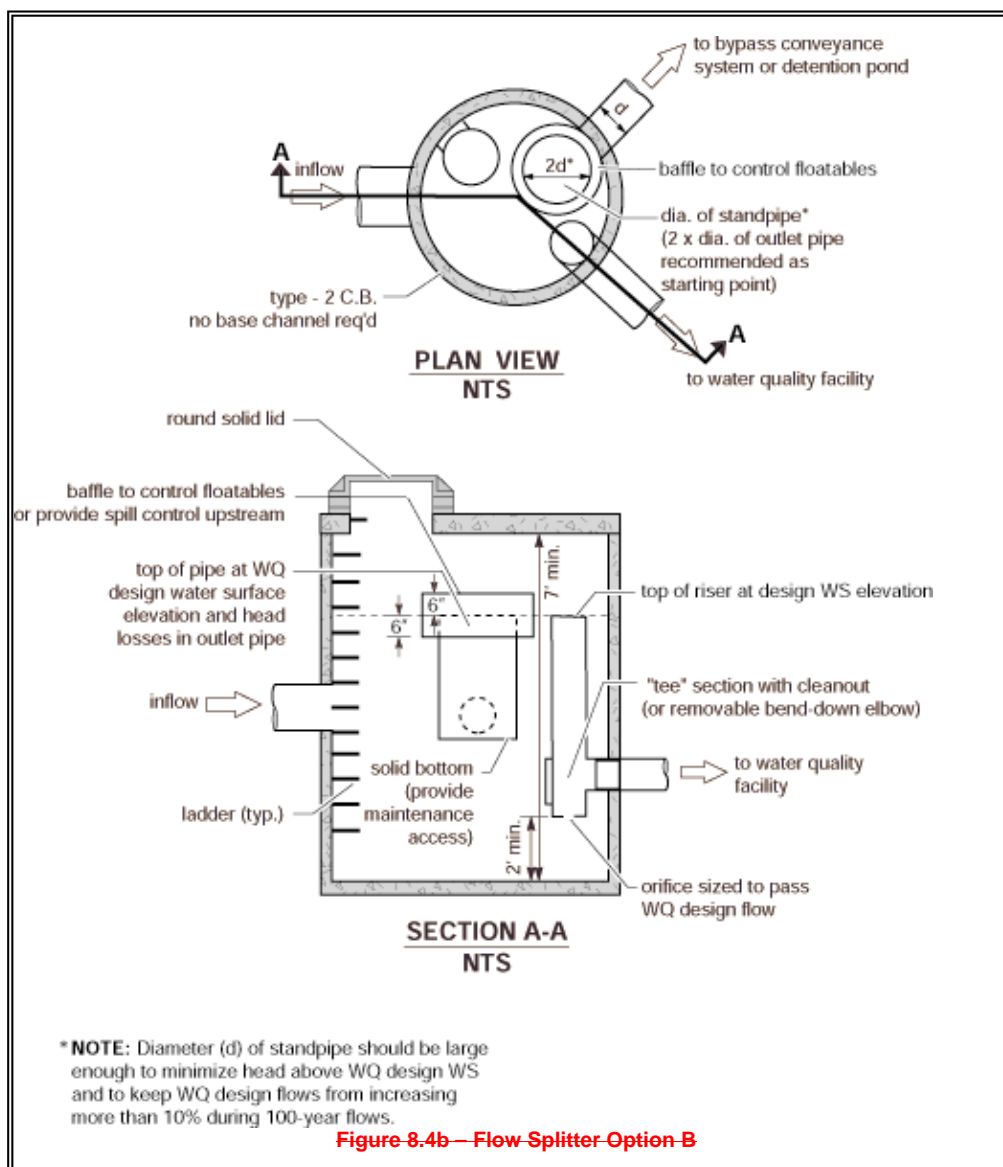


Figure 8.3 (cont) Sand Filter with Level Spreader



Note: The water quality discharge pipe may require an orifice plate be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

Figure 8.4a – Flow Splitter Option A



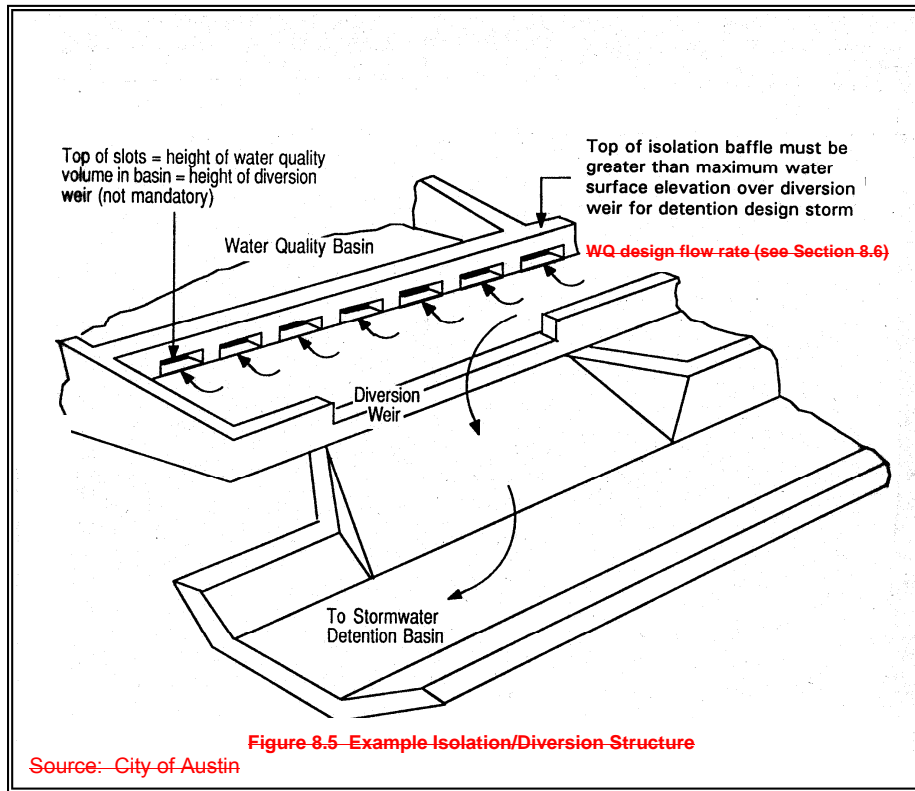


Figure 8.5—Example Isolation/Diversion Structure

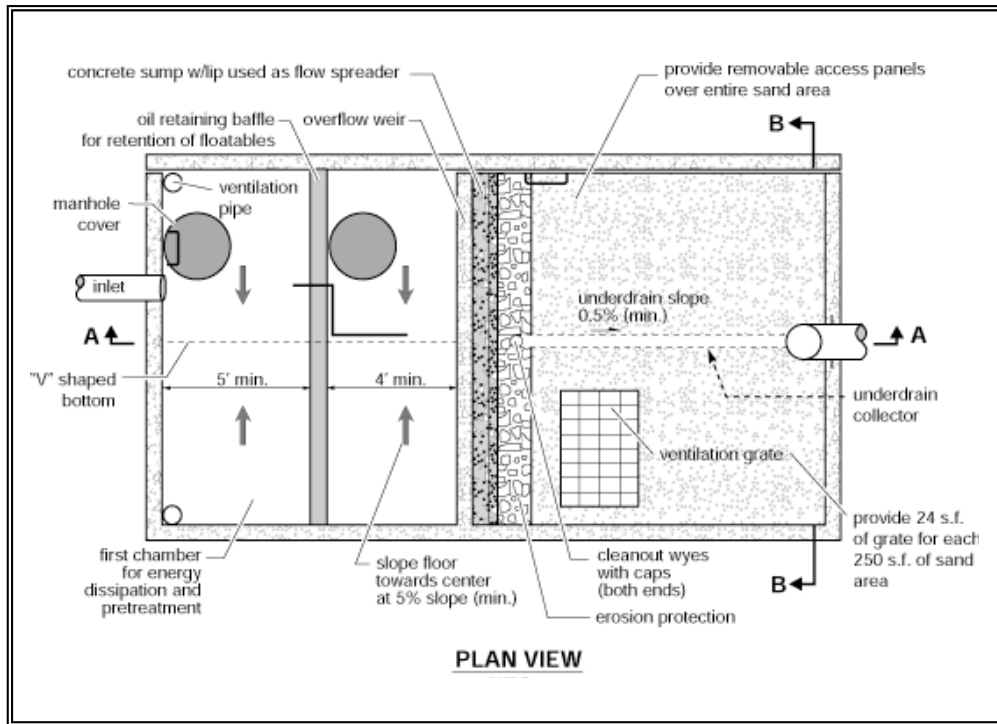


Figure 8.6a—Sand Filter Vault

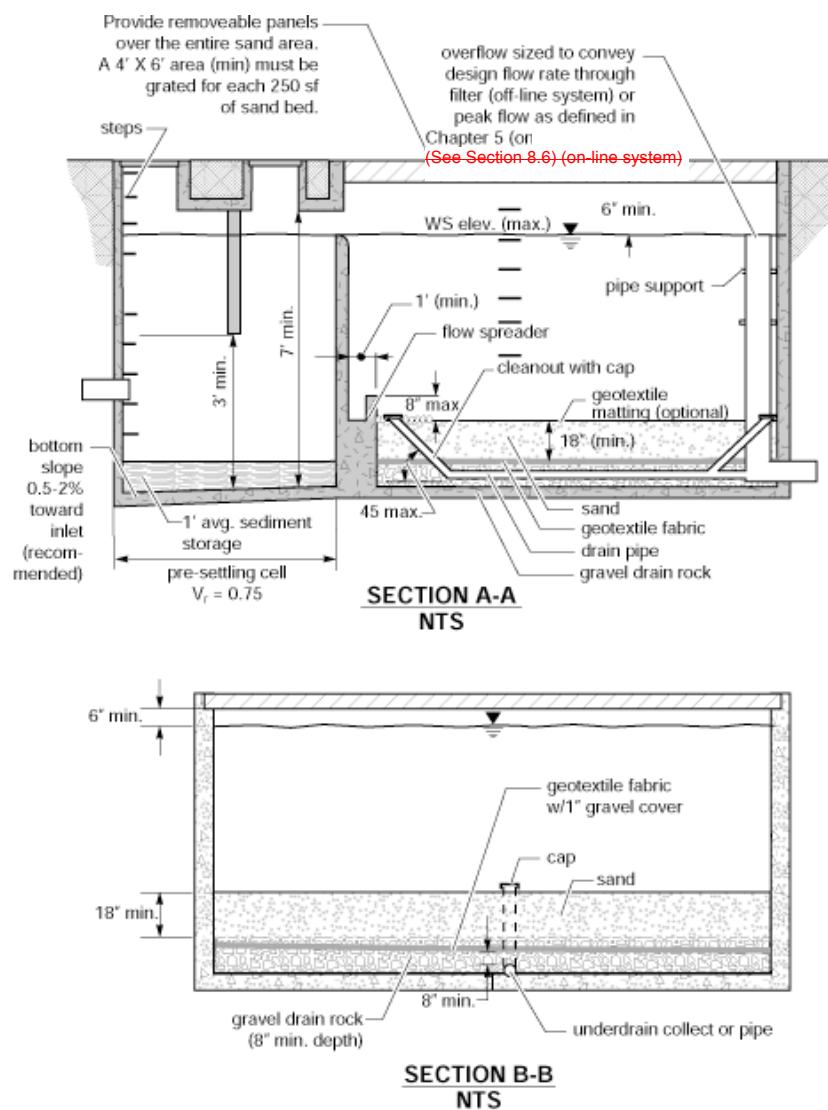


Figure 8.6b—Sand Filter Vault (cont)

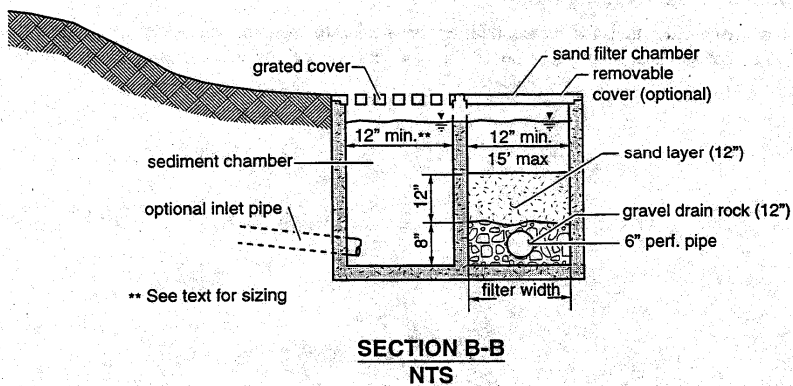
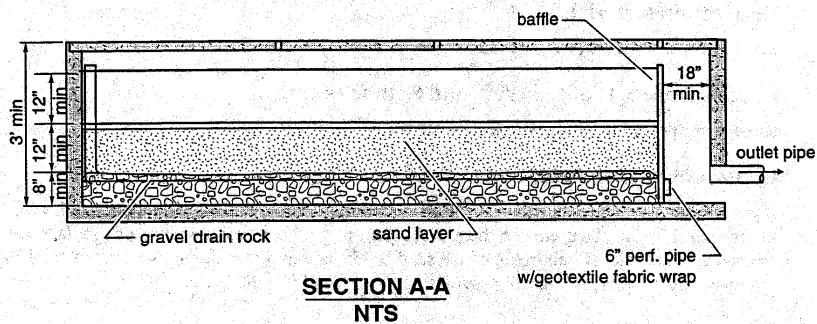
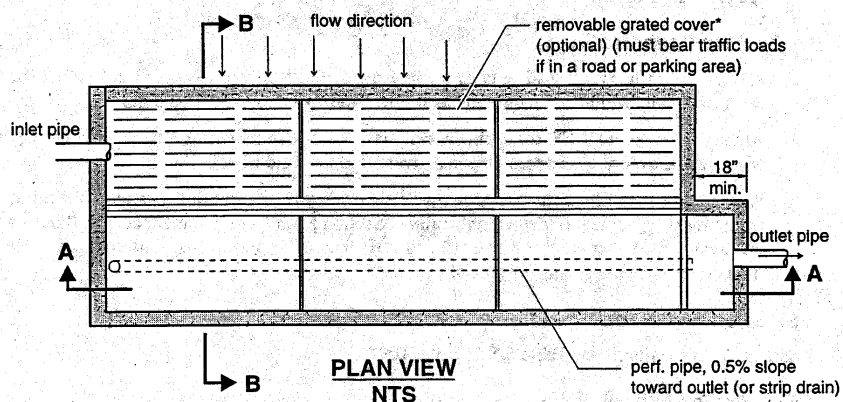


Figure 8.7—Linear Sand Filter

The Media Filter Drain (MFD) has four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. The MFD mix is composed of gravel, perlite, dolomite, and gypsum.

8.3 Performance Objectives

Refer to Chapter 3 for descriptions of the ~~Basic sand filter~~, Oil, Phosphorous, and Enhanced Performance Treatment Goals.

Basic Sand Filter Vault, Sand Filter Vault, and Linear Sand Filter: Ecology expects basic sand filters ~~are expected to~~ achieve the ~~performance goals for Basic Treatment. Based upon experience in King County and Austin, Texas basic sand filters should be capable of achieving the~~ following average pollutant removals:

- Basic Performance Treatment Goal: ~~80 percent %~~ total suspended solids (TSS) at influent Event Mean Concentrations (EMCs) of ~~30-300~~100-200 mg/L (King County, 1998) (Chang, 2000).
- Oil Performance Treatment Goal: Oil and grease to below 10 mg/L daily average and 15 mg/L at any time, with no ongoing or recurring visible sheen in the discharge.

Large Sand filter: Ecology expects large sand filters ~~are expected to~~ ~~remove~~meet the Phosphorous Treatment Goal by removing at least 50 percent% of the total phosphorous compounds (~~influent 0.1 to 0.5 mg/L, as TP~~total phosphorous) and by collecting and treating 95% of the runoff volume. (ASCE and WEF, 1998)

Media filter drain: Ecology expects media filter drains to achieve the:

- Basic Treatment Goal
- Phosphorous Treatment Goal
- Dissolved Metals (Enhanced) Treatment Goals: ~~greater than 30% reduction of dissolved copper, and greater than 60% reduction of dissolved zinc.~~

8.4 Applications and Limitations

~~Sand~~ Filtration can be used in most residential, commercial, and industrial developments where debris, heavy sediment loads, and oils and greases will not clog or prematurely overload the sand, or where adequate pretreatment is provided for these pollutants. Specific applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, high-use sites, high-density multi-family housing, roadways, and bridge decks.

~~Locate~~ sand filters ~~should be located~~ off-line before or after detention (Chang, 2000). Sand filters are also suited for locations with space

constraints in retrofit, and new/re-development situations. Carefully design overflow or bypass structures ~~must be carefully designed~~ to handle the larger storms. ~~An~~ Size off-line ~~system is sized~~ systems to treat 91% of the runoff volume predicted by a continuous runoff model. If a project must comply with Minimum Requirement #7, Flow Control, route the flows bypassing the filter and the filter discharge ~~must be routed~~ to a retention/detention facility.

Pretreatment is necessary to reduce velocities to the sand filter and remove debris, floatables, large particulate matter, and oils. In high water table areas, adequate drainage of the sand filter may require additional engineering analysis and design considerations. Consider an underground filter ~~should be considered~~ in areas subject to freezing conditions. (Urbonas, 1997).

8.5 Site Suitability

~~The following site characteristics should be considered in siting a sand filtration system:~~

- ~~Space availability, including a presettling basin~~
- ~~Sufficient hydraulic head, at least 4 feet from inlet to outlet~~

Adequate Operation and Maintenance capability including accessibility Best Management Practices (BMPs) for O & M Sand Filtration

BMP T8.10: Basic Sand Filter Basin

Description

A sand filter basin is constructed so that its surface is at grade and open to the elements, much as an infiltration basin. However, instead of infiltrating into native soils, stormwater filters through a constructed sand bed with an underdrain system. See [Figures 8.5.1](#) through [8.5.4](#) for more details.

Applications and Limitations

Use a sand filter basin to capture and treat the Water Quality Design Storm volume (see [Section 4.1.1](#)); which is 91% of the total runoff volume as predicted by Western Washington Hydrology Model (WWHM). Only 9% of the total runoff volume would bypass or overflow from the sand filter facility.

- ~~Sufficient pretreatment of oil, debris and solids in the tributary runoff~~

~~8.6 Design Criteria~~

~~**Objective:** To capture and treat the Water Quality Design Storm volume which is 91% of the total runoff volume (95% for large sand filter) as predicted by Western Washington Hydrology Model (WWHM) (or an approved, equivalent continuous runoff model). Only 9% of the total~~

runoff volume (5% for large sand filter) would bypass or overflow from the sand filter facility. Locate off-line sand filters ~~can be located~~ either upstream or downstream of detention facilities. Only locate on-line sand filters ~~should only be located~~ downstream of detention ~~to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.~~

Basic Sand Filter:

~~A summary of the basic sand filter design requirements are given below. For off-line facilities, a flow splitter should be designed to route the water quality design flow rate to the sand filter.~~

~~***On-line*** sand filters must NOT be placed ***upstream*** of a detention facility. This is to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.~~

Site Suitability

Consider the following site characteristics when siting a sand filtration system:

- Space availability, including a presettling basin
- Sufficient hydraulic head, at least 4 feet from inlet to outlet
- Adequate Operation and Maintenance capability including accessibility for O & M
- Sufficient pretreatment of oil, debris and solids in the tributary runoff

Design Criteria

Hydraulics

If the drainage area maintains a base flow between storm events, bypass the base flow around the filter to keep the sand from remaining saturated for extended periods.

Assume a ***design filtration rate*** of 1 inch per hour. Though the sand specified below will initially infiltrate at a much higher rate, that rate will slow as the filter accumulates sediment. When the filtration rate falls to 1 inch per hour, removal of sediment is necessary to maintain rates above the rate assumed for sizing purposes.

On-line:

- Do NOT place ***upstream*** of a detention facility. In order to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.
- Size on-line sand filters placed ***downstream*** of a detention facility must be sized using a continuous runoff model (WWHM or an approved equivalent continuous runoff model) to filter ~~91% of the water quality~~ runoff volume.
- Include an ***overflow*** in the design. The overflow height should be at the maximum hydraulic head of the pond above the sand bed. On-line filters shall have overflows (primary, secondary, and

emergency) in accordance with the design criteria for detention ponds (Volume III, Section 3.2.1).

Off-line:

- Off-line sand filters placed **upstream** of a detention facility must have a flow splitter designed to send all flows at or below the 15-minute water quality flow rate, as predicted by WWHM, to the sand filter. ~~The sand filter must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur). Note that WWHM2 allows any bypasses and the runoff filtered through the sand to be directed to the downstream detention facility.~~
- Size the facility to filter all the runoff sent to it (no overflows from the treatment facility should occur). Note that WWHM allows bypass flows and filtered runoff to be directed to the downstream detention facility.
- Off-line sand filters placed **downstream** of a detention facility must have a flow splitter designed to send all flows at or below the 2-year flow frequency from the detention pond, as predicted by WWHM, to the treatment facility. The treatment facility must be sized to filter all the runoff sent to it (no overflows from the treatment facility should occur).

-

Large Sand Filter: ~~For a summary of the large sand filter off-line filters, design requirements follow the underdrain structure to pass the requirements for the basic sand filter except, for the percent 2-year peak inflow rate, as determined using 15-minute time steps in an approved continuous runoff filtered, use 95% instead of 91%.~~

- ~~Note: An overflow should be included in the design of the basic and large sand filter pond. The overflow height should be at the maximum hydraulic head of the pond above the sand bed model.~~

Additional Design Information: Criteria

1. ~~1. Runoff to be treated by the sand filter must be pretreated~~ Pretreat (e.g., presettling basin, etc. depending on pollutants) runoff directed to the sand filter to remove debris and other solids, ~~and oil from. In high use sites, the pretreatment should be an appropriate oil treatment as described in Section 3.3.~~
2. 2. Design inlet bypass and flow spreading structures (e.g., flow spreaders, weirs or multiple orifice openings) ~~should be designed~~ to capture the applicable design flow rate, minimize turbulence and to spread the flow uniformly across the surface of the sand filter. Install stone riprap or other energy dissipation devices ~~should be installed~~ to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures ~~(see Vol. III).~~

- a. ~~3.~~ If the sand filter is curved or an irregular shape, provide a flow spreader for a minimum of 20 percent of the filter perimeter.
 - b. If the length-to-width ration of the filter is 2:1 or greater, locate a flow spreader on the longer side of the filter and for a minimum length of 20 percent of the facility perimeter.
 - c. Provide erosion protection along the first foot of the sand bed adjacent to the flow spreader. Methods for this include geotextile weighted with sand bags at 15-foot intervals and quarry spalls.
3. The following are design criteria for the underdrain piping:
- Types of acceptable underdrains ~~include:~~
 - A central collector pipe with lateral feeder pipes, ~~or, in an 8-inch gravel backfill or drain rock bed.~~
 - A central collector pipe with a geotextile drain strip in an 8-inch gravel backfill or drain rock bed, ~~or,~~
 - Longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.
 - Upstream of detention, size underdrain piping ~~should be sized~~ to handle double the two-year return frequency flow indicated by ~~the~~ WWHM (the doubling factor is a safety factor used in the absence of a conversion factor from the 1-hr. time step to a 15 minute time step). Downstream of detention, size the underdrain piping ~~should be sized~~ for the two-year return frequency flow indicated by ~~the~~ WWHM. In both instances ~~there should be provide~~ at least one (1) foot of hydraulic head above the invert of the upstream end of the collector pipe. (King County, 1998)
 - ~~Internal diameters of~~ Use underdrain pipes ~~should be pipe with~~ a minimum of internal diameter of six (6) inches ~~and, with~~ two rows of 1/2-inch holes spaced 6 inches apart longitudinally (maximum), ~~with and~~ rows 120 degrees apart (laid with holes downward). Maintain a maximum perpendicular distance between two feeder pipes ~~must be, or the edge of the filter and a feeder pipe, of~~ 15 feet. For all piping ~~is to be use~~ schedule 40 PVC or piping with a greater wall thickness. ~~Drain piping could be installed in basin and trench configurations.~~
 - Slope the main collector underdrain pipe ~~should be at a slope of at~~ 0.5 percent minimum. (King County, 1998)
 - Use a geotextile fabric (specifications in Appendix V-C ~~Appendix V-C) must be used~~) between the sand layer and drain rock or gravel ~~and placed so that. Cover the geotextile fabric with~~ 1-inch of drain rock/gravel ~~is above the fabric. Drain rock should be.~~ Use 0.75-1.5 inch drain rock or gravel backfill, washed free of clay and organic material. (King County, 1998)

Place cleanout wyes with caps or junction boxes ~~must be provided~~ at both ends of the collector pipes. ~~Cleanouts must extend~~Extend cleanouts to the surface of the filter. Supply a valve box ~~must be provided~~ for access to the cleanouts. Provide access for cleaning all underdrain piping ~~should be provided~~. This may consist of installing cleanout ports, which tee into the underdrain system and surface above the top of the sand bed. To facilitate maintenance of the sand filter an inlet shutoff/bypass valve is recommended.

~~Note: Other equivalent energy dissipaters can be used if needed.~~

4. ~~4.~~—Sand specification: The sand ~~shall be 18 inches minimum~~ in a ~~filter depth and~~ must consist of a medium sand meeting the size gradation (by weight) given in ~~Table 8.5.1~~Table 8.1 below. The contractor must obtain a grain size analysis from the supplier to certify that the ~~sand meets the~~ No. 100 and No. 200 sieve requirements ~~are met~~. (*Note: Standard backfill for sand drains, Wa. Std. Spec. 9-03.13, does not meet this specification and ~~should do not be used~~ use Spec 9-03.13 for sand filters.*)

Table 8.5.1 Sand Medium Specification	
U.S. Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<4
200	<2

Source: King County Surface Water Design Manual, September 1998

5. ~~5.~~ Impermeable Liners for Sand Bed Bottom: Impermeable liners are generally required for soluble pollutants such as metals and toxic organics and where the underflow could cause problems with structures. Impermeable liners may ~~be~~consist of clay, concrete or geomembrane. Clay liners should have a minimum thickness of 12 inches and meet the specifications give in ~~Table 8.5.2~~Table 8.2.

Table 8.5.2 Clay Liner Specifications			
Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	cm/sec	1×10^{-6} max.
Plasticity Index of Clay	ASTM D-423 & D-424	percent	Not less than 15
Liquid Limit of Clay	ASTM D-2216	percent	Not less than 30
Clay Particles Passing	ASTM D-422	percent	Not less than 30
Clay Compaction	ASTM D-2216	percent	95% of Standard Proctor Density

Source: City of Austin, 1988

- If a geomembrane liner is used it should have a minimum thickness of 30 mils and be ultraviolet resistant. Protect the geomembrane liner ~~should be protected~~ from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane.
- Concrete liners may also be used for sedimentation chambers and for sedimentation and sand filtration basins less than 1,000 square feet in area. Concrete should be 5 inches thick Class A or better and ~~should be~~ reinforced by steel wire mesh. The steel wire mesh should be 6 gauge wire or larger and 6-inch by 6-inch mesh or smaller. An "Ordinary Surface Finish" is required. When the underlying soil is clay or has an unconfined compressive strength of 0.25 ton per square foot or less, the concrete should have a minimum 6-inch compacted aggregate base. This base must consist of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75- to 1-inch.
- If an impermeable liner is not required then a geotextile fabric liner should be installed that retains the sand and meets the specifications listed in ~~Appendix V-C~~Appendix V-C unless the basin has been excavated to bedrock.
- If an impermeable liner is not provided, then an analysis should be made of possible adverse effects of seepage zones on ground water, and near building foundations, basements, roads, parking lots and sloping sites. Sand filters without impermeable liners should not be

built on fill sites and should be located at least 20-foot downslope and 100-foot upslope from building foundations.

6. ~~6.~~ Include an access ramp with a slope not to exceed 7:1, or equivalent, for maintenance purposes at the inlet and the outlet of a surface filter. Consider an access port for inspection and maintenance.
7. ~~7.~~ Side slopes for earthen/grass embankments should not exceed 3:1 to facilitate mowing.
8. ~~8.~~ High ~~groundwater~~ ground water may damage underground structures or affect the performance of filter underdrain systems. There should be sufficient clearance (at least 2 feet is recommended) between the seasonal high ~~groundwater~~ ground water level (highest level of ground water observed) and the bottom of the sand filter to obtain adequate drainage.

**Construction
Criteria**

No runoff should enter the sand filter prior to completion of construction and approval of site stabilization by the responsible inspector. Construction runoff may be routed to a pretreatment sedimentation facility, but discharge from sedimentation facilities should by-pass downstream sand filters. Careful level placement of the sand is necessary to avoid formation of voids within the sand that could lead to short-circuiting, (particularly around penetrations for underdrain cleanouts) and to prevent damage to the underlying geomembranes and underdrain system. Over-compaction should be avoided to ensure adequate filtration capacity. Sand is best placed with a low ground pressure bulldozer (4 psig or less). After the sand layer is placed water settling is recommended. Flood the sand with 10-15 gallons of water per cubic foot of sand.

**Maintenance
Criteria**

Inspections of sand filters and pretreatment systems should be conducted every 6 months and after storm events as needed during the first year of operation, and annually thereafter if filter performs as designed. Repairs should be performed as necessary. Suggestions for maintenance include:

~~8.7 Construction Criteria~~

~~No runoff should enter the sand filter prior to completion of construction and approval of site stabilization by the responsible inspector. Construction runoff may be routed to a pretreatment sedimentation facility, but discharge from sedimentation facilities should by-pass downstream sand filters. Careful level placement of the sand is necessary to avoid formation of voids within the sand that could lead to short-circuiting, (particularly around penetrations for underdrain cleanouts) and to prevent damage to the underlying geomembranes and underdrain system. Over-compaction should be avoided to ensure adequate filtration capacity. Sand is best placed with a low ground pressure bulldozer (4 psig~~

or less). After the sand layer is placed water settling is recommended. Flood the sand with 10-15 gallons of water per cubic foot of sand.

8.8 Maintenance Criteria

Inspections of sand filters and pretreatment systems should be conducted every 6 months and after storm events as needed during the first year of operation, and annually thereafter if filter performs as designed. Repairs should be performed as necessary. Suggestions for maintenance include:

- Accumulated silt, and debris on top of the sand filter should be removed when their depth exceeds 1/2-inch. The silt should be scraped off during dry periods with steel rakes or other devices. Once sediment is removed, the design permeability of the filtration media can typically be restored by then striating the surface layer of the media. Finer sediments that have penetrated deeper into the filtration media can reduce the permeability to unacceptable levels, necessitating replacement of some or all of the sand.
- Sand replacement frequency is not well established and will depend on suspended solids levels entering the filter (the effectiveness of the pretreatment BMP can be a significant factor).
- Frequent overflow into the spillway or overflow structure or slow drawdown are indicators of plugging problems. A sand filter should empty in 24 hours following a storm event (24 hours for the pre-settling chamber), depending on pond depth. If the hydraulic conductivity drops to one (1) inch per hour corrective action is needed, e.g.:
 - Scraping the top layer of fine-grain sediment accumulation (mid-winter scraping is suggested)
 - Removal of thatch
 - Aerating the filter surface
 - Tilling the filter surface (late-summer rototilling is suggested)
 - Replacing the top 4 inches of sand.
 - Inspecting geotextiles for clogging
- Rapid drawdown in the sand bed (greater than 12 inches per hour) indicates short-circuiting of the filter. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.
- Drawdown tests for the sand bed could be conducted, as needed, during the wet season. These tests can be conducted by allowing the filter to fill (or partially fill) during a storm event, then measuring the

decline in water level over a 4-8 hour period. An inlet and an underdrain outlet valve would be necessary to conduct such a test.

- Formation of rills and gullies on the surface of the filter indicates improper function of the inlet flow spreader, or poor sand compaction. Check for accumulation of debris on or in the flow spreader and refill rills and gullies with sand.
- Avoid driving heavy equipment on the filter to prevent compaction and rut formation.

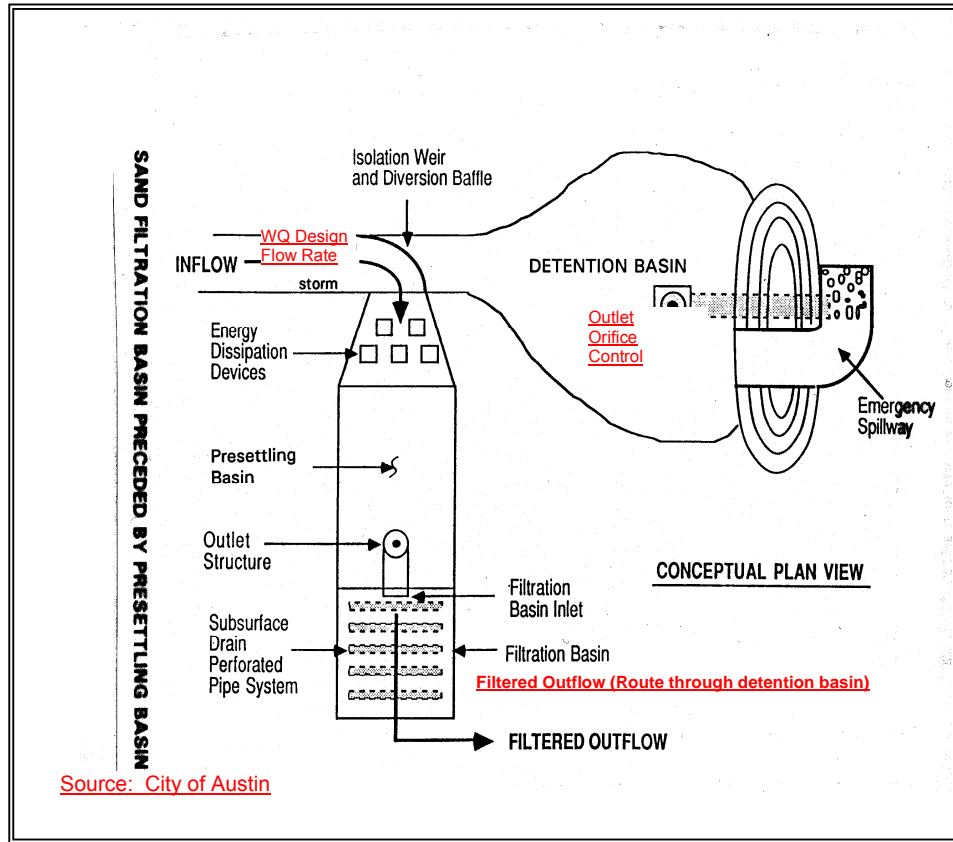


Figure 8.5.1 – Sand Filtration Basin Preceded by Presettling Basin (Variation of a Basic Sand Filter)

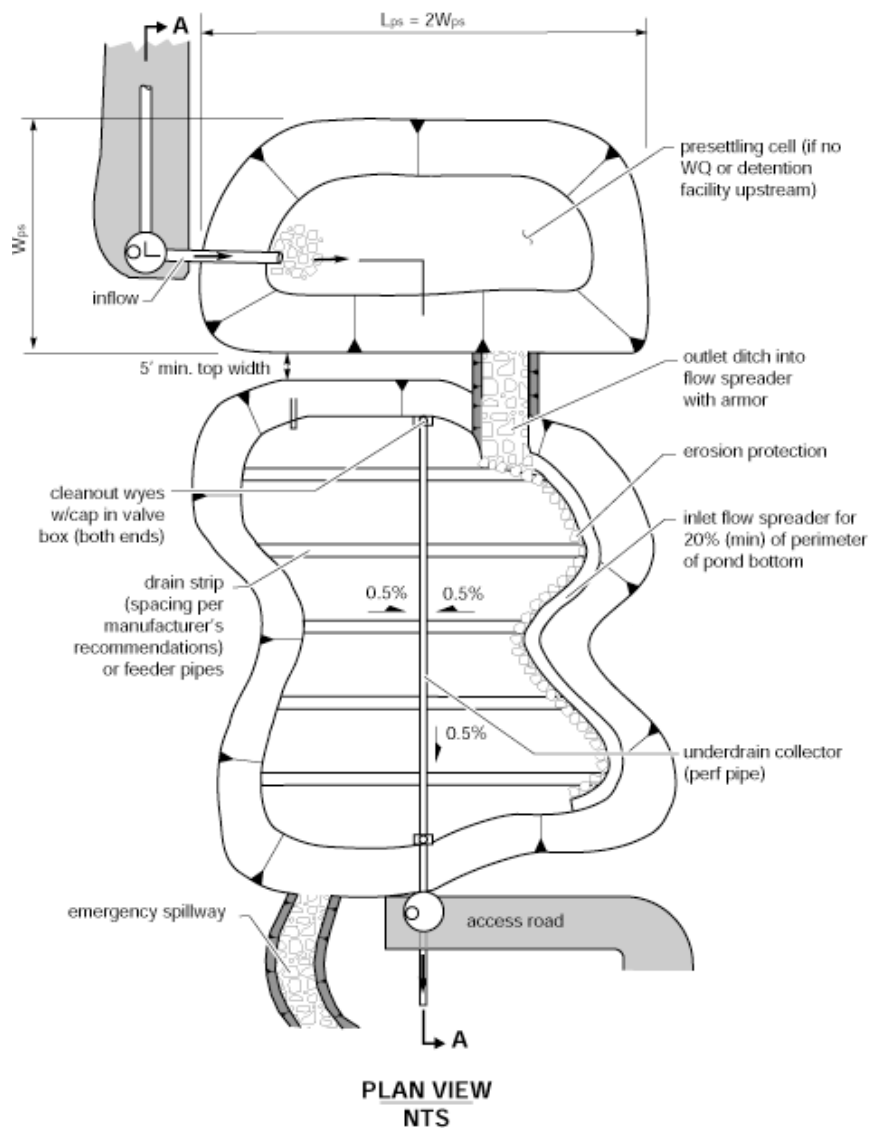
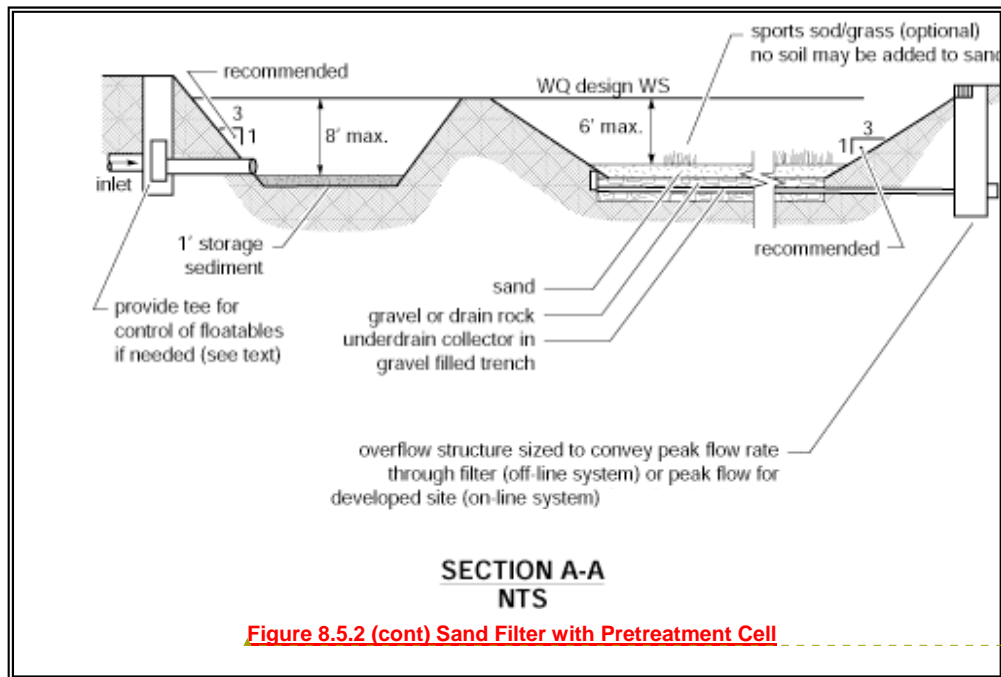


Figure 8.5.2 – Sand Filter with Pretreatment Cell



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Figure 8.3 Sand Filter with Level Spreader

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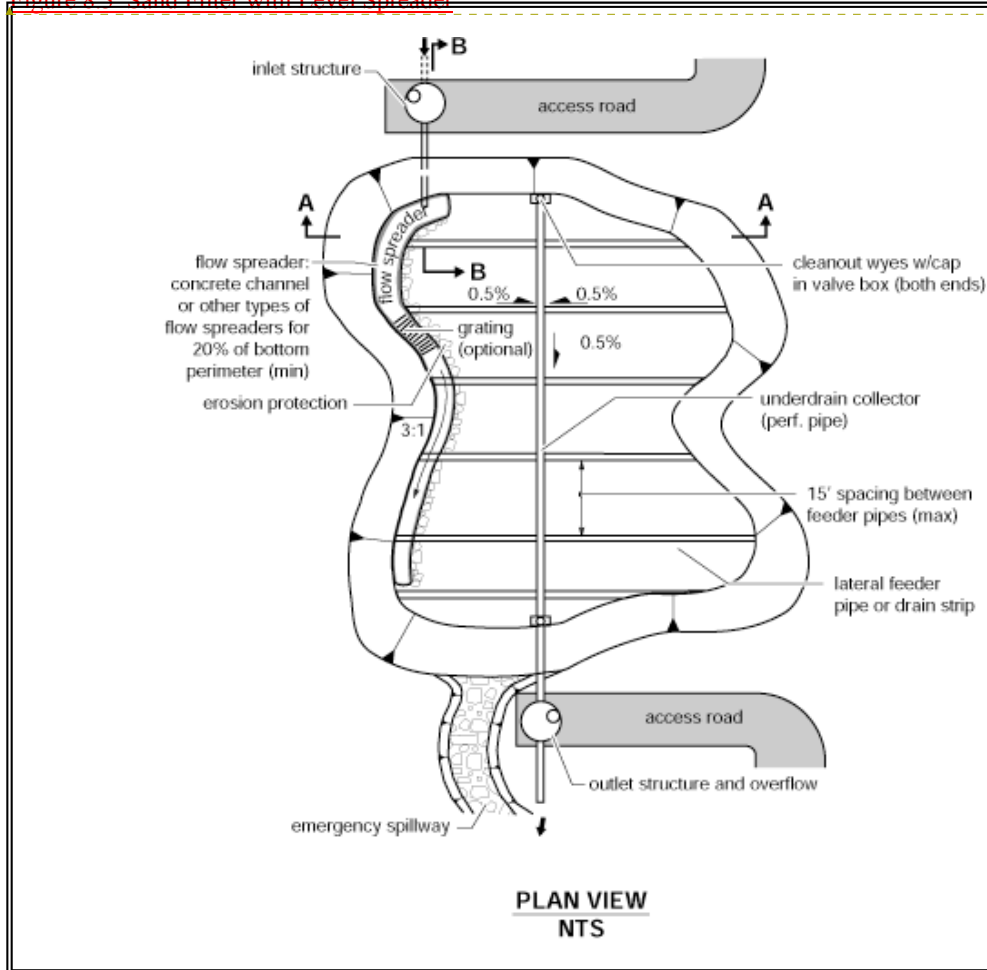


Figure 8.5.3 – Sand Filter with Level Spreader

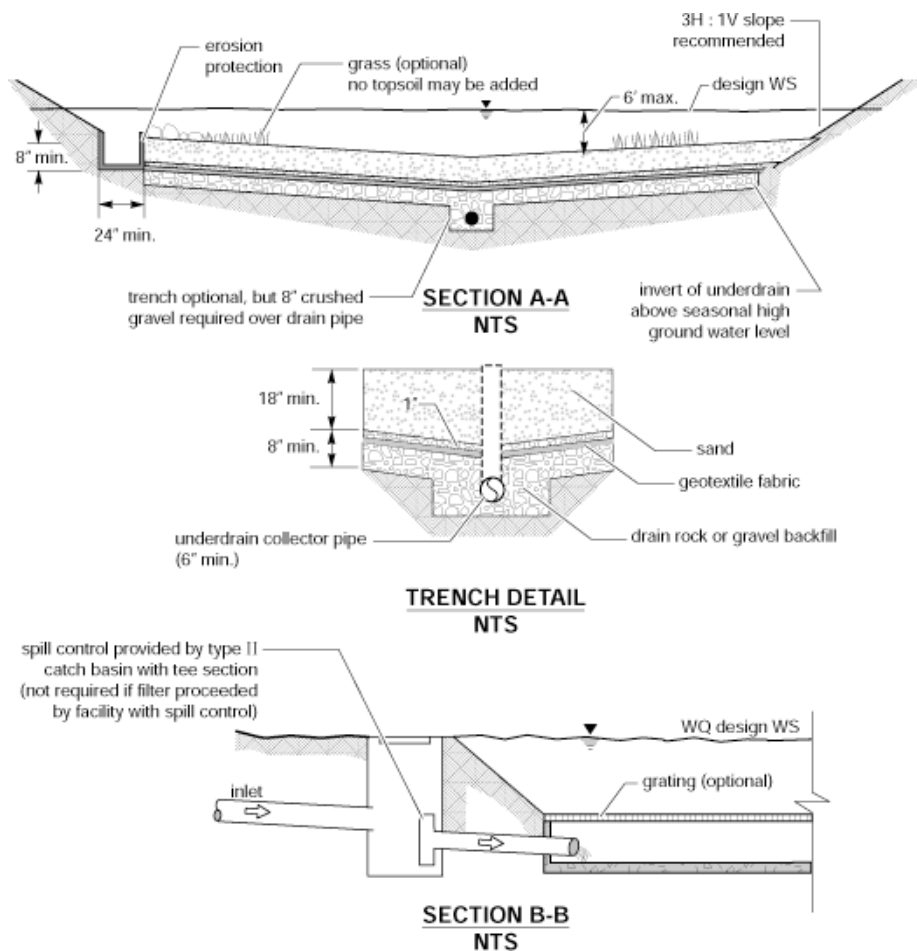
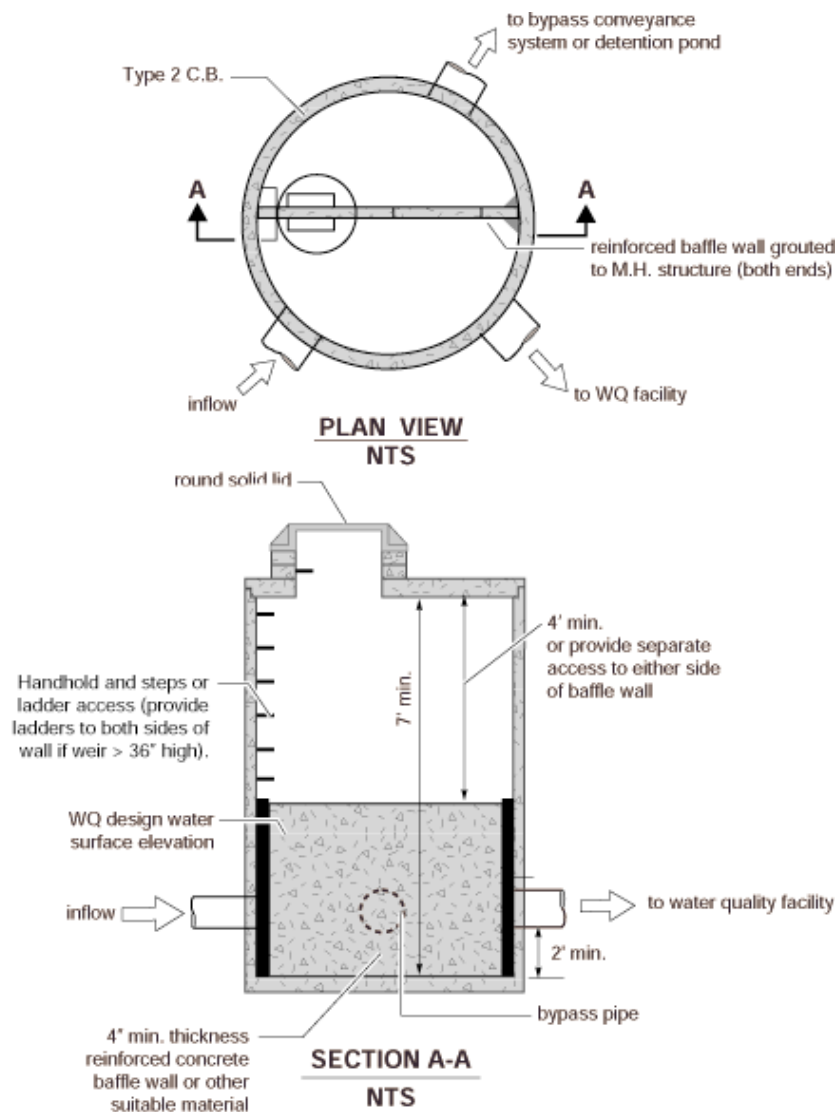


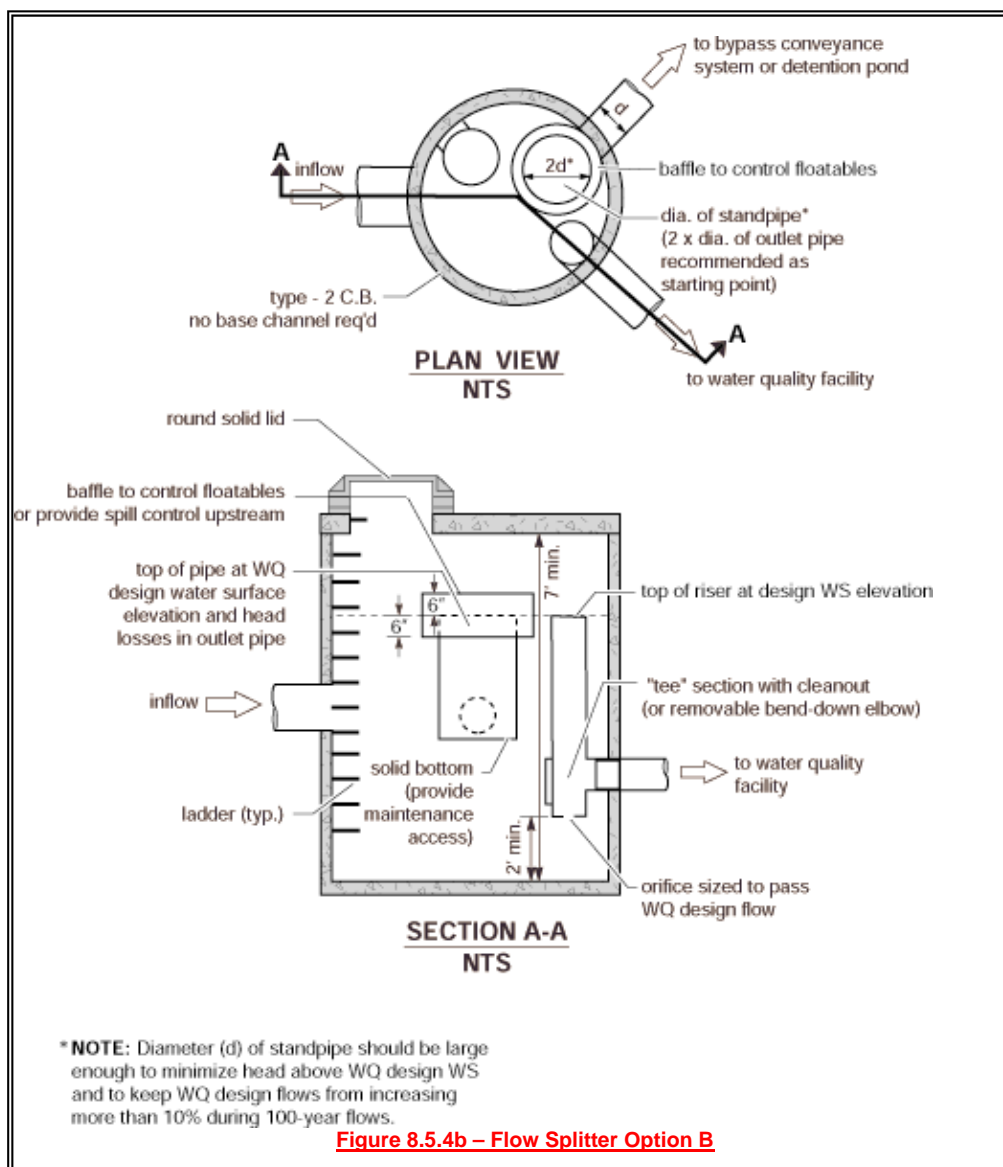
Figure 8.5.3 - (cont) Sand Filter with Level Spreader

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Note: The water quality discharge pipe may require an orifice plate be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0 on the outlet pipe.

Figure 8.5.4a – Flow Splitter Option A



BMP T8.11: Large Sand Filter Basin

Description

A Large Sand Filter Basin is virtually identical to a Basic Sand Filter Basin except that it is sized to provide a higher level of treatment. A Basic Sand Filter Basin is listed as a Basic Treatment per [Section 3.5](#). A Large Sand Filter Basin is approved for under the Enhanced Treatment Menu in [Section 3.4](#).

Applications and Limitations

The Large Sand Filter is generally subject to the same Applications and Limitations as [BMP T8.10 Basic Sand Filter Basin](#). The difference is that the Large Sand Filter Basin uses a higher Water Quality Design Storm volume: 95% of the runoff volume of the period modeled in the WWHM model. Only 5% of the total runoff volume as modeled by WWHM would bypass or overflow from the sand filter facility.

Locate off-line sand filters either upstream or downstream of detention facilities. Only locate on-line sand filters downstream of detention to prevent exposure of the sand filter surface to high flow rates that could cause loss of media and previously removed pollutants.

Site Suitability

The Site Suitability for the Large Sand Filter Basin is the same as BMP T8.10 Basic Sand Filter Basin. Please refer to BMP T8.10 Basic Sand Filter Basin for more details.

Design Criteria

Design Volume

As stated the Applications and Limitations of this BMP, the Facility should be sized to capture the Water Quality Design Volume, which is 95% of the runoff volume for the Large Sand Filter Basin (as opposed the 91% for the Basic Sand Filter Basin).

Overflow and Underdrains

The design flows for the overflow and underdrains must be increased from [BMP T8.10 Basic Sand Filter Basin](#) to this BMP for the Large Sand Filter Basin.

The Basic Sand Filter Basin that uses the 91% runoff volume as the Water Quality Design Volume, a 2-year return interval peak flow from WWHM or equivalent approved continuous model. The corresponding Overflow and Underdrain Design flow is the 2 Year Storm.

Thus, the Overflow and Underdrain design flow can be calculated by increased the 2 year return interval peak flow by the ration of the 95% runoff volume (water quality design volume for this BMP, Large Sand Filter) and the 91% runoff volume (water quality design volume for BMP T8.10 Basic Sand Filter Basin). In equation form:

Design Flow rate for Large Sand Filter Overflow or Under drain = (95% runoff Volume)/(91% Runoff Volume) * 2 year return interval peak flow.

For all other design criteria refer to [BMP T8.10 Basic Sand Filter Basin](#)

~~A sand filter vault is similar to an open sand filter except that the sand layer and underdrains are installed below grade in a vault. It consists of presettling and sand filtration cells.~~

~~***Applications and Limitations***~~

- ~~• Use where space limitations preclude above ground facilities~~
- ~~• Not suitable where high water table and heavy sediment loads are expected~~
- ~~• An elevation difference of 4 feet between inlet and outlet is needed~~

~~-~~

BMP T8.20: Sand Filter Vault

Description

A sand filter vault is similar to an open sand filter except that the sand layer and underdrains are installed below grade in a vault. It consists of presettling and sand filtration cells. See [Figures 8.5.5, 8.5.6a](#) and [8.5.6b](#) for more details.

Application and Limitations

- Use where space limitations preclude above ground facilities
- Not suitable where high water table and heavy sediment loads are expected
- An elevation difference of 4 feet between inlet and outlet is needed

Design Criteria

See design criteria for sand filter basins, including: hydraulics and additional criteria.

Additional Design Criteria for Vaults

- Vaults may be designed as off-line systems or on-line for small drainages
- In an off-line system a diversion structure should be installed to divert the design flow rate into the sediment chamber and bypass the remaining flow to detention/retention (if necessary to meet Minimum Requirement #7), or to surface water.
- Optimize sand inlet flow distribution with minimal sand bed disturbance. A maximum of 8-inch distance between the top of the spreader and the top of the sand bed is suggested. Flows may enter the sand bed by spilling over the top of the wall into a flow spreader pad or alternatively a pipe and manifold system may be used. Any pipe and manifold system must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.
- If an inlet pipe and manifold system is used, the minimum pipe size should be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.

- Erosion protection must be provided along the first foot of the sand bed adjacent to the spreader. Geotextile fabric secured on the surface of the sand bed, or equivalent method, may be used.
- The filter bed should consist of a sand top layer, and a geotextile fabric second layer with an underdrain system.
- Design the presettling cell for sediment collection and removal. A V-shaped bottom, removable bottom panels, or equivalent sludge handling system should be used. One-foot of sediment storage in the presettling cell must be provided.
- The pre-settling chamber must be sealed to trap oil and trash. This chamber is usually connected to the sand filtration chamber through an invert elbow to protect the filter surface from oil and trash.
- If a retaining baffle is necessary for oil/floatables in the presettling cell, it must extend at least one foot above to one foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladder must be provided on both sides of the baffle.
- To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate should be provided for each 250 square feet of sand bed surface area. For sufficient distribution of airflow across the sand bed, grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed area.
- Provision for access is the same as for wet vaults. Removable panels must be provided over the entire sand bed.
- Sand filter vaults must conform to the materials and structural suitability criteria specified for wet vaults.
- Provide a sand filter inlet shutoff/bypass valve for maintenance
- A geotextile fabric over the entire sand bed may be installed that is flexible, highly permeable, three-dimensional matrix, and adequately secured. This is useful in trapping trash and litter.

***Construction
Criteria***

See sand filter basins, [BMP T8.10](#), and [Table 4.5.2](#) in [Section 4.6](#).

***Maintenance
Criteria***

See sand filter basins, [BMP T8.10](#), and [Table 4.5.2](#) in [Section 4.6](#).

| ~~BMP T8.20~~

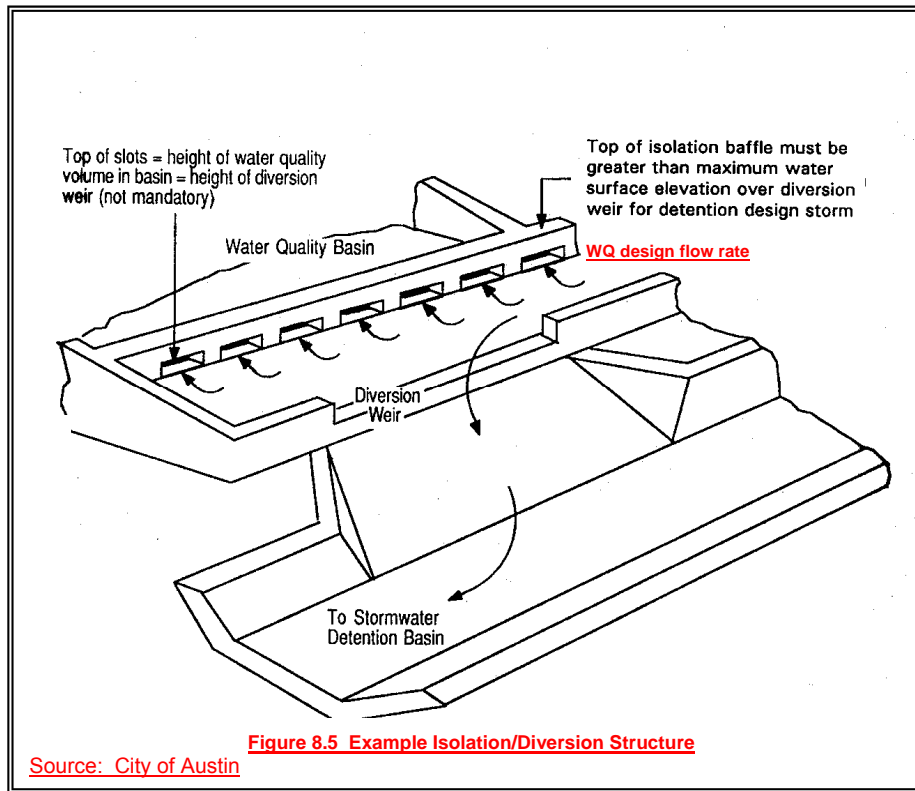


Figure 8.5.5 – Example Isolation/Diversion Structure

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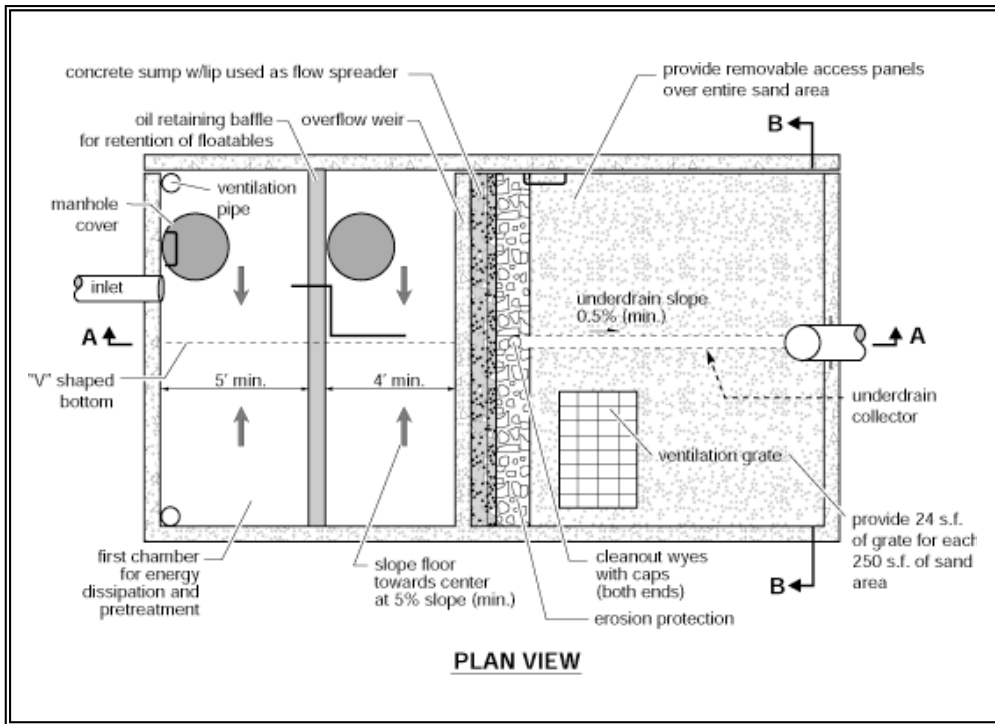
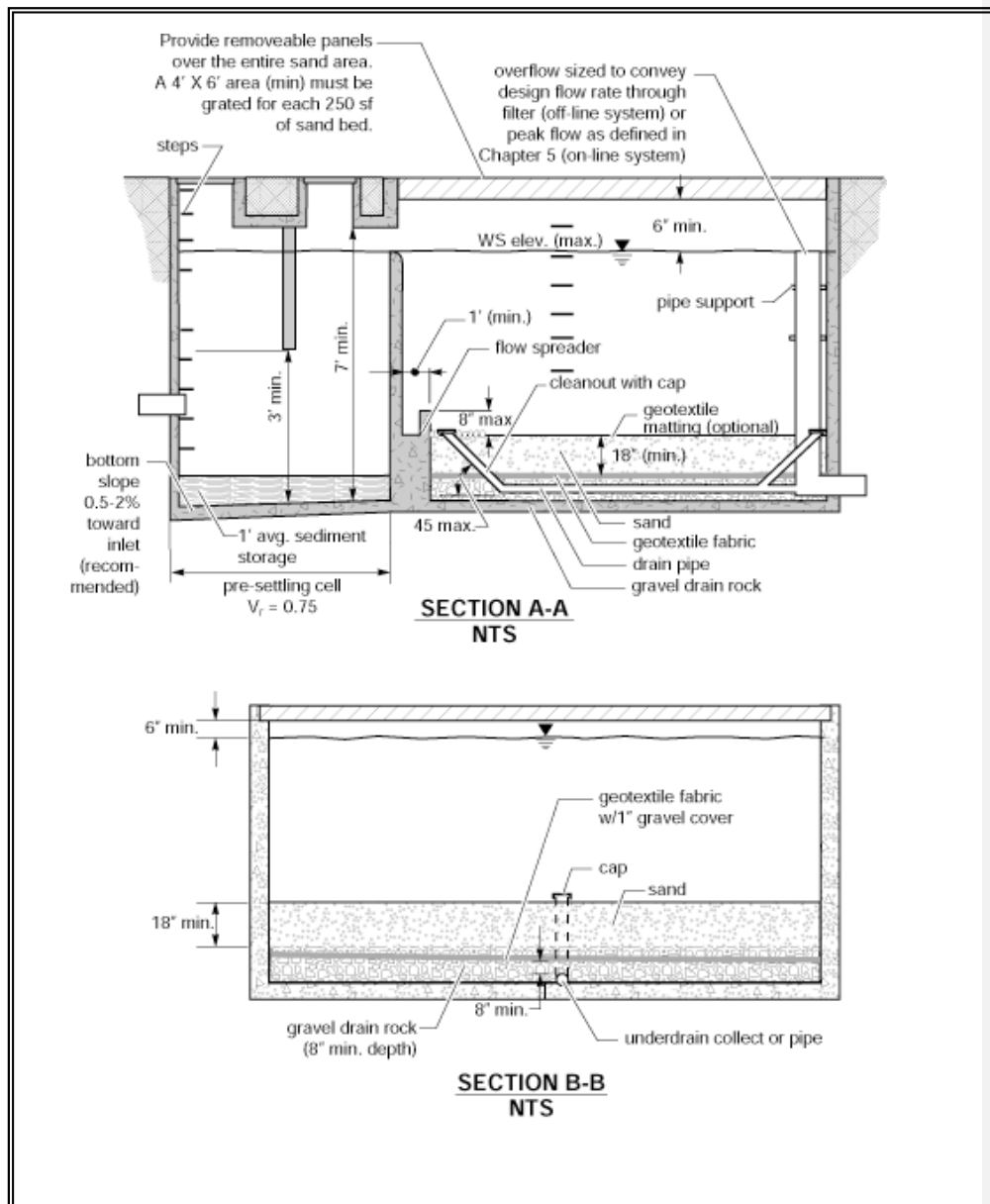


Figure 8.5.6a – Sand Filter Vault

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Figure 8.5.6b – Sand Filter Vault (cont)

BMP T8.30: Linear Sand Filter

Description **(Figure 8.5.7)**

Linear sand filters are typically long, shallow, two-celled, rectangular vaults. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader.

Application and Limitations

- Applicable in long narrow spaces such as the perimeter of a paved surface.
- As a part of a treatment train as downstream of a filter strip, upstream of an infiltration system, or upstream of a wet pond or a biofilter for oil control.
- To treat small drainages (less than 2 acres of impervious area).
- To treat runoff from high-use sites for TSS and oil/grease removal, if applicable.

Description: (Figure 8.7)

Linear sand filters are typically long, shallow, two celled, rectangular vaults. The first cell is designed for settling coarse particles, and the second cell contains the sand bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader.

Application and Limitations

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- As a part of a treatment train as downstream of a filter strip, upstream of an infiltration system, or upstream of a wet pond or a biofilter for oil control.
- To treat small drainages (less than 2 acres of impervious area).
- To treat runoff from high use sites for TSS and oil/grease removal, if applicable.

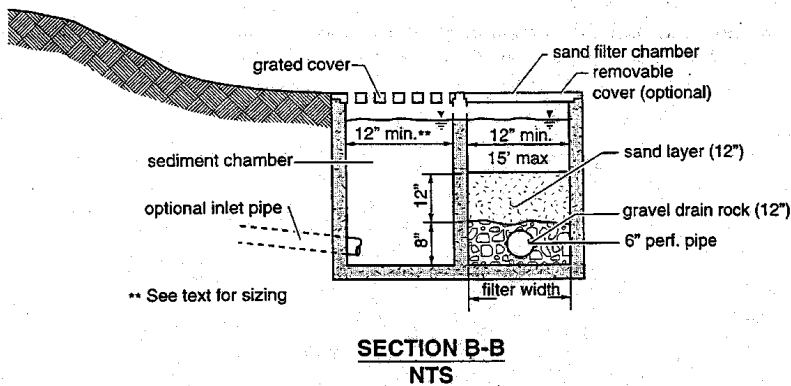
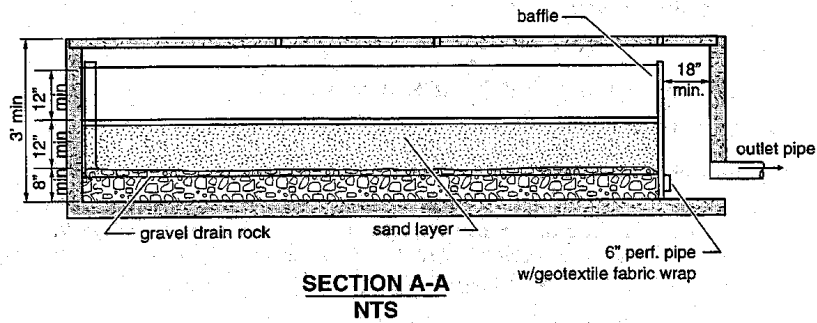
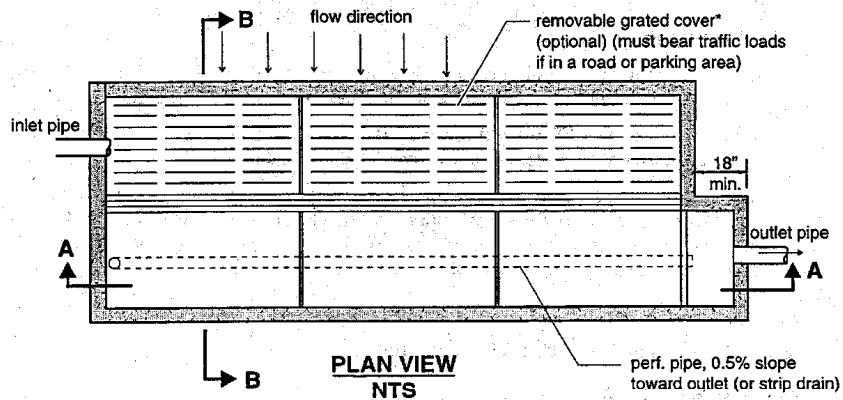
Additional Design Criteria for Linear Sand Filters

- The two cells should be divided by a divider wall that is level and extends a minimum of 12 inches above the sand bed.
- Stormwater may enter the sediment cell by sheet flow or a piped inlet.
- The width of the sand cell must be 1-foot minimum to 15 feet maximum.
- The sand filter bed must be a minimum of 12 inches deep and have an 8-inch layer of drain rock with perforated drainpipe beneath the sand layer.

- The drainpipe must be 6-inch diameter minimum and be wrapped in geotextile and sloped a minimum of 0.5 percent.
- Maximum sand bed ponding depth: 1-foot.
- Must be vented as for sand filter vaults
- Linear sand filters must conform to the materials and structural suitability criteria specified for wet vaults.
- Set sediment cell width as follows:

Sand filter width, (w) inches	12-24	24-48	48-72	72+
Sediment cell width, inches	12	18	24	w/3

Figure 8.5.7 – Linear Sand Filter



BMP T8.40: Media Filter Drain (previously referred to as the Ecology Embankment)

General Description

The media filter drain (MFD), previously referred to as the *ecology embankment*, is a linear flow-through stormwater runoff treatment device that can be sited along highway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The media filter drain can be used where available right of way is limited, sheet flow from the highway surface is feasible, and lateral gradients are generally less than 25% (4H:1V). The media filter drain has a General Use Level Designation (GULD) for basic, enhanced, and phosphorus treatment. Updates/changes to the use-level designation and any design changes will be posted in the *Postpublication Updates* section of the HRM Resource Web Page.

Media filter drains (MFDs) have four basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the MFD mix. This conveyance system usually consists of a gravel-filled underdrain trench or a layer of crushed surfacing base course (CSBC). This layer of CSBC must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in Figures [8.5.8](#), [8.5.9](#), and [8.5.10](#).

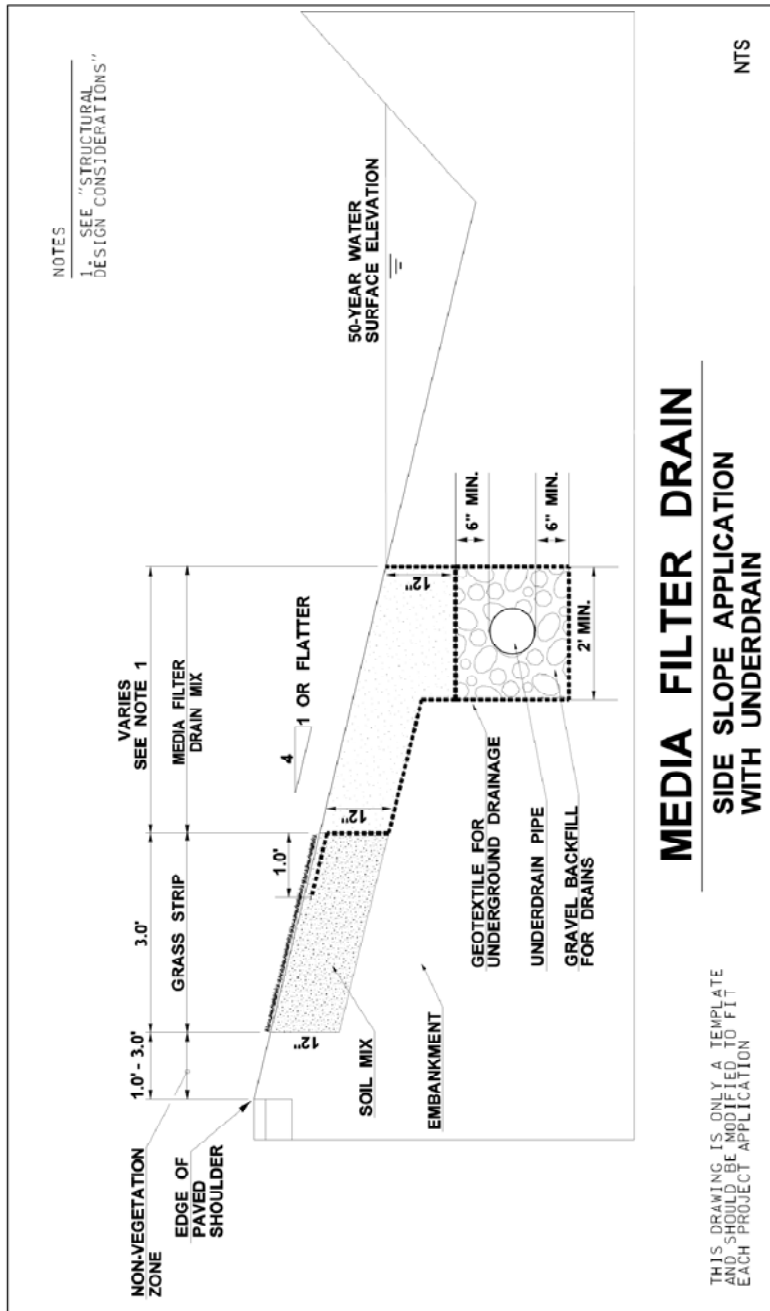


Figure 8.5.8 – Media filter drain: Cross section

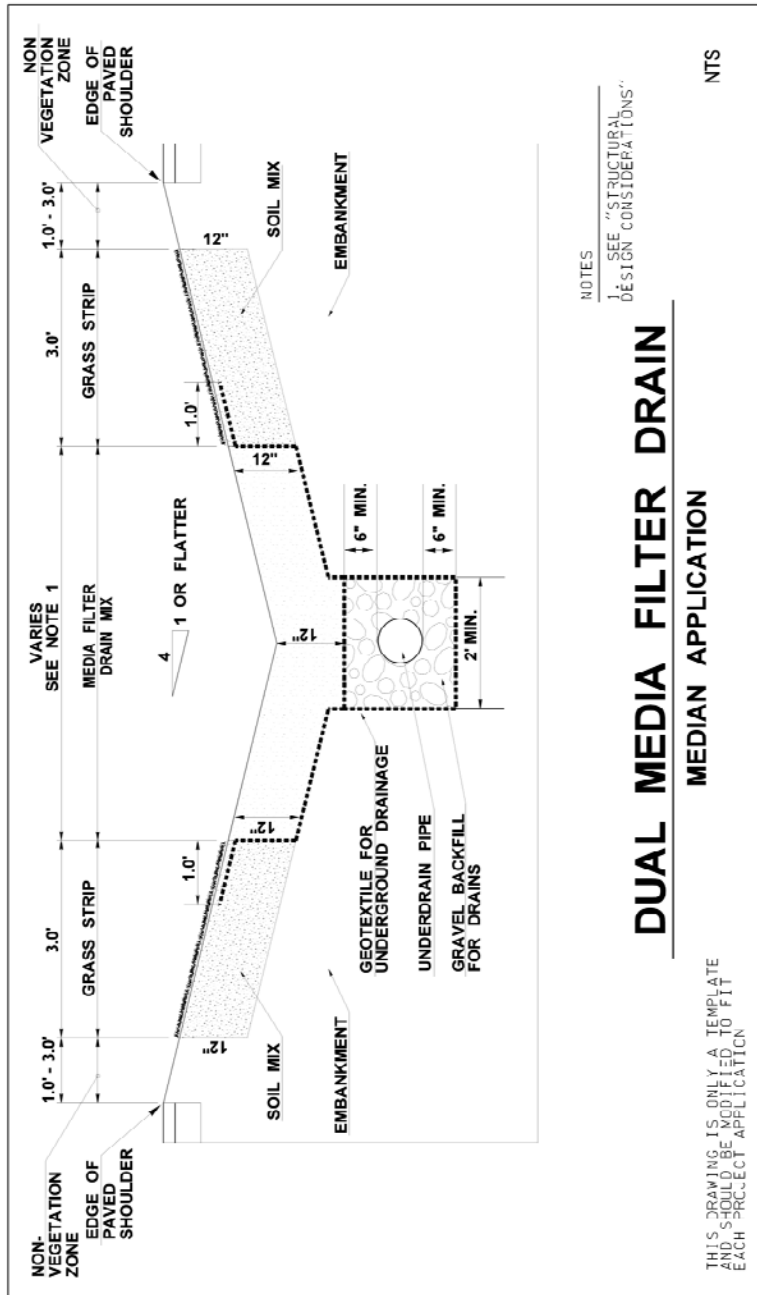


Figure 8.5.9 – Dual media filter drain: Cross section

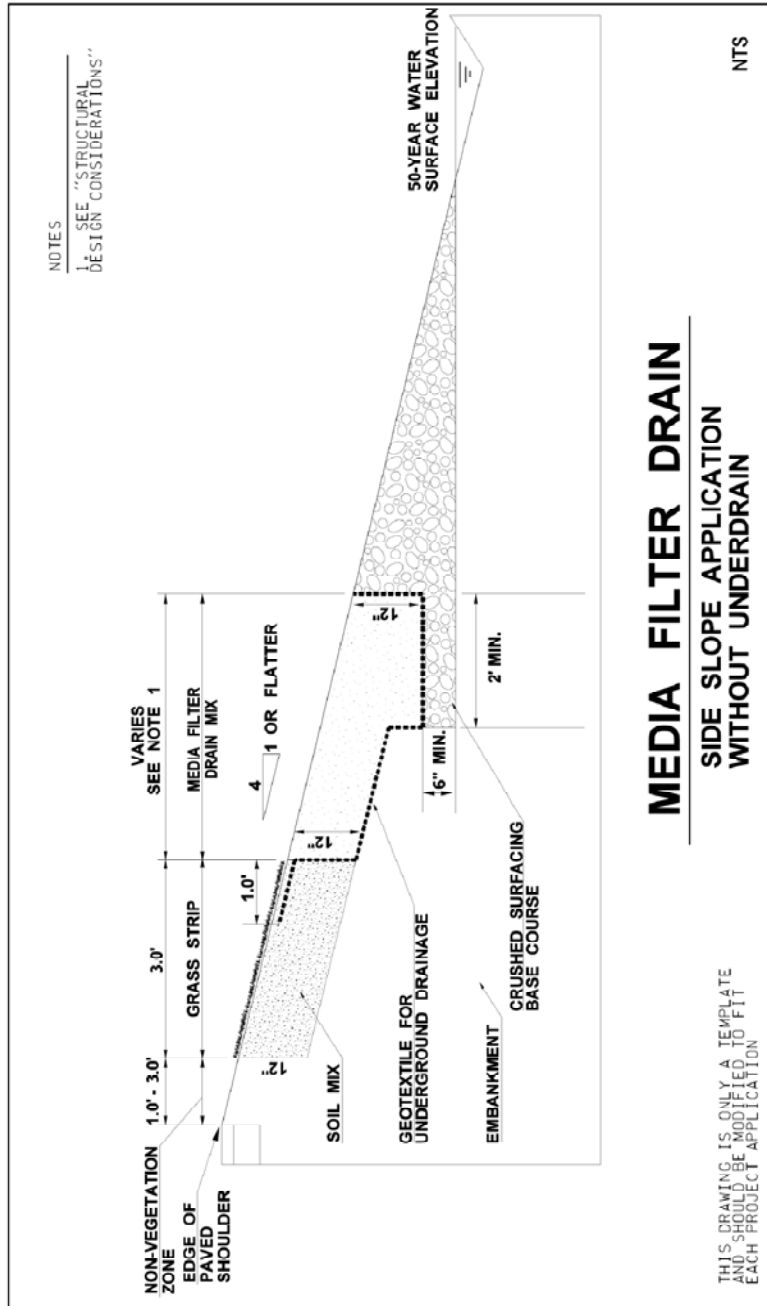


Figure 8.5.10 – Media filter drain without underdrain trench

**Functional
Description**

The media filter drain removes suspended solids, phosphorus, and metals from highway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

Stormwater runoff is conveyed to the media filter drain via sheet flow over a vegetation-free gravel zone to ensure sheet dispersion and provide some pollutant trapping. Next, a grass strip, which may be amended with compost, is incorporated into the top of the fill slope to provide pretreatment, further enhancing filtration and extending the life of the system. The runoff is then filtered through a bed of porous, alkalinity-generating granular medium—the media filter drain mix. Media filter drain mix is a fill material composed of crushed rock (sized by screening), dolomite, gypsum, and perlite. The dolomite and gypsum additives serve to buffer acidic pH conditions and exchange light metals for heavy metals. Perlite is incorporated to improve moisture retention, which is critical for the formation of biomass epilithic biofilm to assist in the removal of solids, metals, and nutrients. Treated water drains from the media filter drain mix bed into the conveyance system below the media filter drain mix. Geotextile lines the underside of the media filter drain mix bed and the conveyance system.

The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream flow control facility or stormwater outfall. The trench's perforated underdrain pipe is a protective measure to ensure free flow through the media filter drain mix and to prevent prolonged ponding. It may be possible to omit the underdrain pipe if it can be demonstrated that the pipe is not necessary to maintain free flow through the media filter drain mix and underdrain trench.

It is critical to note that water should sheet flow across the media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

**Applications and
Limitations**

In many instances, conventional runoff treatment is not feasible due to right of way constraints (such as adjoining wetlands and geotechnical considerations). The media filter drain and the dual media filter drain designs are runoff treatment options that can be sited in most right of way confined situations. In many cases, a media filter drain or a dual media filter drain can be sited without the acquisition of additional right of way needed for conventional stormwater facilities or capital-intensive expenditures for underground wet vaults.

Applications

Media Filter Drains

The media filter drain can achieve basic, phosphorus, and enhanced water quality treatment.

Since maintaining sheet flow across the media filter drain is required for its proper function, the ideal locations for media filter drains in highway settings are highway side slopes or other long, linear grades with lateral side slopes less than 4H:1V and longitudinal slopes no steeper than 5%. As side slopes approach 3H:1V, without design modifications, sloughing may become a problem due to friction limitations between the separation geotextile and underlying soils. The longest flow path from the contributing area delivering sheet flow to the media filter drain should not exceed 150 feet.

If there is sufficient roadway embankment width, the designer should consider placing the grass strip and media mix downslope when feasible. The project office should ensure the MFD does not intercept seeps, springs, or ground water.

Dual Media Filter Drain for Highway Medians

The dual media filter drain is fundamentally the same as the side-slope version. It differs in siting and is more constrained with regard to drainage options. Prime locations for dual media filter drains in a highway setting are medians, roadside drainage or borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual media filter drain. Channelized flows or ditch flows running down the middle of the dual media filter drain (continuous off-site inflow) should be minimized.

Limitations

Media Filter Drains

- **Steep slopes.** Avoid construction on longitudinal slopes steeper than 5%. Avoid construction on 3H:1V lateral slopes, and preferably use less than 4H:1V slopes. In areas where lateral slopes exceed 4H:1V, it may be possible to construct terraces to create 4H:1V slopes or to otherwise stabilize up to 3H:1V slopes. (For details, see *Geometry, Components and Sizing Criteria, Cross Section* in the Structural Design Considerations section below).
- **Wetlands.** Do not construct in wetlands and wetland buffers. In many cases, a media filter drain (due to its small lateral footprint) can fit within the highway fill slopes adjacent to a wetland buffer. In those situations where the highway fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the media filter drain.
- **Shallow ground water.** Mean high water table levels at the project site need to be determined to ensure the media filter drain mix bed and the underdrain (if needed) will not become saturated by shallow ground water.
- **Unstable slopes.** In areas where slope stability may be problematic, consult a geotechnical engineer.

- **Areas of seasonal ground water inundations or basement flooding.**
Site-specific piezometer data may be needed in areas of suspected seasonal high ground water inundations. The hydraulic and runoff treatment performance of the dual media filter drain may be compromised due to backwater effects and lack of sufficient hydraulic gradient.
- Narrow roadway shoulders. In areas where there is a narrow roadway shoulder that does not allow enough room for a vehicle to fully stop or park, consider placing the MFD farther down the embankment slope. This will reduce the amount of rutting in the MFD and decrease overall maintenance repairs.

Design Flow Elements

Flows to Be Treated

The basic design concept behind the media filter drain and dual media filter drain is to fully filter all runoff through the media filter drain mix. Therefore, the infiltration capacity of the medium and drainage below needs to match or exceed the hydraulic loading rate.

Structural Design Considerations

Geometry

Components

No-Vegetation Zone

The no-vegetation zone (vegetation-free zone) is a shallow gravel zone located directly adjacent to the highway pavement. The no-vegetation zone is a crucial element in a properly functioning media filter drain or other BMPs that use sheet flow to convey runoff from the highway surface to the BMP. The no-vegetation zone functions as a level spreader to promote sheet flow and a deposition area for coarse sediments. The no-vegetation zone should be between 1 foot and 3 feet wide. Depth will be a function of how the roadway section is built from subgrade to finish grade; the resultant cross section will typically be triangular to trapezoidal. Within these bounds, width varies depending on maintenance spraying practices.

Grass Strip

The width of the grass strip is dependent on the availability of space within the highway side slope. The baseline design criterion for the grass strip within the media filter drain is a 3-foot-minimum-width, but wider grass strips are recommended if the additional space is available. The designer may consider adding aggregate to the soil mix to help minimize rutting problems from errant vehicles. The soil mix should ensure grass growth for the design life of the media filter drain.

Media Filter Drain Mix Bed

The media filter drain mix is a mixture of crushed rock, dolomite, gypsum, and perlite. The crushed rock provides the support matrix of the medium; the dolomite and gypsum add alkalinity and ion exchange capacity to promote the precipitation and exchange of heavy metals; and the perlite improves moisture retention to promote the formation of biomass within the media filter drain mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the water treatment capacity of the mix. The media filter drain mix has an estimated initial filtration rate of 50 inches per hour and a long-term filtration rate of 28 inches per hour due to siltation. With an additional safety factor, the rate used to size the length of the media filter drain should be 10 inches per hour.

Conveyance System Below Media Filter Drain Mix

The gravel underdrain trench provides hydraulic conveyance when treated runoff needs to be conveyed to a desired location such as a downstream flow control facility or stormwater outfall.

In Group C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the media filter drain mix bed. In some Group A and B soils, an underdrain pipe may be unnecessary if most water percolates into subsoil from the underdrain trench. The need for underdrain pipe should be evaluated in all cases. The underdrain trench should be a minimum of 2 feet wide for either the conventional or dual media filter drain.

The gravel underdrain trench may be eliminated if there is evidence to support that flows can be conveyed laterally to an adjacent ditch or onto a fill slope that is properly vegetated to protect against erosion. The media filter drain mix should be kept free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

Sizing Criteria

Width

The width of the media filter drain mix bed is determined by the amount of contributing pavement routed to the embankment. The surface area of the media filter drain mix bed needs to be sufficiently large to fully infiltrate the runoff treatment design flow rate using the long-term filtration rate of the media filter drain mix. For design purposes, a 50% safety factor is incorporated into the long-term media filter drain mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The media filter drain mix bed should have a bottom width of at least 2 feet in contact with the conveyance system below the media filter drain mix.

Length

In general, the length of a media filter drain or dual media filter drain is the same as the contributing pavement. Any length is acceptable as long as the surface area media filter drain mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

Cross Section

In profile, the surface of the media filter drain should preferably have a lateral slope less than 4H:1V (<25%). On steeper terrain, it may be possible to construct terraces to create a 4H:1V slope, or other engineering may be employed if approved by Ecology, to ensure slope stability up to 3H:1V. If sloughing is a concern on steeper slopes, consideration should be given to incorporating permeable soil reinforcements, such as geotextiles, open-graded/ permeable pavements, or commercially available ring and grid reinforcement structures, as top layer components to the media filter drain mix bed. Consultation with a geotechnical engineer is required.

Inflow

Runoff is conveyed to a media filter drain using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a media filter drain should be less than 5%.

Although there is no lateral pavement slope restriction for flows going to a media filter drain, the designer should ensure flows remain as sheet flow.

Media Filter Drain Mix Bed Sizing Procedure

The media filter drain mix should be a minimum of 12 inches deep, including the section on top of the underdrain trench.

For runoff treatment, sizing the media filter drain mix bed is based on the requirement that the runoff treatment flow rate from the pavement area, $Q_{Highway}$, cannot exceed the long-term infiltration capacity of the media filter drain, $Q_{Infiltration}$.

$$\text{Highway Infiltration } Q \leq Q$$

For western Washington, $Q_{Highway}$ is the flow rate at or below which 91% of the runoff volume for the developed TDA will be treated, based on a 15-minute time step and can be determined using an approved continuous runoff model.

The long-term infiltration capacity of the media filter drain is based on the following equation:

$$\frac{LTIR * L * W}{C * SF} = Q_{Infiltration}$$

where: $LTIR$ = Long-term infiltration rate of the media filter drain mix (use 10 inches per hour for design) (in/hr)

L = Length of media filter drain (parallel to roadway) (ft)

W = Width of the media filter drain mix bed (ft)

C = Conversion factor of 43200 ((in/hr)/(ft/sec))

SF = Safety Factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the media filter drain is the same as the length of the contributing pavement, solve for the width of the media filter drain:

$$W \geq \frac{Q_{Highway} * C * SF}{LTIR * L}$$

Western Washington project applications of this design procedure have shown that, in almost every case, the calculated width of the media filter drain does not exceed 1.0 foot. Therefore, Table 8.5.3 was developed to simplify the design steps and should be used to establish an appropriate width.

Table 8.5.3
Western Washington Design Widths for Media Filter Drains

<u>Pavement width that contributes runoff to the media filter drain</u>	<u>Minimum media filter drain width*</u>
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

* Width does not include the required 1–3 foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 8.5.8).

Underdrain Design

Underdrain pipe can provide a protective measure to ensure free flow through the media filter drain (MFD) mix and is sized similar to storm drains. For MFD underdrain sizing, an additional step is required to determine the flow rate that can reach the underdrain pipe. This is done by

comparing the contributing basin flow rate to the infiltration flow rate through the media filter mix and then using the smaller of the two to size the underdrain. The analysis described below considers the flow rate per foot of MFD, which allows you the flexibility of incrementally increasing the underdrain diameter where long lengths of underdrain are required. When underdrain pipe connects to a storm drain system, place the invert of the underdrain pipe above the 25-year water surface elevation in the storm drain to prevent backflow into the underdrain system.

The following describes the procedure for sizing underdrains installed in combination with media filter drains.

1. Calculate the flow rate per foot from the contributing basin to the media filter drain. The design storm event used to determine the flow rate should be relevant to the purpose of the underdrain. For example, if the MFD installation is in western Washington and the underdrain will be used to convey treated runoff to a detention BMP, size the underdrain for the 50-year storm event. (See the [Hydraulics Manual](#), Figure 2-2.1, for conveyance flow rate determination.)

$$\frac{Q_{highway}}{ft} = \frac{Q_{highway}}{L_{MFD}}$$

where:

$$\frac{Q_{highway}}{ft} = \text{contributing flow rate per foot (cfs/ft)}$$

$$L_{MFD} = \text{length of MFD contributing runoff to the underdrain}$$

(ft)

2. Calculate the MFD flow rate of runoff per foot given an infiltration rate of 10 in/hr through the media filter drain mix.

$$Q_{\frac{MFD}{ft}} = \frac{f \times W \times 1 ft}{ft} \times \frac{1 ft}{12 in} \times \frac{1 hr}{3600 sec}$$

where:

$$Q_{\frac{MFD}{ft}} = \text{flow rate of runoff through MFD mix layer (cfs/ft)}$$

$$W = \text{width of underdrain trench (ft) – see Standard Plan B-55.20-00; the minimum width is 2 ft}$$

$$f = \text{infiltration rate through the MFD mix (in/hr) = 10 in/hr}$$

3. Size the underdrain pipe to convey the runoff that can reach the underdrain trench. This is taken to be the smaller of the contributing basin flow rate or the flow rate through the MFD mix layer.

$$Q_{UD} = \text{smaller} \left\{ \frac{Q_{\text{highway}}}{ft} \text{ or } \frac{Q_{MFD}}{ft} \right\}$$

where:

$\frac{Q_{UD}}{ft}$ = underdrain design flow rate per foot (cfs/ft)

4. Determine the underdrain design flow rate using the length of the MFD and a factor of safety of 1.2.

$$Q_{UD} = 1.2 \times \frac{Q_{UD}}{ft} \times W \times L_{MFD}$$

where:

$\frac{Q_{UD}}{ft}$ = estimated flow rate to the underdrain (cfs)

W = width of the underdrain trench (ft) – see Standard Plan B-55.20-00; the minimum width is 2 ft

L_{MFD} = length of MFD contributing runoff to the underdrain (ft)

5. Given the underdrain design flow rate, determine the underdrain diameter. Round pipe diameters to the nearest standard pipe size and have a minimum diameter of 6 inches. For diameters that exceed 12 inches, contact either the Region or HQ Hydraulics Office.

$$D = 16 \left(\frac{(Q_{UD} \times n)}{s^{0.5}} \right)^{3/8} \underline{\hspace{2cm}}$$

where:

D = underdrain pipe diameter (inches)

n = Manning's coefficient

s = slope of pipe (ft/ft)

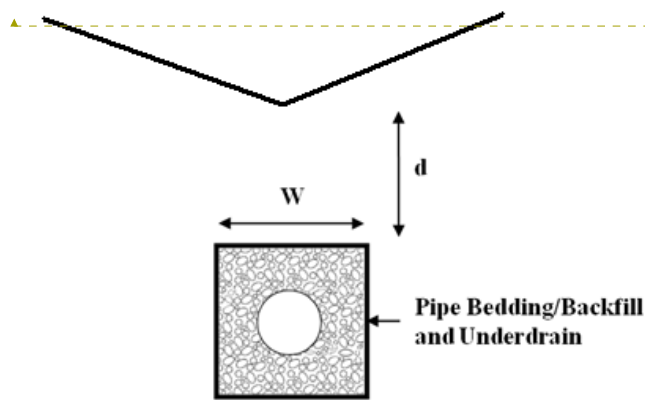
Materials

Media Filter Drain Mix

The media filter drain mix used in the construction of media filter drains consists of the amendments listed in Table 8.5.4. Mixing and transportation must occur in a manner that ensures the materials are thoroughly mixed prior to placement and that separation does not occur during transportation or construction operations.

These materials should be used in accordance with the following *Standard Specifications*:

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2)
- Construction Geotextile for Underground Drainage, 9-33.1



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Figure 8.5.4 - Media filter drain underdrain installation

Crushed Surfacing Base Course (CSBC)

If the design is configured to allow the media filter drain to drain laterally into a ditch, the crushed surfacing base course below the media filter drain should conform to Section 9-03.9(3) of the *Standard Specifications*.

Berms, Baffles, and Slopes

See *Geometry, Components and Sizing Criteria, Cross Section* under Structural Design Considerations above.

Table 8.5.4 Media filter drain mix

Amendment	Quantity												
<p>Mineral aggregate: Aggregate for Media Filter Drain Mix Aggregate for Media filter Drain Mix shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the <i>Standard Specifications for Road, Bridge, and Municipal Construction</i> (2002), which meets the following test requirements for quality. The use of recycled material is not permitted.:</p> <p>Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min.</p> <p>Aggregate for the Media Filter Drain Mix shall conform to the following requirements for grading and quality:</p> <table> <tr> <th>Sieve Size</th><th>Percent Passing (by weight)</th></tr> <tr> <td>1/2" square</td><td>100</td></tr> <tr> <td>3/8" square</td><td>90-100</td></tr> <tr> <td>U.S. No. 4</td><td>30-56</td></tr> <tr> <td>U.S. No. 10</td><td>0-10</td></tr> <tr> <td>U.S. No. 200</td><td>0-1.5</td></tr> </table> <p>% fracture, by weight, min. 75</p> <p>Static stripping test Pass</p> <p>The fracture requirement shall be at least two fractured faces and will apply to material retained on the U.S. No. 10.</p> <p>Aggregate for the Media Filter Drain shall be substantially free from adherent coatings. The presence of a thin, firmly adhering film of weathered rock shall not be considered as coating unless it exists on more than 50% of the surface area of any size between successive laboratory sieves.</p>	Sieve Size	Percent Passing (by weight)	1/2" square	100	3/8" square	90-100	U.S. No. 4	30-56	U.S. No. 10	0-10	U.S. No. 200	0-1.5	3 cubic yards
Sieve Size	Percent Passing (by weight)												
1/2" square	100												
3/8" square	90-100												
U.S. No. 4	30-56												
U.S. No. 10	0-10												
U.S. No. 200	0-1.5												
<p>Perlite:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Horticultural grade, free of any toxic materials) <input type="checkbox"/> 0-30% passing US No. 18 Sieve <input type="checkbox"/> 0-10% passing US No. 30 Sieve 	1 cubic yard per 3 cubic yards of mineral aggregate												
<p>Dolomite: CaMg(CO₃)₂ (calcium magnesium carbonate)</p> <ul style="list-style-type: none"> <input type="checkbox"/> Agricultural grade, free of any toxic materials) <input type="checkbox"/> 100% passing US No. 8 Sieve <input type="checkbox"/> 0% passing US No. 16 Sieve 	10 pounds per cubic yard of perlite												
<p>Gypsum: Noncalcined, agricultural gypsum CaSO₄•2H₂O (hydrated calcium sulfate)</p> <ul style="list-style-type: none"> <input type="checkbox"/> Agricultural grade, free of any toxic materials) <input type="checkbox"/> 100% passing US No. 8 Sieve <input type="checkbox"/> 0% passing US No. 16 Sieve 	1.5 pounds per cubic yard of perlite												

Site Design Elements

Landscaping (Planting Considerations)

Landscaping for the grass strip is the same as for biofiltration swales unless otherwise specified in the special provisions for the project's construction documents.

Operations and Maintenance

Maintenance will consist of routine roadside management. While herbicides must not be applied directly over the media filter drain, it may be necessary to periodically control noxious weeds with herbicides in areas around the media filter drain as part of a roadside management program. The use of pesticides may be prohibited if the media filter drain is in a critical aquifer recharge area for drinking water supplies. The designer should check with the local area water purveyor or local health department. Areas of the media filter drain that show signs of physical damage will be replaced by local maintenance staff in consultation with region hydraulics/water quality staff.

Construction Criteria

Keep effective erosion and sediment control measures in place until grass strip is established.

Do not allow vehicles or traffic on the MFD to minimize rutting and maintenance repairs

Signing

Nonreflective guideposts will delineate the media filter drain. This practice allows personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the media filter drain is in a critical aquifer recharge area for drinking water supplies, signage prohibiting the use of pesticides must be provided.

Chapter 9. - Biofiltration Treatment Facilities

Note: Figures in Chapter 9 are courtesy of King County, except as noted.

This Chapter addresses ~~five~~ Best Management Practices (BMPs) that are classified as biofiltration treatment facilities:

Biofilters are vegetated treatment systems (typically grass) that remove pollutants by means of sedimentation, filtration, soil sorption, and/or plant uptake. They are typically configured as swales or flat filter strips.

9.1 Purpose

The BMPs discussed in this Chapter are designed to remove low concentrations and quantities of total suspended solids (TSS), heavy metals, petroleum hydrocarbons, and/or nutrients from stormwater.

9.2 Applications

A biofilter can be used as a basic treatment BMP for contaminated stormwater runoff from roadways, driveways, parking lots, and highly impervious ultra-urban areas or as the first stage of a treatment train. In cases where hydrocarbons, high TSS, or debris would be present in the runoff, such as high-use sites, a pretreatment system for those components would be necessary. Off-line location is preferred to avoid flattening vegetation and the erosive effects of high flows. ~~Biofilters should be considered~~ Consider biofilters in retrofit situations where appropriate. (Center for Watershed Protection, 1998)

9.3 Site Suitability

Consider the following factors ~~must be considered~~ for determining site suitability:

- Target pollutants are amenable to biofilter treatment
- Accessibility for Operation and Maintenance
- Suitable growth environment; (soil, etc.) for the vegetation
- Adequate siting for a pre-treatment facility if high petroleum hydrocarbon levels (oil/grease) or high TSS loads could impair treatment capacity or efficiency
- If the biofilter can be impacted by snowmelts and ice, refer to Caraco and Claytor for additional design criteria (USEPA, 1997).

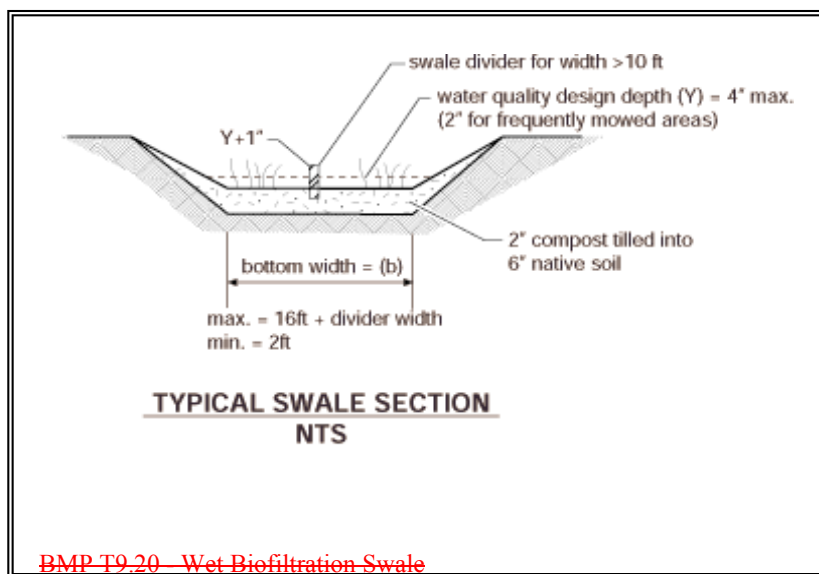
9.4 Best Management Practices

This Chapter presents the ~~following numerous~~ Biofiltration Treatment BMPs:

~~BMP T9.10~~ Basic Biofiltration Swale

Description

Biofiltration swales are typically shaped as a trapezoid or a parabola as shown in [Figure 9.4.1](#).



~~BMP T9.20~~ Wet Biofiltration Swale

~~BMP T9.30~~ Continuous Inflow Biofiltration Swale

~~BMP T9.40~~ Basic Filter Strip & Compost Amended Filter Strip

~~BMP T9.50~~ Narrow Area Filter Strip

~~BMP T9.10~~ Basic Biofiltration Swale

~~Description:~~

Biofiltration swales are typically shaped as a trapezoid or a parabola as shown in Figure 9.1.

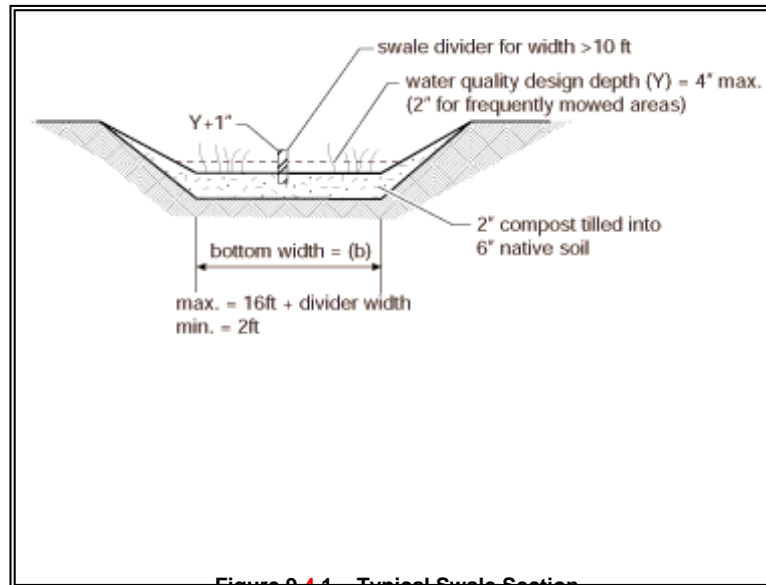


Figure 9.1.1 – Typical Swale Section

Limitations

Data suggest that the performance of biofiltration swales is highly variable from storm to storm. Ecology recommends considering other treatment methods that perform more consistently, such as sand filters and wet ponds, before using a biofiltration swale. Biofiltration swales downstream of devices of equal or greater effectiveness can convey runoff, but do not consider them to offer a treatment benefit. (Horner, 2000)

Design Criteria

- [Table 9.4.1](#) specifies design criteria. Use a 9 minute hydraulic residence time at a multiple of the peak 15 minute Water Quality Design Flow Rate (Q) representing 91% runoff volume as determined by the Western Washington Hydrology Model (WWHM).

Limitations:

Data suggest that the performance of biofiltration swales is highly variable from storm to storm. It is therefore recommended that treatment methods providing more consistent performance, such as sand filters and wet ponds, be considered first. Swales downstream of devices of equal or greater effectiveness can convey runoff but should not be expected to offer a treatment benefit. (Horner, 2000)

Design Criteria:

- ~~Design criteria are specified in Table 9.1. A 9 minute hydraulic residence time is used at a multiple of the peak 15 minute Water Quality Design Flow Rate (Q) representing 91% runoff volume as determined by the Western Washington Hydrology Model (WWHM). (See Volume I)~~
- Check the hydraulic capacity/stability for inflows greater than design flows. Bypass high flows, or control release rates into the biofilter, if necessary.
- Install level spreaders (min. 1-inch gravel) at the head and every 50 feet in swales of ≥ 4 feet width. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofilter as needed.
- Use energy dissipators (riprap) for increased downslopes.

Guidance for Bypassing Off-line Facilities:

Most biofiltration swales are currently designed to be on-line facilities. However, an off-line design is possible. Swales designed in an off-line mode should not engage a bypass until the flow rate exceeds a value determined by multiplying Q, the off-line water quality design flow rate predicted by the WWHM, by the ratio determined in [Figure 9.4.6b](#). ~~Figure 9.5b.~~ This modified design flow rate is an estimate of the design flow rate determined by using SBUH procedures. ~~Ecology's intent is to maintain recent biofiltration sizing recommendations (9 minutes detention at the peak design flow rate estimated by SBUH for a 6 month, 24 hour storm with a Type 1A rainfall distribution) until more definitive information is collected concerning bioswale performance.~~ The only advantage of designing a swale to be off-line is that the stability check, which may make the swale larger, is not necessary.

Sizing Procedure for Biofiltration Swales

This guide provides biofilter swale design procedures in full detail, along with examples.

Preliminary Steps (P)

P-1 Determine the Water Quality design flow rate (Q) in 15-minute time-steps using the WWHM. Use the correct flow rate, off-line or on-line, for ~~your~~the design situation.

P-2 Establish the longitudinal slope of the proposed biofilter.

P-3 Select a vegetation cover suitable for the site. Refer to [Tables 9.4.2, 9.4.3](#) ~~Tables 9.2, 9.3,~~ and [9.4.4](#) (in text) to select vegetation for western Washington.

Design Calculations for Biofiltration Swale:

~~There are a number of ways of applying the design procedure introduced by Chow (Chow, 1959). These variations depend on the order in which steps are performed, what constants are established at the beginning of the process and which ones are calculated, and what values are assigned to the variables selected initially.~~

The procedure recommended here is an adaptation ~~appropriate from the design procedure originate by Chow (Chow, 1959)~~ for biofiltration applications ~~of the type being installed~~ in the Puget Sound region.

This procedure reverses Chow's order, designing first for capacity and then for stability. The capacity analysis emphasizes the promotion of biofiltration, rather than transporting flow with the greatest possible hydraulic efficiency. Therefore, it is based on criteria that promote sedimentation, filtration, and other pollutant removal mechanisms. Because these criteria include a lower maximum velocity than permitted for stability, the biofilter dimensions usually do not have to be modified after a stability check.

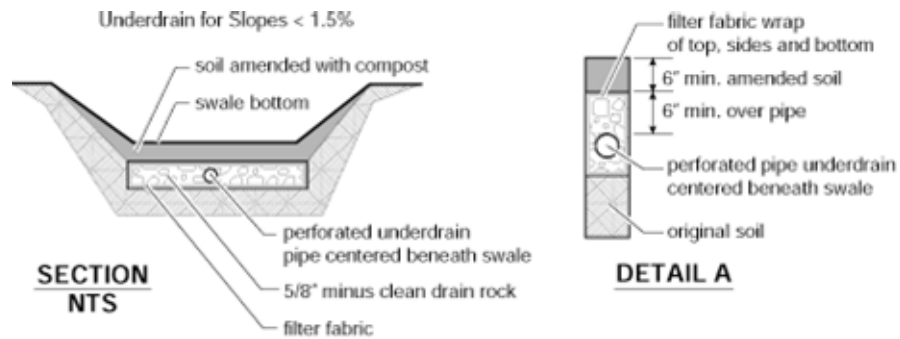
Design Steps (D):

D-1. Select the type of vegetation, and design depth of flow (based on frequency of mowing and type of vegetation). ([Table 9.4.1](#)~~(Table 9.1)~~)

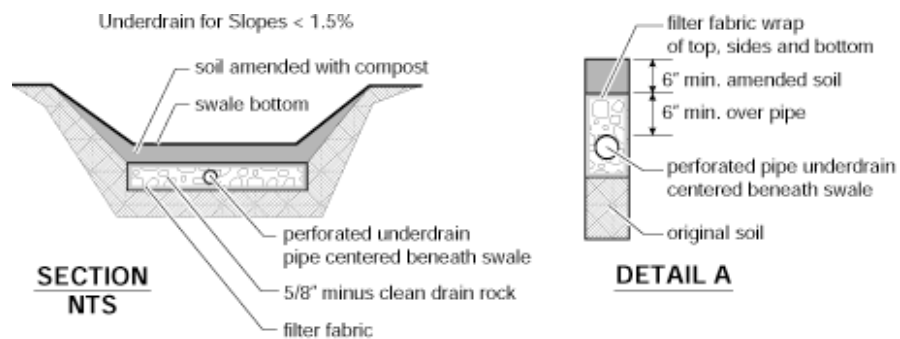
D-2. Select a value of Manning's n (~~Table 9.1~~[Table 9.4.1](#) with footnote #3).

Table 9.4.1 Sizing Criteria		
Design parameter	BMP T 9.10-Biofiltration swale	BMP T 9.40-Filter strip
Longitudinal Slope	0.015 - 0.025 ¹	0.01 - 0.33
Maximum velocity	1 ft / sec (@ K multiplied by the WQ design flow rate ; for stability, 3 ft/sec max.	0.5 ft / sec @ K multiplied by the WQ design flow rate
Maximum water depth ²	2"- if mowed frequently; 4" if mowed infrequently	1-inch max.
Manning coefficient (22)	(0.2 - 0.3) ³ (0.24 if mowed infrequently)	0.35
Bed width (bottom)	(2 - 10 ft) ⁴	---
Freeboard height	0.5 ft	---
Minimum hydraulic residence time at Water Quality Design Flow Rate	9 minutes (18 minutes for continuous inflow) (See Volume I, Appendix B)	9 minutes
Minimum length	100 ft	Sufficient to achieve hydraulic residence time in the filter strip
Maximum sideslope	3 H : 1 V 4H:1V preferred	Inlet edge ≥ 1" lower than contributing paved area
Max. tributary drainage flowpath	---	150 feet
Max. longitudinal slope of contributing area	---	0.05 (steeper than 0.05 need upslope flow spreading and energy dissipation)
Max. lateral slope of contributing area	---	0.02 (at the edge of the strip inlet)

1. For swales, if the slope is less than 1.5% install an underdrain using a perforated pipe, or equivalent. Amend the soil if necessary to allow effective percolation of water to the underdrain. Install the low-flow drain 6" deep in the soil. Slopes greater than 2.5% need check dams (riprap) at vertical drops of 12-15 inches. Underdrains can be made of 6 inch Schedule 40 PVC perforated pipe with 6" of drain gravel on the pipe. The gravel and pipe must be enclosed by geotextile fabric. (See [Figures 9.4.2](#) [Figures 9.2](#) and [9.4.3](#) [9.3](#))
2. Below the design water depth install an erosion control blanket, at least 4" of topsoil, and the selected biofiltration mix. Above the water line use a straw mulch or sod.
3. This range of Manning's n can be used in the equation; $b = Qn/1.49y(1.67)s(0.5) - Zy$ with wider bottom width b, and lower depth, y, at the same flow. This provides the designer with the option of varying the bottom width of the swale depending on space limitations. Designing at the higher n within this range at the same flow decreases the hydraulic design depth, thus placing the pollutants in closer contact with the vegetation and the soil.
4. For swale widths up to 16 feet the cross-section can be divided with a berm (concrete, plastic, compacted earthfill) using a flow spreader at the inlet ([Figure 9.4.4](#) [Figure 9.4](#))



NOTE: Underdrain must infiltrate or drain freely to an acceptable discharge point.

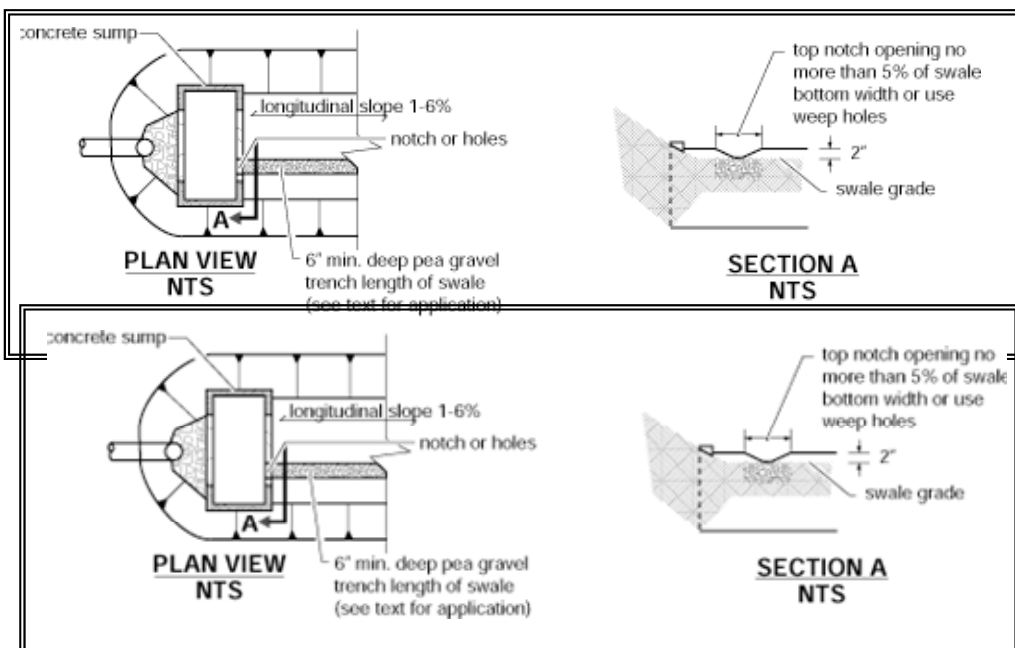


NOTE: Underdrain must infiltrate or drain freely to an acceptable discharge point.

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Figure 9.4.2 – Biofiltration Swale Underdrain Detail

Figure 9.4.3 – Biofiltration Swale Low-Flow Drain Detail



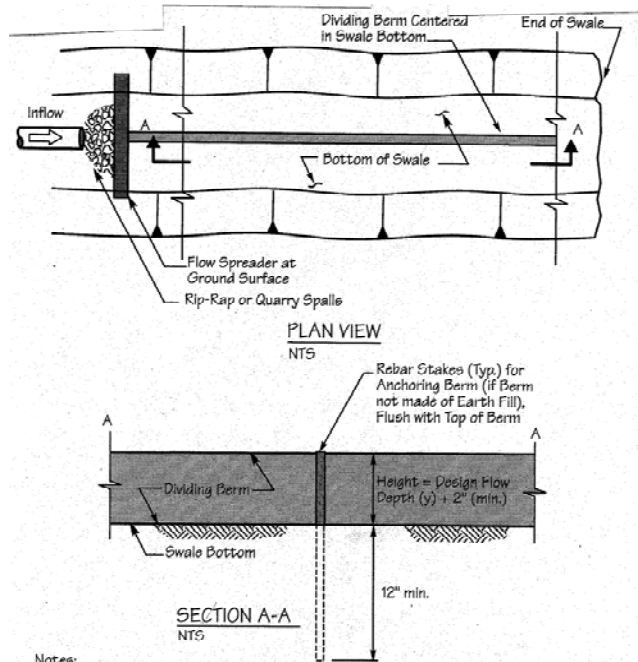


Figure 9.4.4 – Swale Dividing Berm

D-3. Select swale shape-typically trapezoidal or parabolic.

D-4. Use Manning's equation and first approximations relating hydraulic radius and dimensions for the selected swale shape to obtain a working value of a biofilter width dimension:

$$Q = \frac{1.49AR^{0.67}s^{0.5}}{n} \quad Q = \frac{1.49AR^{0.67}s^{0.5}}{n} \quad (1)$$

$$A_{\text{rectangle}} = Ty \quad A_{\text{rectangle}} = Ty \quad (2)$$

$$R_{\text{rectangle}} = \frac{Ty}{T + 2y} \quad R_{\text{rectangle}} = \frac{Ty}{T + 2y} \quad (3)$$

Where:

- Q = Water Quality Design flow rate in 15-minute time steps based on WWHM, (ft³/s, cfs)
- n = Manning's n (dimensionless)
- s = Longitudinal slope as a ratio of vertical rise/horizontal run (dimensionless)
- A = Cross-sectional area (ft²)
- R = Hydraulic radius (ft)
- T = top width of trapezoid or width of a rectangle (ft)
- y = depth of flow (ft)
- b = bottom width of trapezoid (ft)

If equations 2 and 3 are substituted into equation 1 and solved for T, complex equations result that are difficult to solve manually. However, approximate solutions can be found by recognizing that $T \gg y$ and $Z^2 \gg 1$, and that certain terms are nearly negligible. The approximation solutions for rectangular and trapezoidal shapes are:

$$R_{\text{rectangle}} \approx y, R_{\text{trapezoid}} \approx y, R_{\text{parabolic}} \approx 0.67y, R_v \approx 0.5y$$

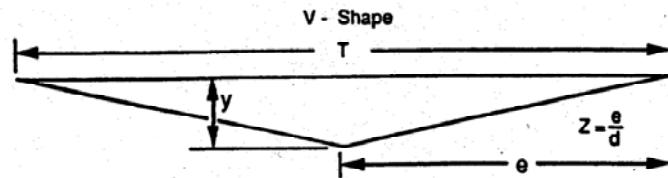
Substitute $R_{\text{trapezoid}}$ and $A_{\text{trapezoid}} = by + Zy^2$ into Equation 1, and solve for the bottom width b (trapezoidal swale):

$$b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy$$

For a trapezoid, select a side slope Z of at least 3. Compute b and then top width T, where $T = b + 2yZ$. (Note: Adjustment factor of 2.5 accounts for the differential between Water Quality design flow rate and the SBUH design flow. This equation is used to estimate an initial cross-sectional area. It does not affect the overall biofiltration swale size.)

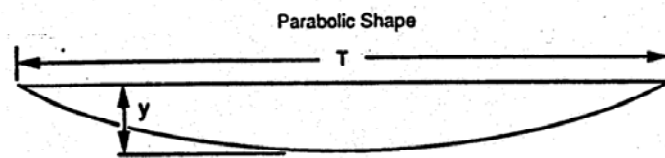
If b for a swale is greater than 10 ft, either investigate how Q can be reduced, divide the flow by installing a low berm, or arbitrarily set b = 10 ft and continue with the analysis. For other swale shapes refer to [Figure 9.4.5 Fig. 9.5.](#)

CHANNEL GEOMETRY



Cross-Sectional Area (A) = zy^2
 Top Width (T) = $2yZ$

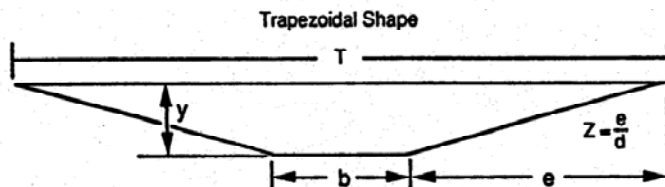
Hydraulic Radius (R) = $\frac{zy}{2\sqrt{Z^2 + 1}}$



Cross-Sectional Area (A) = $\frac{2}{3}Ty$

Top Width (T) = $\frac{1.5A}{y}$

Hydraulic Radius (R) = $\frac{T^2y}{1.5T^2 + 4y^2}$



Cross-Sectional Area (A) = $by + Zy^2$
 Top Width (T) = $b + 2yz$

Hydraulic Radius (R) = $\frac{by + Zy^2}{b + 2y\sqrt{Z^2 + 1}}$

Figure 9.4.5 – Geometric Formulas for Common Swale Shapes

Source: Livingston, et al, 1984

D-5. Compute A:

$$\begin{aligned} A_{\text{rectangle}} &= Ty \quad A_{\text{rectangle}} = Ty \quad \text{or} \quad A_{\text{trapezoid}} = by + Zy^2 \\ A_{\text{trapezoid}} &= by + Zy^2 \\ A_{\text{filter strip}} &= Ty \end{aligned}$$

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D-6. Compute the flow velocity at design flow rate:

$$V = K \frac{Q}{A}$$

K = A ratio of the peak 10-minute flow predicted by SBUH to the water quality design flow rate estimated using the WWHM. The value of K is determined from [Figure 9.4.6a](#) ~~Figure 9.6a~~ for on-line facilities, or [Figure 9.4.6b](#) ~~Figure 9.6b~~ for off-line facilities.

If $V > 1.0$ ft/sec (or $V > 0.5$ ft/sec for a filter strip), repeat steps D-1 to D-6 until the condition is met. A velocity greater than 1.0 ft/sec was found to flatten grasses, thus reducing filtration. A velocity lower than this maximum value will allow a 9-minute hydraulic residence time criterion in a shorter biofilter. If the value of V suggests that a longer biofilter will be needed than space permits, investigate how Q can be reduced (e.g., use of low impact development BMP's), or increase y and/or T (up to the allowable maximum values) and repeat the analysis.

D-7. Compute the swale length (L, ft)

$$L = Vt \text{ (60 sec/min)}$$

Where: t = hydraulic residence time (min)

Use t = 9 minutes for this calculation (use t = 18 minutes for a continuous inflow biofiltration swale). If a biofilter length is greater than the space permits, follow the advice in step D-6.

If a length less than 100 feet results from this analysis, increase it to 100 feet, the minimum allowed. In this case, it may be possible to save some space in width and still meet all criteria. This possibility can be checked by computing V in the 100 ft biofilter for t = 9 minutes, recalculating A (if $V < 1.0$ ft/sec) and recalculating T.

D-8. If there is still not sufficient space for the biofilter, the local government and the project proponent should consider the following solutions (listed in order of preference):

- 1) ~~1)~~ Divide the site drainage to flow to multiple biofilters.
- 2) ~~2)~~ Use infiltration to provide lower discharge rates to the biofilter (only if the Site Suitability Criteria in Chapter 3, Volume III are met).

- |
- 3) ~~3)~~ Increase vegetation height and design depth of flow (note: the design must ensure that vegetation remains standing during design flow).

Figure 9.4.6a – Ratio of SBUH Peak/WQ Flow

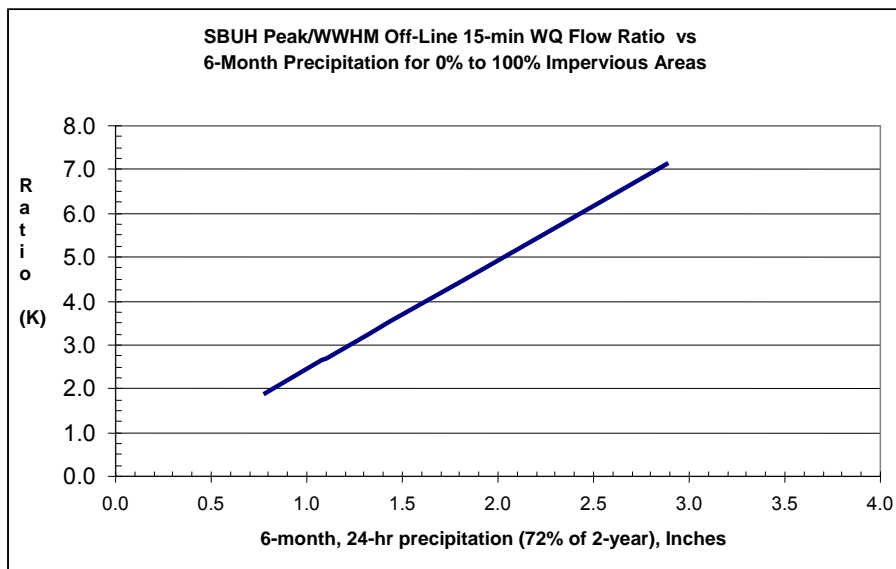


Figure 9.4.6b – Ratio of SBUH Peak/WQ Flow

- 4) Reduce the developed surface area to gain space for biofiltration.
- 5) Increase the longitudinal slope.

- 6) Increase the side slopes.
- 7) Nest the biofilter within or around another BMP.

Check for Stability (Minimizing Erosion)

The stability check must be performed for the combination of highest expected flow and least vegetation coverage and height. A check is not required for biofiltration swales that are located "off-line" from the primary conveyance/detention system. Maintain the same units as in the biofiltration capacity analysis.

SC-1. Perform the stability check for the 100-year, return frequency flow using 15-minute time steps using an approved continuous runoff model. Until WWHM peak flow rates in 15-minute time steps are available the designer can use the WWHM 100-yr. hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps.

SC-2. Estimate the vegetation coverage ("good" or "fair") and height on the first occasion that the biofilter will receive flow, or whenever the coverage and height will be least. Avoid flow introduction during the vegetation establishment period by timing planting or bypassing.

SC-3. Estimate the degree of retardance from [Table 9.4.2](#) ~~Table 9.2.~~ When uncertain, be conservative by selecting a relatively low degree.

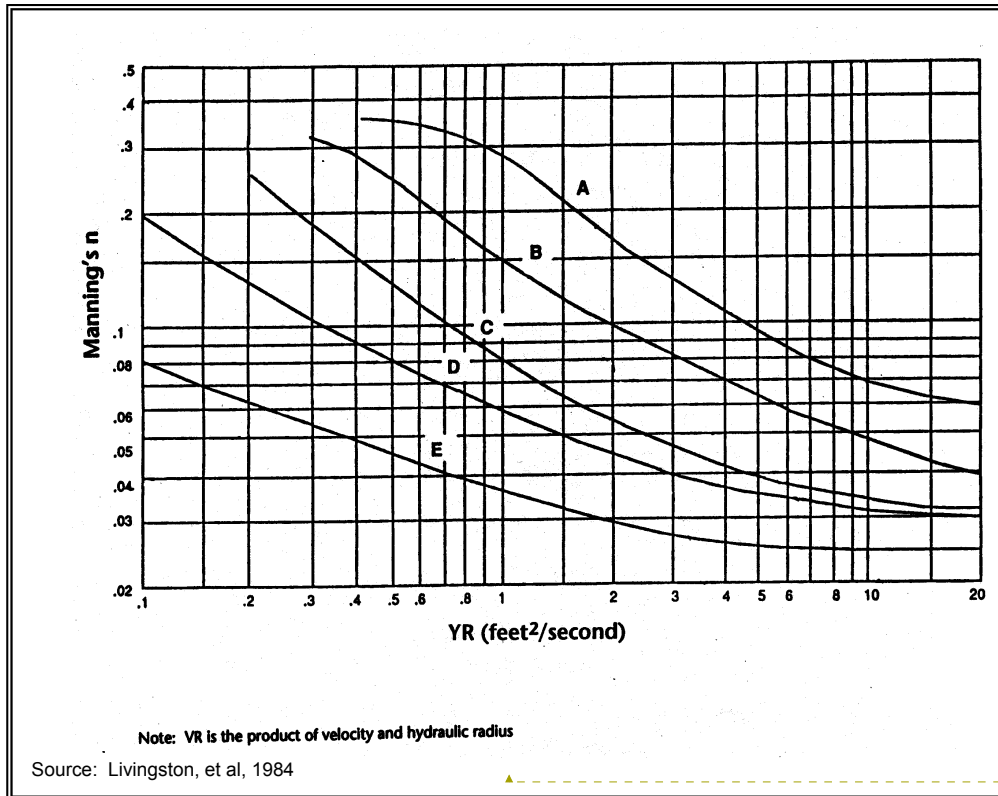
The maximum permissible velocity for erosion prevention (V_{max}) is 3 feet per second.

Stability Check Steps (SC)

Table 9.4.2 Guide for Selecting Degree of Retardance ^(a)		
Coverage	Average Grass Height (inches)	Degree of Retardance
Good	<2	E. Very Low
	2-6	D. Low
	6-10	C. Moderate
	11-24	B. High
	>30	A. Very High
Fair	<2	E. Very Low
	2-6	D. Low
	6-10	D. Low
	11-24	C. Moderate
	>30	B. High

See Chow (1959). In addition, Chow recommended selection of retardance C for a grass-legume mixture 6-8 inches high and D for a mixture 4-5 inches high. No retardance recommendations have appeared for emergent wetland species. Therefore, judgment must be used. Since these species generally grow less densely than grasses, using a "fair" coverage would be a reasonable approach.

SC-4. Select a trial Manning's n for the high flow condition. The minimum value for poor vegetation cover and low height (possibly, knocked from the vertical by high flow) is 0.033. A good initial choice under these conditions is 0.04.



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Figure 9.4.7 – The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A-E)

SC-5. Refer to [Figure 9.4.7](#) ~~Figure 9.7~~ to obtain a first approximation for VR of 3 feet/second.

SC-6. Compute hydraulic radius, R , from VR in [Figure 9.4.7](#) ~~Figure 9.7~~ and a V_{max}

SC-7. Use Manning's equation to solve for the actual VR.

SC-8. Compare the actual VR from step SC-7 and first approximation from step SC-5. If they do not agree within 5 percent, repeat steps SC-4 to SC-8 until acceptable agreement is reached. If $n < 0.033$ is needed to get agreement, set $n = 0.033$, repeat step SC-7, and then proceed to step SC-9.

SC-9. Compute the actual V for the final design conditions:

Check to be sure $V < V_{\max}$ of 3 feet/second.

SC-10. Compute the required swale cross-sectional area, A , for stability:

SC-11. Compare the A , computed in step SC-10 of the stability analysis, with the A from the biofiltration capacity analysis (step D-5).

If less area is required for stability than is provided for capacity, the capacity design is acceptable. If not, use A from step SC-10 of the stability analysis and recalculate channel dimensions.

SC-12. Calculate the depth of flow at the stability check design flow rate condition for the final dimensions and use A from step SC-10.

SC-13. Compare the depth from step SC-12 to the depth used in the biofiltration capacity design (Step D-1). Use the larger of the two and add 0.5 ft. of freeboard to obtain the total depth (y_t) of the swale. Calculate the top width for the full depth using the appropriate equation.

SC-14. Recalculate the hydraulic radius: (use b from Step D-4 calculated previously for biofiltration capacity, or Step SC-11, as appropriate, and y_t = total depth from Step SC-13)

SC-15. Make a final check for capacity based on the stability check design storm (this check will ensure that capacity is adequate if the largest expected event coincides with the greatest retardance). Use Equation 1, a Manning's n selected in step D-2, and the calculated channel dimensions, including freeboard, to compute the flow capacity of the channel under these conditions. Use R from step SC-14, above, and $A = b(y_t) + Z(y_t)^2$ using b from Step D-4, D-15, or SC-11 as appropriate.

If the flow capacity is less than the stability check design storm flow rate, increase the channel cross-sectional area as needed for this conveyance. Specify the new channel dimensions.

Completion Step (CO)

CO. Review all of the criteria and guidelines for biofilter planning, design, installation, and operation above and specify all of the appropriate features for the application.

Example of Design Calculations for Biofiltration Swales

Preliminary Steps

P-1. Assume that the WWHM based Water Quality Design Flow Rate in 15 minute time-steps, Q , is 0.2 cfs. Assume an on-line facility.

P-2. Assume the slope (s) is 2 percent.

P-3. Assume the vegetation will be a grass-legume mixture and it will be infrequently mowed.

Design for Biofiltration Swale Capacity

D-1. Set winter grass height at 5" and the design flow depth (y) at 3 inches.

D-2. Use $n = 0.20$ to $n_2 = 0.30$

D-3. Base the design on a trapezoidal shape, with a side slope $Z = 3$.

D-4a. Calculate the bottom width, b ;

Where:

$$\begin{aligned} n &= 0.20 & y &= 0.25 \text{ ft} \\ Q &= 0.2 \text{ cfs} & s &= 0.02 \\ Z &= 3 \end{aligned}$$

$$b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy$$

$$\cancel{b \approx 4.0 \text{ ft}}$$

$$b \approx 4.0 \text{ ft}$$

At n_2 ; $b_2 = 6.5$ feet

D-4b. Calculate the top width (T)

$$T = b + 2yZ = 4.0 + [2(0.25)(3)] = 5.5 \text{ feet}$$

D-5. Calculate the cross-sectional area (A)

$$A = by + Zy^2 = (4.0)(0.25) + (3)(0.25^2) = 1.19 \text{ ft}^2$$

D-6. Calculate the flow velocity (V)

$$V = K \frac{Q}{A} = 0.17 \text{ ft} / \text{sec}$$

for $K = 1$. Actual K is determined per [Figure 9.4.6a](#) ~~Figure 9.5a~~

$$0.17 < 1.0 \text{ ft/sec} \therefore \text{OK}$$

D-7 Calculate the Length (L)

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$$L = Vt(60 \text{ sec/min})$$

$$= 0.17 (9)(60)$$

For $t = 9$ min, $L = 92$ ft. at n ; expand to a minimum of 100 foot length per design criterion

At n_2 ; $L = 100$ ft.

Note: Where b is less than the maximum value, it may be possible to reduce L by increasing b . In this case, because L is determined by the requirement for a minimum length of 100 feet, it is not possible.

Check for Channel Stability

SC-1. Base the check on passing the 100-year, return frequency flow (15 minute time steps) through a swale with a mixture of Kentucky bluegrass and tall fescue on loose erodible soil. Until WWHM peak flow rates in 15-minute time steps are available the designer can use the WWHM 100-yr. hourly peak flows times an adjustment factor of 1.6 to approximate peak flows in 15-minute time steps. Assume that the adjusted peak Q is 1.92 cfs.

SC-2. Base the check on a grass height of 3 inches with "fair" coverage (lowest mowed height and least cover, assuming flow bypasses or does not occur during grass establishment).

SC-3. From [Table 9.4.2](#) ~~Table 9.2.2~~ Degree of Retardance = D (low)

Set $V_{\max} = 3$ ft/sec

SC-4. Select trial Manning's $n = 0.04$

SC-5. From [Figure 9.4.7](#) ~~Figure 9.7.2~~ $VR_{\text{appx}} = 3$ ft²/s

SC-6. Calculate R

$$R = \frac{VR_{\text{appx}}}{V_{\max}} = 1.0 \text{ ft}$$

SC-7. Calculate VR_{actual}

$$VR_{\text{actual}} = \frac{1.49}{n} R^{1.67} S^{0.5} = 5.25 \text{ ft}^2 / \text{sec}$$

SC-8. VR_{actual} from step SC-7 $>$ VR_{appx} from step SC-5 by $> 5\%$.

Select new trial $n = 0.0475$

[Figure 9.4.7](#) ~~Figure 9.7.2~~ $VR_{\text{appx}} = 1.7$ ft²/s

$R = 0.57$ ft.

$VR_{\text{actual}} = 1.73$ ft²/s (within 5% of $VR_{\text{appx}} = 1.7$)

SC-9. Calculate V

$$V = \frac{VR_{\text{actual}}}{R} = \frac{1.73}{0.57} = 3 \text{ ft / sec}$$

$$V = 3 \text{ ft/sec} \leq 3 \text{ ft/sec, } V_{\text{max}} \therefore \therefore \text{OK}$$

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SC-10. Calculate Stability Area

$$A_{\text{Stability}} = \frac{Q}{3} = \frac{1.92}{3} = 0.64 \text{ ft}^2$$

SC-11. Stability Check

$A_{\text{Stability}} = 0.64 \text{ ft}^2$ is less than A_{Capacity} from step D-5 ($A_{\text{Capacity}} = 1.19 \text{ ft}^2$). \therefore OK

If $A_{\text{Stability}} > A_{\text{Capacity}}$, it will be necessary to select new trial sizes for width and flow depth (based on space and other considerations), recalculate A_{Capacity} , and repeat steps SC-10 and SC-11.

SC-12. Calculate depth of flow at the stability design flow rate condition using the quadratic equation solution:

$$y = \frac{-b \pm \sqrt{b^2 - 4Z(-A)}}{2Z}$$

For $b = 4$, $y = 0.14 \text{ ft}$ (positive root)

SC-13. Use the greater value of y from SC-12 or that assumed in D-1. In this case, the greater depth is 0.25-foot, which was the basis for the biofiltration capacity design. Add 0.5 feet freeboard to that depth.

Total channel depth = 0.75 ft

Top Width = $b + 2yZ$

$$= 4 + (2)(0.25)(3)$$

$$= 8.5 \text{ ft}$$

SC-14. Recalculate hydraulic radius and flow rate

For $b = 4 \text{ ft}$, $y = 0.25 \text{ ft}$

$Z = 3$, $s = 0.02$, $n = 0.2$

$$A = by + Zy^2 = 4.68 \text{ ft}^2$$

$$R = \{by + Zy^2\} / \{b + 2y(Z^2 + 1)\}^{0.5} = 0.53 \text{ ft.}$$

SC-15. Calculate Flow Capacity at Greatest Resistance

$$Q = \frac{1.49AR^{0.67}s^{0.5}}{n} = \frac{1.49AR^{0.67}s^{0.5}}{n} = 3.2 \text{ cfs}$$

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$$Q = 3.2 \text{ cfs} > 1.92 \text{ cfs} \therefore \text{OK}$$

Completion Step

CO-1. Assume 100 feet of swale length is available.

The final channel dimensions are:

Bottom width, $b = 4$ feet

Channel depth = 0.75 feet

Top width = $b + 2yZ = 8.5$ feet

No check dams are needed for a 2% slope.

Soil Criteria

- The following top soil mix at least 8-inch deep:
 - Sandy loam 60-90 %
 - Clay 0-10 %
 - Composted organic matter, 10-30 %
(excluding animal waste, toxics)
- Use compost amended soil where practicable
- Till to at least 8-inch depth
- For longitudinal slopes of < 2 percent use more sand to obtain more infiltration
- If ground water contamination is a concern, seal the bed with clay or a geomembrane liner

Vegetation Criteria

- See Tables [9.4.39.3](#), [9.4.9.4.4](#) and [9.4.59.5](#) for recommended grasses, wetland plants, and groundcovers.
- Select fine, turf-forming, water-resistant grasses where vegetative growth and moisture will be adequate for growth.
- Irrigate if moisture is insufficient during dry weather season.
- Use sod with low clay content and where needed to initiate adequate vegetative growth. Preferably sod should be laid to a minimum of one-foot vertical depth above the swale bottom.
- Consider sun/shade conditions for adequate vegetative growth and avoid prolonged shading of any portion not planted with shade tolerant vegetation.

- Stabilize soil areas upslope of the biofilter to prevent erosion
- Fertilizing a biofilter should be avoided if at all possible in any application where nutrient control is an objective. Test the soil for nitrogen, phosphorous, and potassium and consult with a landscape professional about the need for fertilizer in relation to soil nutrition and vegetation requirements. If use of a fertilizer cannot be avoided, use a slow-release fertilizer formulation in the least amount needed.

Recommended grasses (see Tables 9.4.3 and 9.4.4 below)

Table 9.4.3 Grass Seed Mixes Suitable for Biofiltration Swale Treatment Areas			
Mix 1		Mix 2	
75-80 percent	tall or meadow fescue	60-70 percent	tall fescue
10-15 percent	seaside/colonial bentgrass	10-15 percent	seaside/colonial bentgrass
5-10 percent	Redtop	10-15 percent	meadow foxtail
		6-10 percent	alsike clover
		1-5 percent	marshfield big trefoil
		1-6 percent	Redtop

Note: all percentages are by weight. * based on Briargreen, Inc.

Table 9.4.4 Groundcovers And Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington	
Groundcovers	
kinnikinnick*	<i>Arctostaphylos uva-ursi</i>
Epimedium	<i>Epimedium grandiflorum</i>
creeping forget-me-not	<i>Omphalodes verna</i>
--	<i>Euonymus lanceolata</i>
yellow-root	<i>Xanthorhiza simplissima</i>
--	<i>Genista</i>
white lawn clover	<i>Trifolium repens</i>
*	
-----	<i>Rubus calycinoides</i>
strawberry*	<i>Fragaria chiloensis</i>
broadleaf lupine*	<i>Lupinus latifolius</i>
Grasses (drought-tolerant, minimum mowing)	
dwarf tall fescues	<i>Festuca</i> spp. (e.g., Many Mustang, Silverado)
hard fescue	<i>Festuca ovina duriuscula</i> (e.g., Reliant, Aurora)
tufted fescue	<i>Festuca amethystine</i>
buffalo grass	<i>Buchloe dactyloides</i>
red fescue*	<i>Festuca rubra</i>
tall fescue grass*	<i>Festuca arundinacea</i>
blue oatgrass	<i>Helictotrichon sempervirens</i>

**Construction
Criteria**

The biofiltration swale should not be put into operation until areas of exposed soil in the contributing drainage catchment have been sufficiently stabilized. Deposition of eroded soils can impede the growth of grass in the swale and reduce swale treatment effectiveness. Thus, effective erosion and sediment control measures should remain in place until the swale vegetation is established (see Volume II for erosion and sediment control BMPs). Avoid compaction during construction. Grade biofilters to attain uniform longitudinal and lateral slopes.

**Maintenance
Criteria**

- Inspect biofilters at least once every 6 months, preferably during storm events, and also after storm events of > 0.5 inch rainfall/ 24 hours. Maintain adequate grass growth and eliminate bare spots.

Construction Criteria

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Maintenance Criteria

- ~~• Inspect biofilters at least once every 6 months, preferably during storm events, and also after storm events of > 0.5 inch rainfall/ 24 hours. Maintain adequate grass growth and eliminate bare spots.~~
- Mow grasses, if needed for good growth {typically maintain at 4 – 9 inches and not below design flow level (King County, 1998)}.
- Remove sediment as needed at head of the swale if grass growth is inhibited in greater than 10 percent of the swale, or if the sediment is blocking the distribution and entry of the water (King County, 1998).
- Remove leaves, litter, and oily materials, and re-seed or resod, and regrade, as needed. Clean curb cuts and level spreaders as needed.

Prevent scouring and soil erosion in the biofilter. If flow channeling occurs, regrade and reseed the biofilter, as necessary.

Maintain access to biofilter inlet, outlet, and to mowing ([Figure 9.4.8](#)([Figure 9.8](#)))

- If a swale is equipped with underdrains, vehicular traffic on the swale bottom (other than grass mowing equipment) should be avoided to prevent damage to the drainpipes.

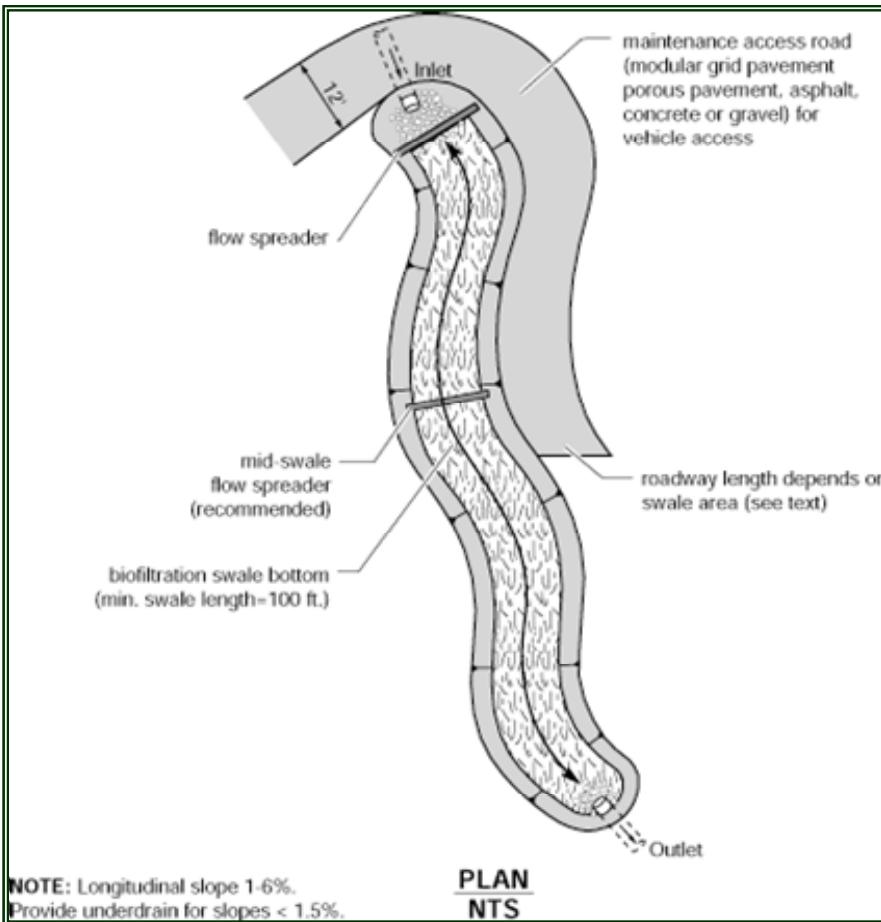


Figure 9.4.8 – Biofiltration Swale Access Features

BMP T9.20: Wet Biofiltration Swale

Description

A wet biofiltration swale is a variation of a basic biofiltration swale. Designers can use wet biofiltration swales when the longitudinal slope is slight, water tables are high, or a continuous low base flow is likely to result in saturated soil. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, use vegetation specifically adapted to saturated soil conditions. Different vegetation in turn requires modification of several of the design parameters for the basic biofiltration swale.

Performance Objectives

To remove low concentrations of pollutants such as TSS, heavy metals, nutrients, and petroleum hydrocarbons.

Applications/Limitations

Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable because one or more of the following conditions exist:

Description

~~A wet biofiltration swale is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, vegetation specifically adapted to saturated soil conditions is needed. Different vegetation in turn requires modification of several of the design parameters for the basic biofiltration swale.~~

Performance Objectives

~~To remove low concentrations of pollutants such as TSS, heavy metals, nutrients, and petroleum hydrocarbons.~~

Applications/Limitations

~~Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable because one or more of the following conditions exist:~~

- The swale is on till soils and is downstream of a detention pond providing flow control.
- Saturated soil conditions are likely because of seeps or base flows on the site.
- Longitudinal slopes are slight (generally less than 2 percent).

Design Criteria

Use the same design approach as for basic biofiltration swales except to add the following:

Design Criteria

~~Use the same design approach as for basic biofiltration swales except to add the following:~~

Adjust for extended wet season flow. If the swale will be downstream of a detention pond providing flow control, multiply the treatment area (bottom width times length) of the swale by 2, and readjust the swale length, if desired. Maintain a 5:1 length to width ratio.

Intent: An increase in the treatment area of swales following detention ponds is required because of the differences in vegetation established in a constant flow environment. Flows following detention are much more prolonged. These prolonged flows result in more stream-like conditions than are typical for other wet biofilter situations. Since vegetation growing in streams is often less dense, this increase in treatment area is needed to ensure that equivalent pollutant removal is achieved in extended flow situations.

Swale Geometry: Same as specified for basic biofiltration swales except for the following modifications:

Criterion 1: The bottom width may be increased to 25 feet maximum, but a minimum length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. *Note: The minimum swale length is still 100 feet.*

Criterion 2: If longitudinal slopes are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of retaining walls, log check dams, or short riprap sections. **No underdrain or low-flow drain is required.**

High-Flow Bypass: A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line water quality design flow that has been increased by the ratio indicated in [Figure 9.4.6b](#)~~Figure 9.5b.~~ The bypass is necessary to protect wetland vegetation from damage. Unlike grass, wetland vegetation will not quickly regain an upright attitude after being laid down by high flows. New growth, usually from the base of the plant, often taking several weeks, is required to regain its upright form. The bypass may be an open channel parallel to the wet biofiltration swale.

Water Depth and Base Flow: Same as for basic biofiltration swales except the design water depth shall be 4 inches for all wetland vegetation selections, and **no underdrains or low-flow drains are required.**

Flow Velocity, Energy Dissipation, and Flow Spreading: Same as for basic biofiltration swales except no flow spreader is needed.

Access: Same as for basic biofiltration swales except access is only required to the inflow and the outflow of the swale; access along the

length of the swale is not required. Also, wheel strips may not be used for access in the swale.

Intent: An access road is not required along the length of a wet swale because of infrequent access needs. Frequent mowing or harvesting is not desirable. In addition, wetland plants are fairly resilient to sediment-induced changes in water depth, so the need for access should be infrequent.

Soil Amendment: Same as for basic biofiltration swales.

Planting Requirements: Same as for basic biofiltration swales except for the following modifications:

1. A list of acceptable plants and recommended spacing is shown in [Table 9.4.5](#)~~Table 9.5.~~. In general, it is best to plant several species to increase the likelihood that at least some of the selected species will find growing conditions favorable.
2. A wetland seed mix may be applied by hydroseeding, but if coverage is poor, planting of rootstock or nursery stock is required. Poor coverage is considered to be more than 30 percent bare area through the upper 2/3 of the swale after four weeks.

Recommended Design Features: Same as for basic biofiltration swales

Construction Considerations: Same as for basic biofiltration swales

Maintenance Considerations: Same as for basic biofiltration swales except mowing of wetland vegetation is not required. However, harvesting of very dense vegetation may be desirable in the fall after plant die-back to prevent the sloughing of excess organic material into receiving waters. Many native *Juncus* species remain green throughout the winter; therefore, fall harvesting of *Juncus* species is not recommended.

Table 9.4.5 Recommended Plants for Wet Biofiltration Swale		
Common Name	Scientific Name	Spacing (on center)
Shortawn foxtail	<i>Alopecurus aequalis</i>	seed
Water foxtail	<i>Alopecurus geniculatus</i>	seed
Spike rush	<i>Eleocharis spp.</i>	4 inches
Slough sedge*	<i>Carex obnupta</i>	6 inches or seed
Sawbeak sedge	<i>Carex stipata</i>	6 inches
Sedge	<i>Carex spp.</i>	6 inches
Western mannagrass	<i>Glyceria occidentalis</i>	seed
Velvetgrass	<i>Holcus mollis</i>	seed
Slender rush	<i>Juncus tenuis</i>	6 inches
Watercress*	<i>Rorippa nasturtium-aquaticum</i>	12 inches
Water parsley*	<i>Oenanthe sarmentosa</i>	6 inches
Hardstem bulrush	<i>Scirpus acutus</i>	6 inches
Small-fruited bulrush	<i>Scirpus microcarpus</i>	12 inches

* Good choices for swales with significant periods of flow, such as those downstream of a detention facility.

Note: Cattail (*Typha latifolia*) is not appropriate for most wet swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.

BMP T9.30: Continuous Inflow Biofiltration Swale

Description

In situations where water enters a biofiltration swale continuously along the side slope rather than discretely at the head, a different design approach—the continuous inflow biofiltration swale—is needed. The basic swale design is modified by increasing swale length to achieve an equivalent average residence time.

Applications

A continuous inflow biofiltration swale is to be **used when inflows are not concentrated**, such as locations along the shoulder of a road without curbs. This design may also be **used where frequent, small point flows enter a swale**, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts. In general, no inlet port should carry more than about 10 percent of the flow.

Description

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Applications

~~A continuous inflow biofiltration swale is to be **used when inflows are not concentrated**, such as locations along the shoulder of a road without curbs. This design may also be **used where frequent, small point flows enter a swale**, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts. In general, no inlet port should carry more than about 10 percent of the flow.~~

A continuous inflow swale is not appropriate for a situation in which significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge point in order to provide adequate treatment for the increased flows.

Design Criteria

Same as specified for **basic biofiltration swale** except for the following:

- The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be on-line facilities.

Design Criteria

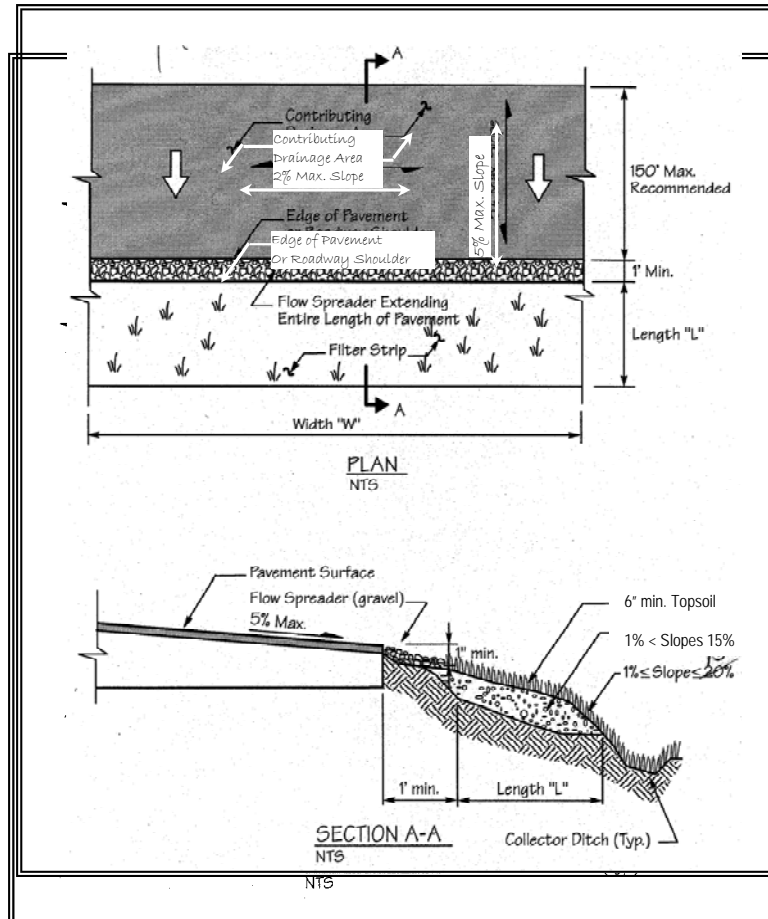
~~Same as specified for **basic biofiltration swale** except for the following:~~

- ~~• The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be on-line facilities.~~
- If only a single design flow is used, the flow rate at the outlet should be used. The goal is to achieve an average residence time through the swale of 9 minutes as calculated using the on-line water quality design flow rate multiplied by the ratio, K, in [Figure 9.4.6a](#)~~Figure 9.5a.~~ Assuming an even distribution of inflow into the side of the swale double the hydraulic residence time to a minimum of 18 minutes.
- For continuous inflow biofiltration swales, interior side slopes above the WQ design treatment elevation shall be planted in grass. A typical lawn seed mix or the biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale. **Intent:** The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the biofiltration treatment area.

BMP T9.40: Basic Filter Strip

Description

A basic filter strip is flat with no side slopes (Figure 9.4.9). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip. Treatment is by passage of water over the surface, and through grass.



Description:

A basic filter strip is flat with no side slopes (Figure 9.9). Contaminated stormwater is distributed as sheet flow across the inlet width of a biofilter strip.

Figure 9.4.9 – Typical Filter Strip

Applications and Limitations

The basic filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways.

~~Applications/Limitations:~~

~~The basic filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways. Where a filter strip area is compost-amended to a minimum of 10% organic content in accordance with BMP T5.13; with hydroseeded grass maintained at 95% density and a 4-inch length by mowing and periodic re-seeding (possible landscaping with herbaceous shrubs), the filter strip serves as an Enhanced Treatment option.~~

Design Criteria for Filter strips:

- Use the Design Criteria specified in [Table 9.4.1](#) ~~Table 9.1.~~
- Filter strips should only receive sheet flow.
- Use curb cuts \geq 12-inch wide and 1-inch above the filter strip inlet.

Calculate the design flow depth using Manning's equation as follows:

$$KQ = (1.49A R^{0.67} s^{0.5})/n$$

Substituting for AR:

$$KQ = (1.49Ty^{1.67} s^{0.5})/n$$

Where:

$$Ty = A_{\text{rectangle, ft}}^2$$

y \approx R_{rectangle}, design depth of flow, ft. (1 inch maximum)

Q = peak Water Quality design flow rate based on WWHM, ft³/sec
(See Appendix I-B, Volume I)

K = The ratio determined by using [Figure 9.4.6a](#) ~~Figure 9.5a~~

n = Manning's roughness coefficient

s = Longitudinal slope of filter strip parallel to direction of flow

T = Width of filter strip perpendicular to the direction of flow, ft.

A = Filter strip inlet cross-sectional flow area (rectangular), ft²

R = hydraulic radius, ft.

Rearranging for y:

$$y = [KQn/1.49Ts^{0.5}]^{0.6}$$

y must not exceed 1 inch

Note: As in swale design an adjustment factor of K accounts for the differential between the WWHM Water Quality design flow rate and the SBUH design flow

Calculate the design flow velocity V , ft./sec., through the filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft./sec

Calculate required length, ft., of the filter strip at the minimum hydraulic residence time, t , of 9 minutes:

$$L = tV = 540V$$

~~BMP T9.50 Narrow Area Filter Strip~~

~~Description:~~

~~This section describes a filter strip design[†] for impervious areas with flowpaths of 30 feet or less that can drain along their widest dimension to grassy areas.~~

~~Applications/Limitations:~~

~~A narrow area filter strip could be used at roadways with limited right-of-way, or for narrow parking strips, the narrow strip. If space is available to use the basic filter strip design, that design should be used in preference to the narrow filter strip.~~

~~The treatment objectives, applications and limitations, design criteria, materials specifications, and construction and maintenance requirements set forth in the basic filter strip design apply to narrow filter strip applications.~~

~~Design Criteria:~~

~~Design criteria for narrow area filter strips are the same as specified for basic filter strips. The sizing of a narrow area filter strip is based on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).~~

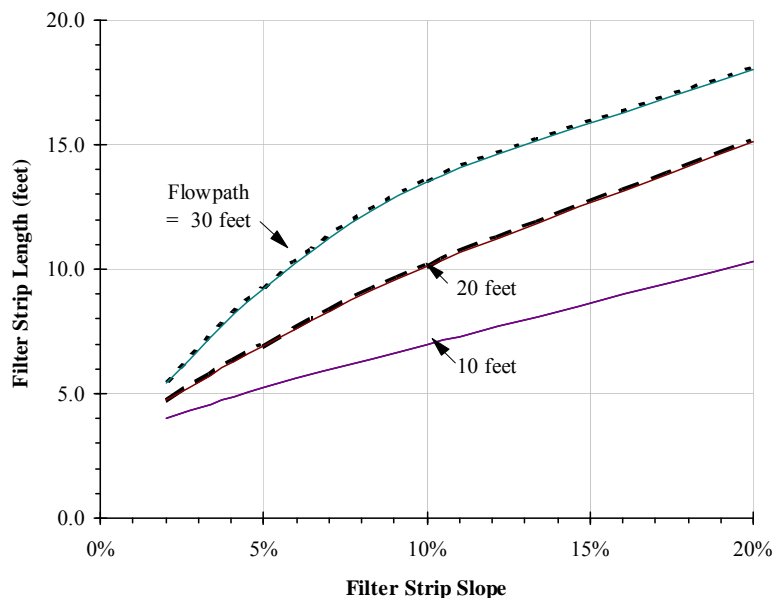
~~*Step 1:* Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining sheet flow to the strip. Normally this is the same as the width of the paved area, but if the site is sloped, the flow path may be longer than the width of the impervious area.~~

[†] — This narrow area filter strip design method is included here because technical limitations exist in the basic design method which result in filter strips that are proportionately longer as the contributing drainage becomes narrower (a result that is counter-intuitive). Research by several parties is underway to evaluate filter strip design parameters. This research may lead to more stringent design requirements that would supersede the design criteria presented here.

Step 2: Calculate the longitudinal slope of the filter strip (along the direction of unconcentrated flow), averaged over the total width of the filter strip. The minimum sizing slope is 2 percent. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum allowable filter strip slope is 20 percent. If the slope exceeds 20 percent, the filter strip must be stepped down the slope so that the treatment areas between drop sections do not have a longitudinal slope greater than 20 percent. Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. Vertical drops along the slope must not exceed 12 inches in height. If this is not possible, a different treatment facility must be selected.

Step 3: Select the appropriate filter strip length for the flowpath length and filter strip longitudinal slope (Steps 1 and 2 above) from the graph in Figure 9.10. The filter strip must be designed to provide this minimum length *L* along the entire stretch of pavement draining into it.

To use the graph: Find the length of the flowpath on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the design longitudinal slope of the filter strip (x-axis) is directly below. Read the filter strip length on the y-axis which corresponds to the intersection point.



Note: minimum allowable filter strip length is 4 feet

Figure 9.10 – Filter Strip Lengths for Narrow Right-of-Way

Chapter 10. - Wetpool Facilities

Note: Figures in Chapter 10 are from the King County Surface Water Design Manual

10.1 Purpose

This Chapter presents the methods, criteria, and details for analysis and design of wetponds, wetvaults, and stormwater wetlands. These facilities have as a common element a permanent pool of water - the wetpool. Each of the wetpool facilities can be combined with a detention or flow control pond in a combined facility. ~~Included are the following specific facility designs:~~

~~BMP T10.10 - Wetponds - Basic and Large~~

~~BMP T10.20 - Wetvaults~~

~~BMP T10.30 - Stormwater Wetlands~~

~~BMP T10.40 - Combined Detention and Wetpool Facilities~~

10.2 Application

The wetpool facility designs described for the four BMPs in this Chapter will achieve the performance objectives cited in [Chapter 3](#) ~~Chapter 3~~ for specific treatment menus.

10.3 Best Management Practices (BMPs) for Wetpool Facilities

The four BMPs discussed below are currently recognized as effective treatment techniques using wetpool facilities. The specific BMPs that are selected should be coordinated with the Treatment Facility Menus discussed in [Chapter 3](#) ~~Chapter 3~~.

BMP T10.10: Wetponds - Basic and Large

Purpose and Definition

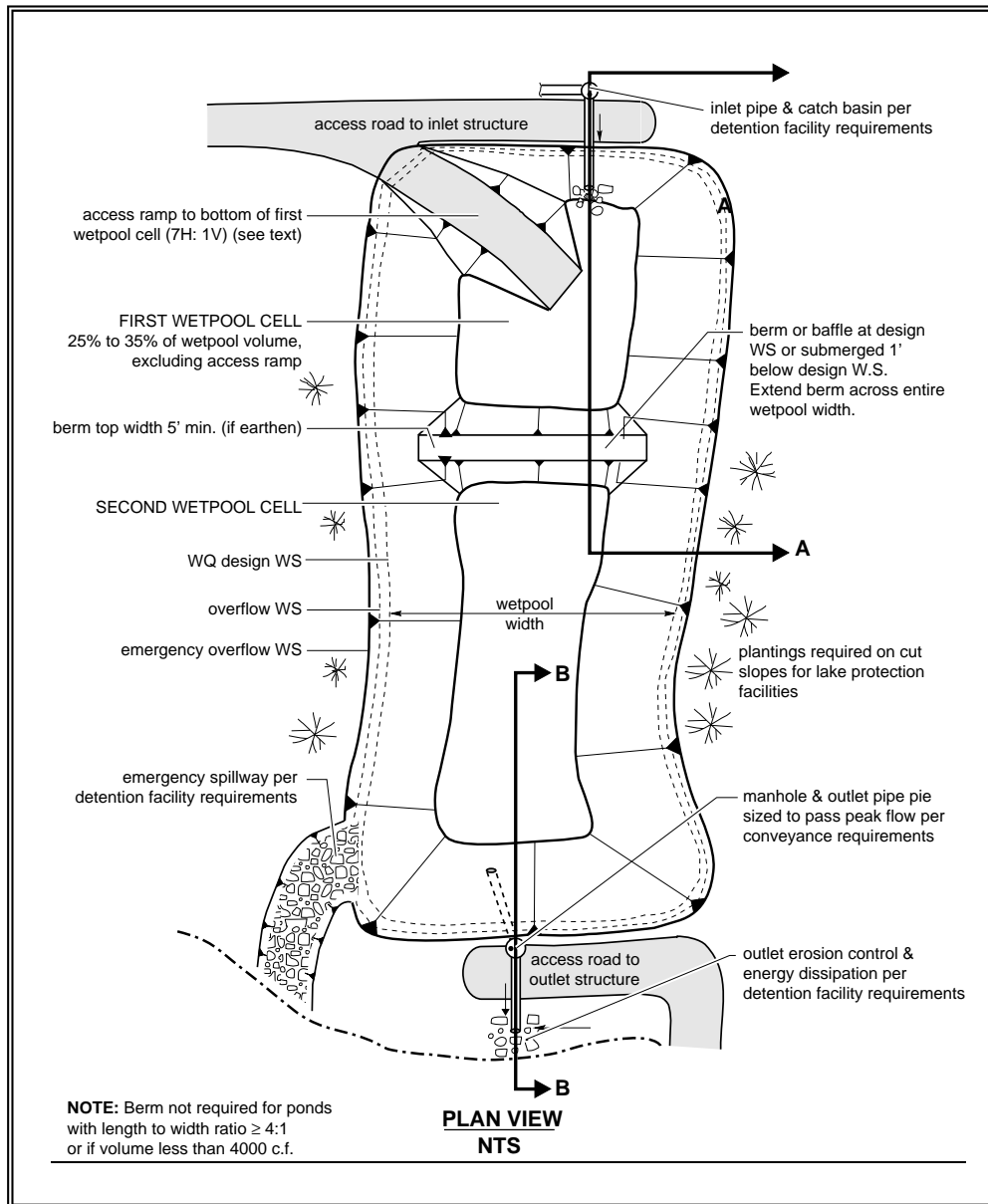
A wetpond is a constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment for nutrient removal. Peak flow control can be provided in the "live storage" area above the permanent pool. [Figures 10.31a](#) and [10.3.1b](#) illustrates a typical wet pond BMP.

Purpose and Definition

~~A wetpond is a constructed stormwater pond that retains a permanent pool of water ("wetpool") at least during the wet season. The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the~~

~~permanent pool volume to provide additional treatment for nutrient removal. Peak flow control can be provided in the "live storage" area above the permanent pool. Figures 10-1a and 10-1b illustrates a typical wet pond BMP.~~

The following design, construction, and operation and maintenance criteria cover two wetpond applications - the basic wetpond and the large wetpond. Large wetponds are designed for higher levels of pollutant removal.



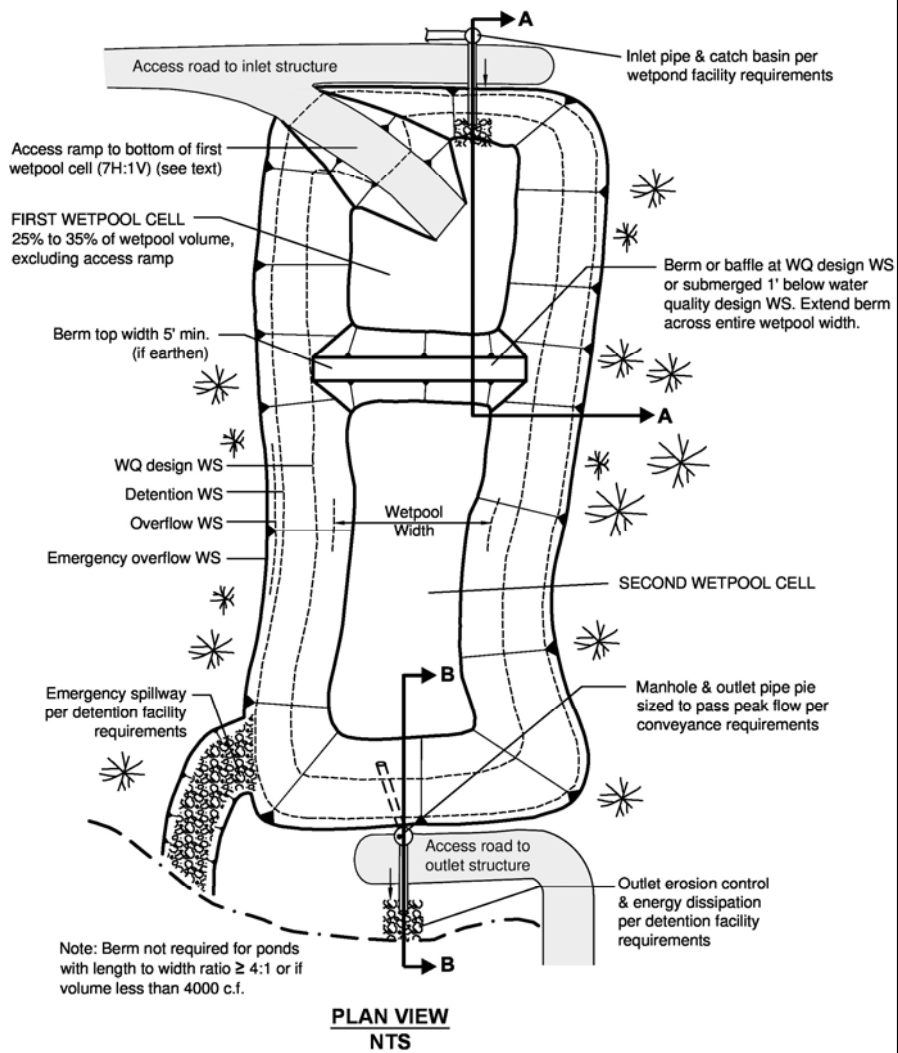


Figure 10.3.1a – Wetpond



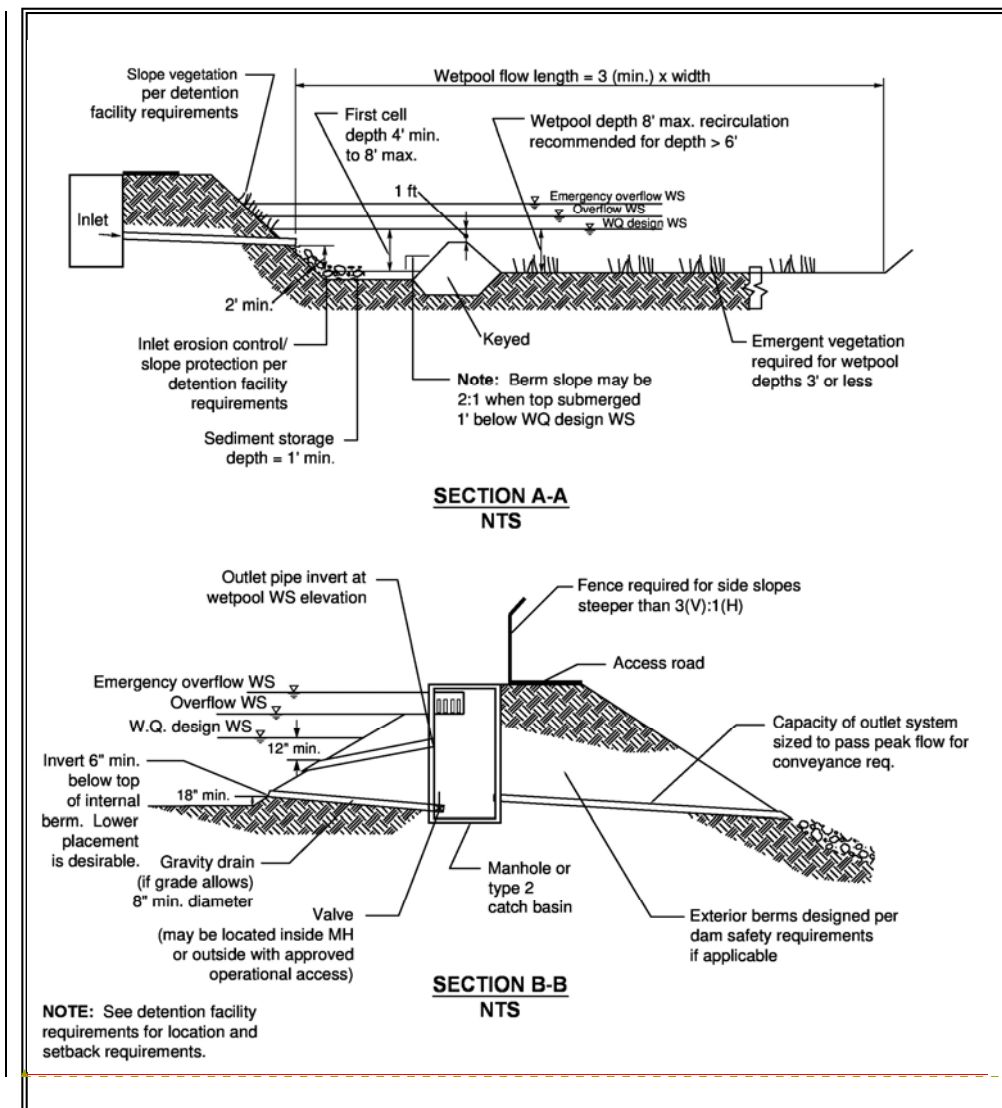
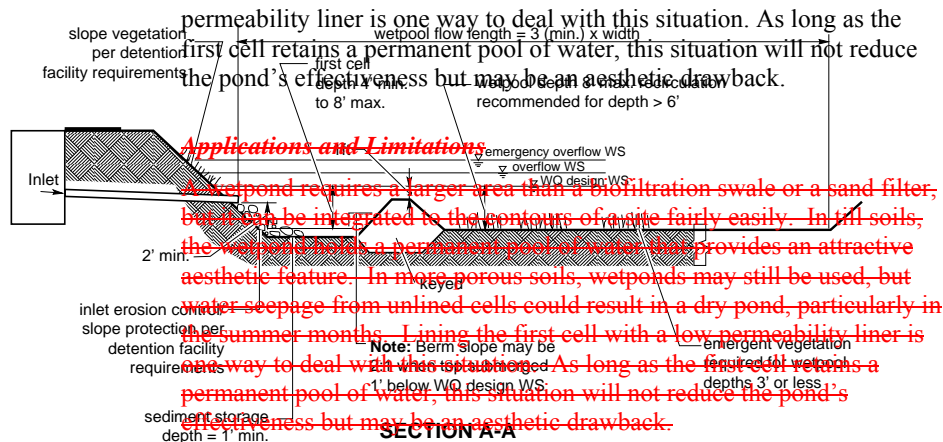


Figure 10.3.1b – Wetpond

Applications and Limitations

A wetpond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wetpond holds a permanent pool of water that provides an attractive aesthetic feature. In more porous soils, wetponds may still be used, but water seepage from unlined cells could result in a dry pond, particularly in the summer months. Lining the first cell with a low



Design Criteria

The primary design factor that determines a wetpond's treatment efficiency is the volume of the wetpool. The larger the wetpool volume, the greater the potential for pollutant removal. For a basic wetpond, the wetpool volume provided shall be equal to or greater than the total volume of runoff from the watershed. Alternatively, use an approved continuous runoff model to give you the Water Quality Design Storm Volume. This volume is equal to the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91% of the entire runoff volume over a multi-decade period of record. The WWHM and MGS Flood identify this volume for you.

storm event. ~~Alternatively, the 91st percentile, 24-hour runoff volume indicated by an approved continuous runoff model.~~

A large wetpond requires a wetpool volume at least 1.5 times larger than the ~~total volume of runoff from the 6-month, 24-hour storm event.~~ Water Quality Design Storm Volume. Also important are the avoidance of short-circuiting and the promotion of plug flow. **Plug flow** describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm. Design features that encourage plug flow and avoid dead zones are:

- Dissipating energy at the inlet.
- Providing a large length-to-width ratio.
- Providing a broad surface for water exchange using a berm designed as a broad-crested weir to divide the wetpond into two cells rather than a constricted area such as a pipe.
- Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Sizing Procedure

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume using: a) the SCS (now known as NRCS) curve number equations presented in Volume III, Chapter 2, Section 2.3.2-, or b) an approved continuous runoff. A basic wetpond requires a volume equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, use the 91st percentile, 24-hour runoff Water Quality Design Storm Volume indicated by an approved continuous runoff model. A large wetpond requires a volume at least 1.5 times the total volume of runoff from the 6-month, 24-hour storm event, or 1.5 times the 91st percentile, 24-hour runoff volume indicated Water Quality Design Storm Volume identified by an approved continuous runoff model.

Step 2: Determine wetpool dimensions. Determine the wetpool dimensions satisfying the design criteria outlined below and illustrated in Figures 10.3.1a Figures 10.1a and 10.3.1b 10.1b. A simple way to check the volume of each wetpool cell is to use the following equation:

$$V = \frac{h(A_1 + A_2)}{2}$$

where V = wetpool volume (cf)
 h = wetpool average depth (ft)
 A_1 = water quality design surface area of wetpool (sf)
 A_2 = bottom area of wetpool (sf)

Step 3: Design pond outlet pipe and determine primary overflow water surface. The pond outlet pipe shall be placed on a reverse grade from the pond's wetpool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

- Use the nomographs in Figures 10.3.2 Figures 10.2 and 10.3.3 10.3 to select a trial size for the pond outlet pipe sufficient to pass the on-line WQ design flow, Q_{wq} indicated by WWHM or other approved continuous runoff model.
- Use Figure 10.3.4 Figure 10.4 to determine the critical depth d_c at the outflow end of the pipe for Q_{wq} .
- Use Figure 10.3.5 Figure 10.5 to determine the flow area A_c at critical depth.
- Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).
- Calculate the velocity head V_H ($V_H = V_c^2 / 2g$, where g is the gravitational constant, 32.2 feet per second).

- f) Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + d_c + V_H).
- g) Adjust outlet pipe diameter as needed and repeat Steps (a) through (e).

Step 4: Determine wetpond dimensions. General wetpond design criteria and concepts are shown in [Figure 10.3.1a](#) ~~Figure 10.1a~~ and [10.3.1b](#) ~~10.1b~~.

Wetpool Geometry

- The wetpool shall be divided into two cells separated by a baffle or berm. The first cell shall contain between 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume. The term baffle means a vertical divider placed across the entire width of the pond, stopping short of the bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

Intent: The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water volume as possible. Alternative methods to the full-length berm or baffle that provide equivalent flow characteristics may be approved on a case-by-case basis by the Local Plan Approval Authority.

- Sediment storage shall be provided in the first cell. The sediment storage shall have a minimum depth of 1-foot. A fixed sediment depth monitor should be installed in the first cell to gauge sediment accumulation unless an alternative gauging method is proposed.
- The minimum depth of the first cell shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.
- The maximum depth of each cell shall not exceed 8 feet (exclusive of sediment storage in the first cell). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see Planting requirements).
- Inlets and outlets shall be placed to maximize the flowpath through the facility. The ratio of flowpath length to width from the inlet to the outlet shall be at least 3:1. The **flowpath length** is defined as the distance from the inlet to the outlet, as measured at mid-depth. The **width** at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
- Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be single celled (i.e., no baffle or berm is required). However, it is especially important in this case that the flow path length be maximized. The ratio of flow path length to width shall be at least 4:1 in single celled wetponds, but should preferably be 5:1.

- All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.
- The first cell ~~may~~**must** be lined in accordance with the liner requirements contained in [Section 4.4](#)~~Section 4.4.~~

Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. If the berm embankments are greater than 4 feet in height, the berm must be constructed by excavating a key equal to 50 percent of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions. The geotechnical analysis shall address situations in which one of the two cells is empty while the other remains full of water.
- The top of the berm may extend to the WQ design water surface or be 1-foot below the WQ design water surface. If at the WQ design water surface, berm side slopes should be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged 1-foot.

Intent: Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V. An alternative to the submerged berm design is the use of barrier planting to prevent easy access to the divider berm in an unfenced wetpond.

- If good vegetation cover is not established on the berm, erosion control measures should be used to prevent erosion of the berm back-slope when the pond is initially filled.
- The interior berm or baffle may be a retaining wall provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it should be submerged one foot below the design water surface to discourage access by pedestrians.
- Criteria for wetpond side slopes are included in [Section 4.3](#)~~Section 4.3.~~

Embankments

Embankments that impound water must comply with the Washington State Dam Safety Regulations ([Chapter 173-175 WAC](#)~~(Chapter 173-175 WAC).~~). If the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet (435,600 cubic feet or 3.26 million gallons) above natural ground level, then dam safety design and review are required by the Department of Ecology. See Section 3.2.1 of Volume III.

Inlet and Outlet

See [Figure 10.3.1a](#) ~~Figure 10.1a~~ and [10.3.1b](#) ~~10.1b~~ for details on the following requirements:

- The inlet to the wetpond shall be submerged with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1-foot, if possible.

Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

- An outlet structure shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used (see Volume III, Figure 3.42.3 for an illustration). No sump is required in the outlet structure for wetponds not providing detention storage. The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. The overflow criteria provided below specifies the sizing and position of the grate opening.
- The pond outlet pipe (as opposed to the manhole or type 2 catch basin outlet pipe) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface. Note: A floating outlet, set to draw water from 1-foot below the water surface, is also acceptable if vandalism concerns are adequately addressed.

Intent: The inverted outlet pipe provides for trapping of oils and floatables in the wetpond.

- The pond outlet pipe shall be sized, at a minimum, to pass the on-line WQ design flow. Note: The highest invert of the outlet pipe sets the WQ design water surface elevation.
- The overflow criteria for single-purpose (treatment only, not combined with flow control) wetponds are as follows:
 - a) The requirement for primary overflow is satisfied by either the grated inlet to the outlet structure or by a birdcage above the pond outlet structure.
 - b) The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe. *Note: The grate invert elevation sets the overflow water surface elevation.*
 - c) The grated opening should be sized to pass the 100-year design flow. The capacity of the outlet system should be sized to pass the peak flow for the conveyance requirements.

- An emergency spillway shall be provided and designed according to the requirements for detention ponds (see Section 3.2.1 of Volume III).
- The Local Plan Approval Authority may require a bypass/ shutoff valve to enable the pond to be taken offline for maintenance purposes.
- A gravity drain for maintenance is recommended if grade allows.

Intent: It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.

- The drain invert shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.

Intent: To prevent highly sediment-laden water from escaping the pond when drained for maintenance.

- The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

- Operational access to the valve shall be provided to the finished ground surface.
- The valve location shall be accessible and well-marked with 1-foot of paving placed around the box. It must also be protected from damage and unauthorized operation.
- A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.
- All metal parts shall be corrosion-resistant. Galvanized materials should not be used unless unavoidable.

Intent: Galvanized metal contributes zinc to stormwater, sometimes in very high concentrations.

Access and Setbacks

- All facilities shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the local government, and 100 feet from any septic tank/drainfield.
- All facilities shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical report must address the potential impact of a wet pond on a steep slope.

- Access and maintenance roads shall be provided and designed according to the requirements for detention ponds. Access and maintenance roads shall extend to both the wetpond inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond.
- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Planting Requirements

Planting requirements for detention ponds also apply to wetponds.

- Large wetponds intended for phosphorus control should not be planted within the cells, as the plants will release phosphorus in the winter when they die off.
- If the second cell of a basic wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See [Table 10.3.1](#) ~~Table 10.1~~ for recommended emergent wetland plant species for wetponds. Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

Note: The recommendations in [Table 10.3.1](#) ~~Table 10.1~~ are for western Washington only. Local knowledge should be used to adapt this information if used in other areas.

- Cattails (*Typha latifolia*) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.
- If the wetpond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the WQ design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements. The purpose of planting is to discourage waterfowl use of the pond and to provide shading. Some suitable trees and shrubs include vine maple (*Acer circinatum*), wild cherry (*Prunus emarginata*), red osier dogwood (*Cornus stolonifera*), California myrtle (*Myrica californica*), Indian plum (*Oemleria cerasiformis*), and Pacific yew (*Taxus brevifolia*) as well as numerous ornamental species.

Recommended Design Features

The following design features should be incorporated into the wetpond design where site conditions allow:

- The method of construction of soil/landscape systems can cause natural selection of specific plant species. Consult a soil restoration or wetland soil scientist for site-specific recommendations. The soil formulation will impact the plant species that will flourish or suffer on

the site, and the formulation should be such that it encourages desired species and discourages undesired species.

- For wetpool depths in excess of 6 feet, it is recommended that some form of recirculation be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions.
- A flow length-to-width ratio greater than the 3:1 minimum is desirable. If the ratio is 4:1 or greater, then the dividing berm is not required, and the pond may consist of one cell rather than two. A one-cell pond must provide at least 6-inches of sediment storage depth. A one cell pond must also provide a minimum depth of 4 feet for the volume equivalent to the first cell of a two-cell design.
- A tear-drop shape, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
- A small amount of base flow is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.
- Evergreen or columnar deciduous trees along the west and south sides of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.
Intent: Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar, etc.) typically have fewer leaves than other deciduous trees.
- The number of inlets to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.
- The access and maintenance road could be extended along the full length of the wetpond and could double as playcourts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.
- The following design features should be incorporated to enhance aesthetics where possible:
 - Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.
 - Provide side slopes that are sufficiently gentle to avoid the need for fencing (3:1 or flatter).

- Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into site design.
- Include fountains or integrated waterfall features for privately maintained facilities.
- Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.
- Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.

Construction Criteria

- Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner - see below).

Construction Criteria

- ~~Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner - see below).~~
- Sediment that has accumulated in the pond at the end of construction may be used in excessively drained soils to meet the liner requirements if the sediment meets the criteria for low permeability or treatment liners in keeping with guidance in [Chapter 4](#)~~Chapter 4-~~. Sediment used for a soil liner must be graded to provide uniform coverage and must meet the thickness specifications in [Chapter 4](#)~~Chapter 4-~~. The sediment must not reduce the design volume of the pond. The pond must be over-excavated initially to provide sufficient room for the sediments to serve as a liner.

Operation and Maintenance

- Maintenance is of primary importance if wetponds are to continue to function as originally designed. A local government, a designated group such as a homeowners' association, or a property owner shall accept the responsibility for maintaining the structures and the impoundment area. A specific maintenance plan shall be formulated outlining the schedule and scope of maintenance operations.

Operation and Maintenance

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- The pond should be inspected by the local government annually. The maintenance standards contained in [Section 4.6](#) are measures for determining if maintenance actions are required as identified through the annual inspection.
- Site vegetation should be trimmed as necessary to keep the pond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare should be revegetated and eroded areas should be regraded prior to being revegetated.
- Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements. Sediments must be disposed in accordance with current local health department requirements and the Minimum Functional Standards for Solid Waste Handling. See Volume IV, Appendix IV-G Recommendations for Management of Street Waste for additional guidance.
- Any standing water removed during the maintenance operation must be properly disposed of. The preferred disposal option is discharge to a sanitary sewer at an approved location. Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met. ~~Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met.~~ See Volume IV, Appendix IV-G for additional guidance.

Table 10.3.1
Emergent Wetland Plant Species Recommended for Wetponds

Species	Common Name	Notes	Maximum Depth
INUNDATION TO 1-FOOT			
<i>Agrostis exarata</i> ⁽¹⁾	Spike bent grass	Prairie to coast	to 2 feet
<i>Carex stipata</i>	Sawbeak sedge	Wet ground	
<i>Eleocharis palustris</i>	Spike rush	Margins of ponds, wet meadows	to 2 feet
<i>Glyceria occidentalis</i>	Western mannagrass	Marshes, pond margins	to 2 feet
<i>Juncus tenuis</i>	Slender rush	Wet soils, wetland margins	
<i>Oenanthe sarmentosa</i>	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
<i>Scirpus atrovinctus</i> (formerly <i>S. cyperinus</i>)	Woolgrass	Tolerates shallow water; tall clumps	
<i>Scirpus microcarpus</i>	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
<i>Sagittaria latifolia</i>	Arrowhead		
INUNDATION 1 TO 2 FEET			
<i>Agrostis exarata</i> ⁽¹⁾	Spike bent grass	Prairie to coast	
<i>Alisma plantago-aquatica</i>	Water plantain		
<i>Eleocharis palustris</i>	Spike rush	Margins of ponds, wet meadows	

<i>Glyceria occidentalis</i>	Western mannagrass	Marshes, pond margins	
<i>Juncus effusus</i>	Soft rush	Wet meadows, pastures, wetland margins	
<i>Scirpus microcarpus</i>	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
<i>Sparganium emmersum</i>	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 TO 3 FEET			
<i>Carex obnupta</i>	Slough sedge	Wet ground or standing water	1.5 to 3 feet
<i>Beckmania syzigachne</i> ⁽¹⁾	Western sloughgrass	Wet prairie to pond margins	
<i>Scirpus acutus</i> ⁽²⁾	Hardstem bulrush	Single tall stems, not clumping	to 3 feet
<i>Scirpus validus</i> ⁽²⁾	Softstem bulrush		
INUNDATION GREATER THAN 3 FEET			
<i>Nuphar polysepalum</i>	Spatterdock	Deep water	3 to 7.5 feet
<i>Nymphaea odorata</i> ⁽¹⁾	White waterlily	Shallow to deep ponds	to 6 feet
<p>Notes:</p> <p>⁽¹⁾ Non-native species. <i>Beckmania syzigachne</i> is native to Oregon. Native species are preferred.</p> <p>⁽²⁾ <i>Scirpus</i> tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.</p> <p>Primary sources: Municipality of Metropolitan Seattle, <i>Water Pollution Control Aspects of Aquatic Plants</i>, 1990. Hortus Northwest, <i>Wetland Plants for Western Oregon</i>, Issue 2, 1991. Hitchcock and Cronquist, <i>Flora of the Pacific Northwest</i>, 1973.</p>			

| **Figure 10.3.2 – Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control**



Figure 10.3.3 – Headwater Depth for Corrugated Pipe Culverts with Inlet Control

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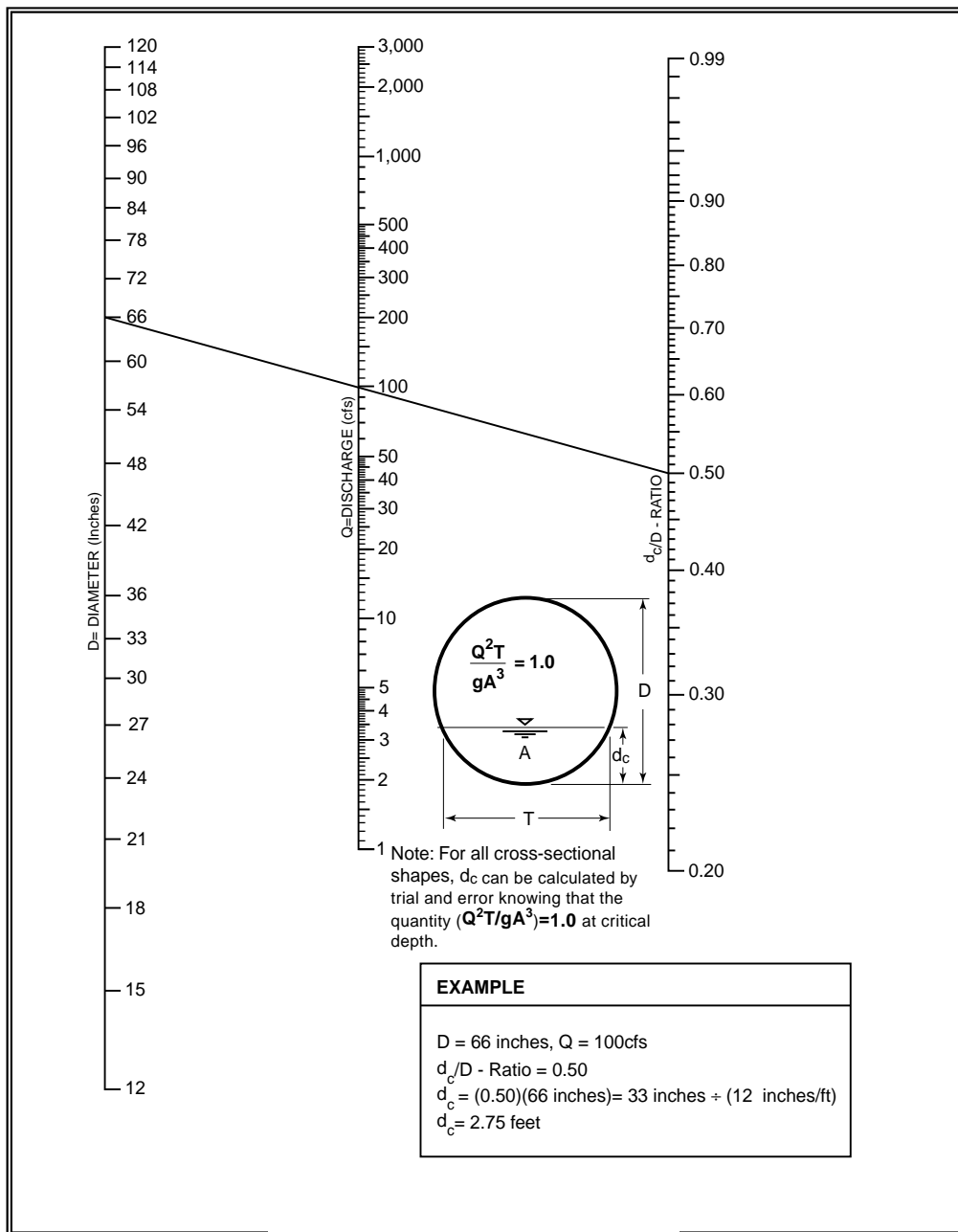
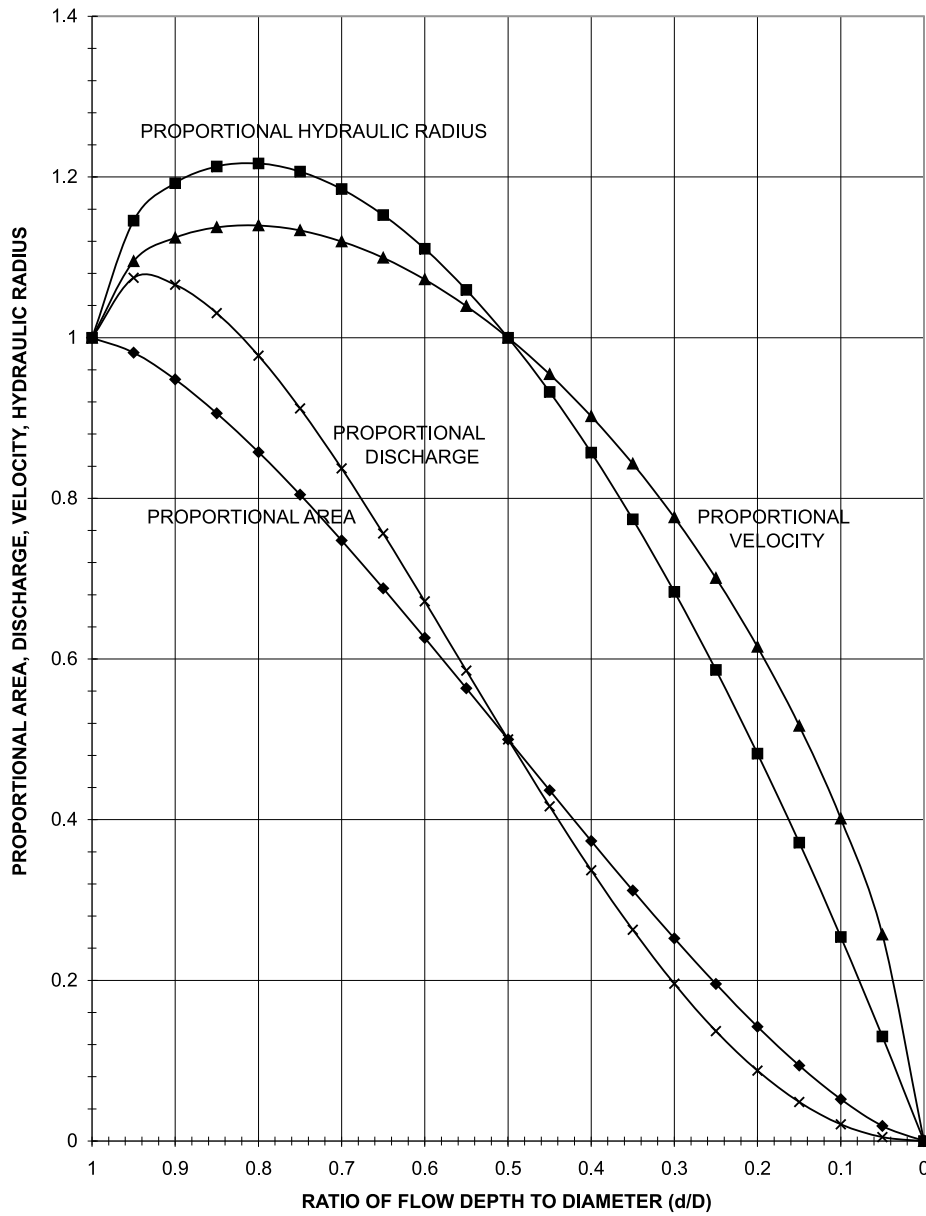


Figure 10.3.4 – Critical Depth of Flow for Circular Culverts



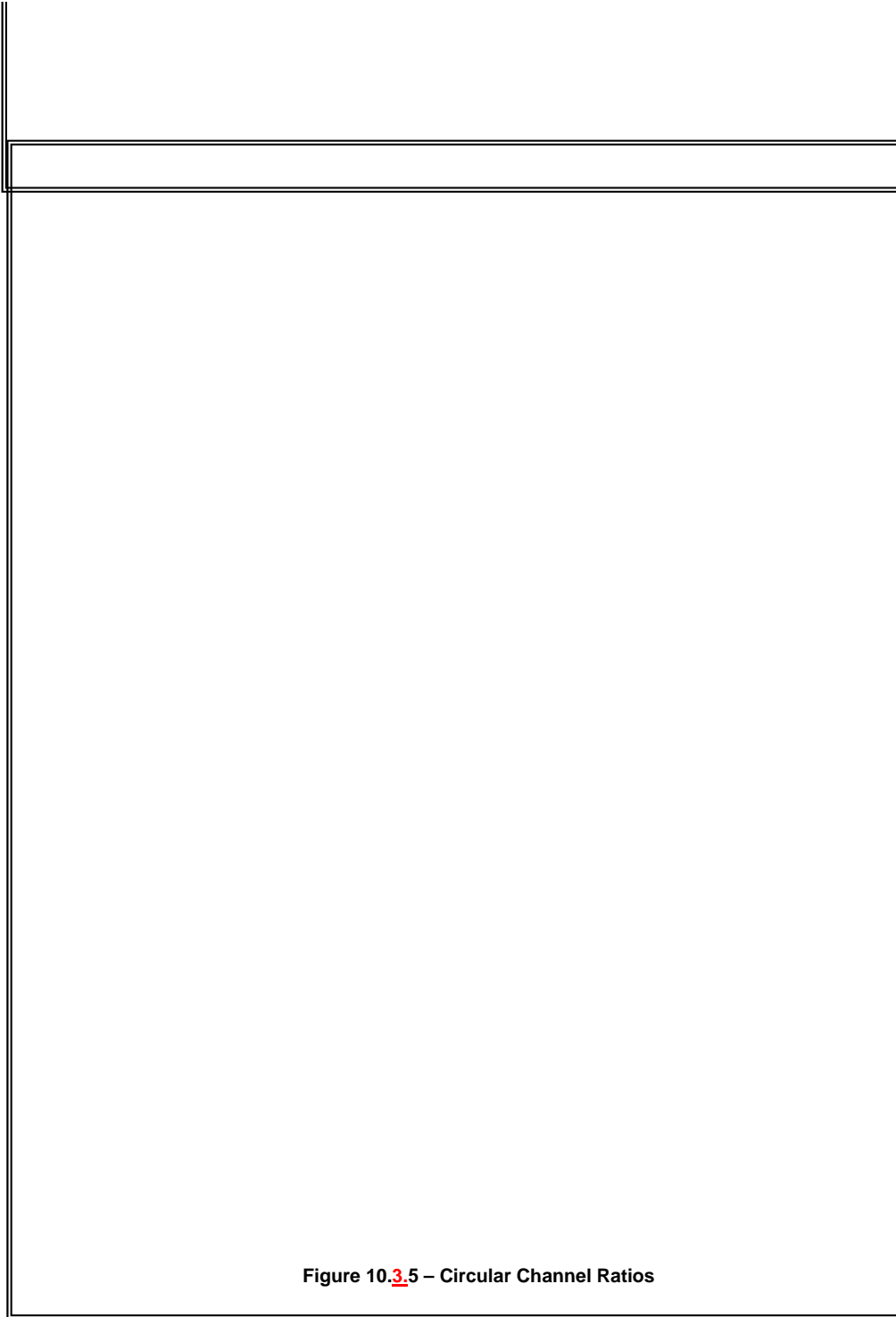


Figure 10.3.5 – Circular Channel Ratios

BMP T10.20: Wetvaults

Purpose and Definition

A wetvault is an underground structure similar in appearance to a detention vault, except that a wetvault has a permanent pool of water (wetpool) which dissipates energy and improves the settling of particulate pollutants (see the wetvault details in [Figure 10.3.6](#)). Being underground, the wetvault lacks the biological pollutant removal mechanisms, such as algae uptake, present in surface wetponds.

Applications and Limitations

A wetvault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other treatment BMPs. The use of wetvaults for residential development is highly discouraged. Combined detention and wetvaults are allowed; see [BMP T10.40](#).

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A wetvault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. There is also concern that oxygen levels will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

Below-ground structures like wetvaults are relatively difficult and expensive to maintain. The need for maintenance is often not seen and as a result routine maintenance does not occur.

If oil control is required for a project, a wetvault may be combined with an API oil/water separator.

Design Criteria

Sizing Procedure

As with wetponds, the primary design factor that determines the removal efficiency of a wetvault is the volume of the wetpool. The larger the volume, the higher the potential for pollutant removal. Performance is also improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios, dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

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Sizing Procedure

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The sizing procedure for a wetvault is identical to the sizing procedure for a wetpond. The wetpool volume for the wetvault shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, ~~use the 91st percentile, 24-hour runoff~~[Water Quality Design Storm](#) Volume estimated by an approved continuous runoff model ~~may be used.~~

Typical design details and concepts for the wetvault are shown in [Figure 10.3.6](#). ~~Figure 10.6.~~

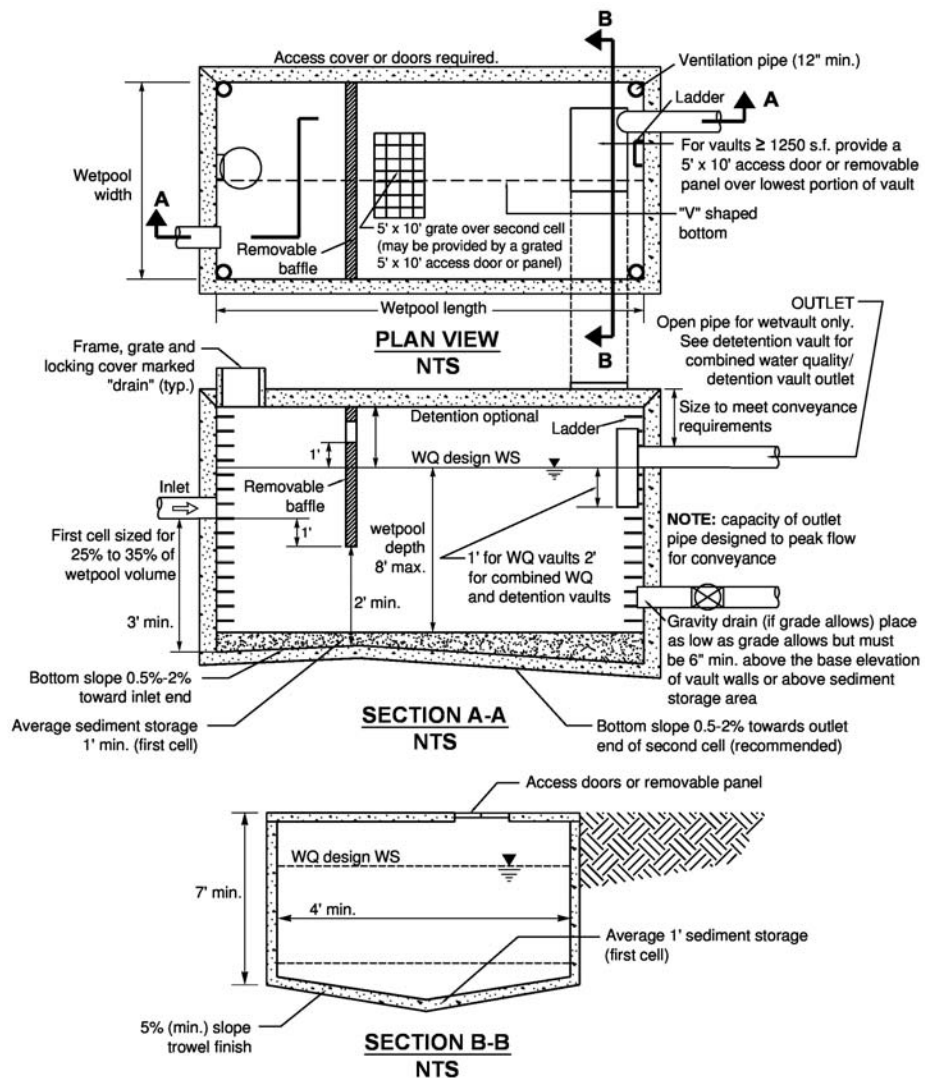
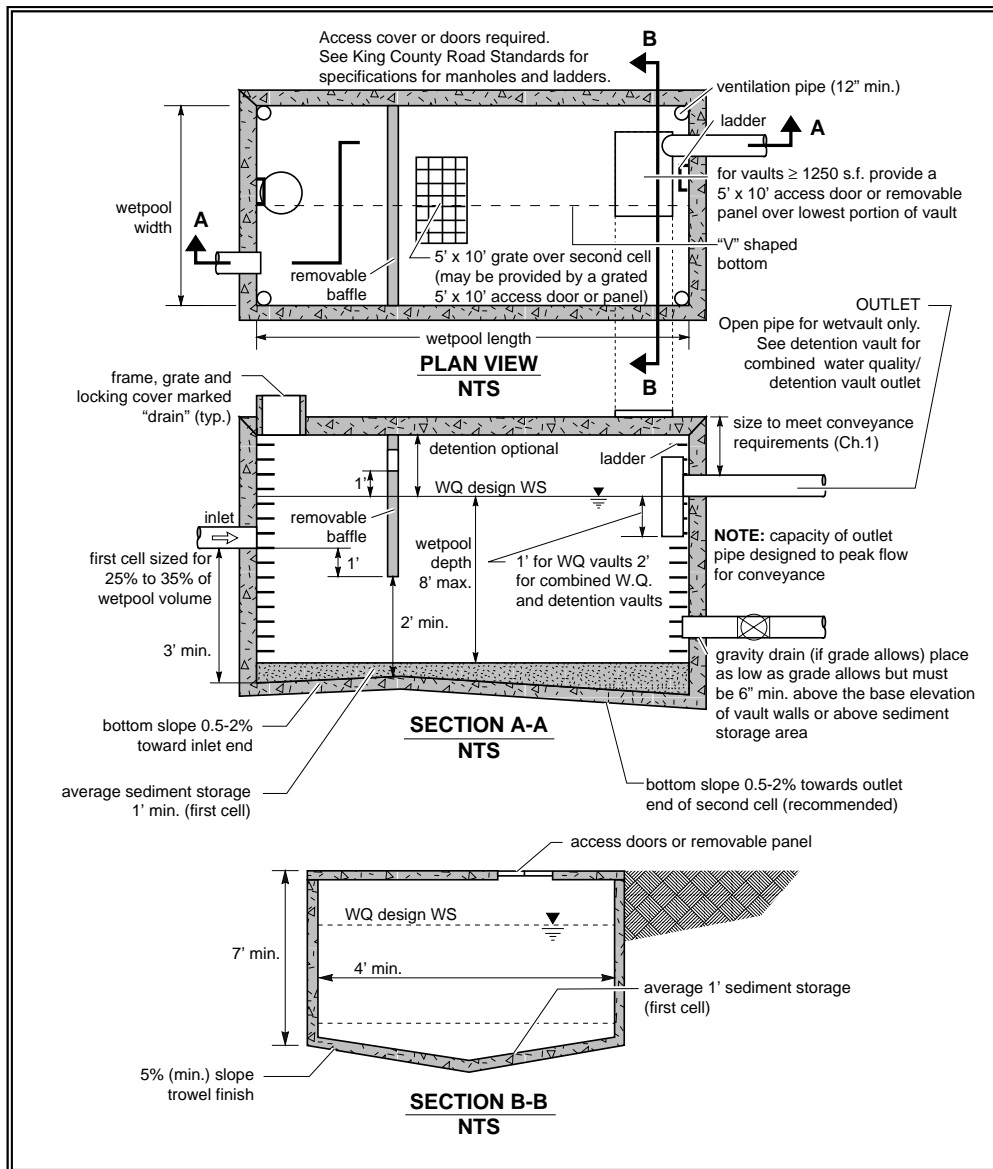


Figure 10.3.6 – Wetvault



Wetpool Geometry

Same as specified for wetponds (see [BMP T10.10](#)~~BMP T10.10~~) except for the following two modifications:

- The sediment storage in the first cell shall be an average of 1-foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

<u>Vault Width</u>	<u>Sediment Depth (from bottom of side wall)</u>
15'	10"
20'	9"
40'	6"
60'	4"

- The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.

Vault Structure

- The vault shall be separated into two cells by a wall or a removable baffle. If a wall is used, a 5-foot by 10-foot removable maintenance access must be provided for both cells. If a removable baffle is used, the following criteria apply:
 - The baffle shall extend from a minimum of 1-foot above the WQ design water surface to a minimum of 1-foot below the invert elevation of the inlet pipe.
 - The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
- If the vault is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, the baffle or wall may be omitted and the vault may be one-celled.
- The two cells of a wetvault should not be divided into additional subcells by internal walls. If internal structural support is needed, it is preferred that post and pier construction be used to support the vault lid rather than walls. Any walls used within cells must be positioned so as to lengthen, rather than divide, the flowpath.

Intent: Treatment effectiveness in wetpool facilities is related to the extent to which plug flow is achieved and short-circuiting and dead zones are avoided. Structural walls placed within the cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.

- The bottom of the first cell shall be sloped toward the access opening. Slope should be between 0.5 percent (minimum) and 2 percent

(maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells. The intent of sloping the bottom is direct the sediment accumulation to the closest access point for maintenance purposes. Sloping the second cell towards the access opening for the first cell is also acceptable.

- The vault bottom shall slope laterally a minimum of 5 percent from each side towards the center, forming a broad "v" to facilitate sediment removal. Note: More than one "v" may be used to minimize vault depth.

Exception: The Local Plan Approval Authority may allow the vault bottom to be flat if removable panels are provided over the entire vault. Removable panels should be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

- The highest point of a vault bottom must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.
- Provision for passage of flows should the outlet plug shall be provided.
- Wetvaults may be constructed using arch culvert sections provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.

Intent: To prevent decreasing the surface area available for oxygen exchange.

- Wetvaults shall conform with the "Materials" and "Structural Stability" criteria specified for detention vaults in Volume III, Chapter 3.
- Where pipes enter and leave the vault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.

Inlet and Outlet

- The inlet to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe should be submerged at least 1-foot, if possible.

Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

- Unless designed as an off-line facility, the capacity of the outlet pipe and available head above the outlet pipe should be designed to convey the 100-year design flow for developed site conditions without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.

- The outlet pipe shall be back-sloped or have tee section, the lower arm of which should extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.
- The Local Plan Approval Authority may require a bypass/shutoff valve to enable the vault to be taken offline for maintenance.

Access Requirements

Same as for detention vaults (see Volume III, Section 3.2) except for the following additional requirement for wetvaults:

- A minimum of 50 square feet of grate should be provided over the second cell. For vaults in which the surface area of the second cell is greater than 1,250 square feet, 4 percent of the top should be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. Note: a grated access door can be used to meet this requirement.

Intent: The grate allows air contact with the wetpool in order to minimize stagnant conditions which can result in oxygen depletion, especially in warm weather.

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Volume III, Section 3.2).

Recommended Design Features

The following design features should be incorporated into wetvaults where feasible, but they are not specifically required:

- The floor of the second cell should slope toward the outlet for ease of cleaning.
- The inlet and outlet should be at opposing corners of the vault to increase the flowpath.
- A flow length-to-width ratio greater than 3:1 minimum is desirable.
- Lockable grates instead of solid manhole covers are recommended to increase air contact with the wetpool.
- Galvanized materials shall not be used unless unavoidable.
- The number of inlets to the wetvault should be limited, and the flowpath length should be maximized from inlet to outlet for all inlets to the vault.

Construction Criteria

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise.

Operation and Maintenance

- Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault. Vault maintenance procedures must meet OSHA confined space entry requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

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- Facilities should be inspected by the local government annually. The maintenance standards contained in [Section 4.6](#) of this volume are measures for determining if maintenance actions are required as identified through the annual inspection.
- Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements. Sediments must be disposed in accordance with current local health department requirements and the Minimum Functional Standards for Solid Waste Handling. See Volume IV, Appendix IV-G Recommendations for Management of Street Waste for additional guidance.
- Any standing water removed during the maintenance operation must be properly disposed of. The preferred disposal option is discharge to a sanitary sewer at an approved location. ~~Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met.~~ Other disposal options include discharge back into the wetpool facility or the storm sewer system if certain conditions are met. See Volume IV, Appendix IV-G for additional guidance.

Modifications for Combining with a Baffle Oil/Water Separator

If the project site is a high-use site and a wetvault is proposed, the vault may be combined with a baffle oil/water separator to meet the runoff treatment requirements with one facility rather than two. Structural modifications and added design criteria are given below. However, the maintenance requirements for baffle oil/water separators must be adhered to, in addition to those for a wetvault. This will result in more frequent inspection and cleaning than for a wetvault used only for TSS removal. See [Chapter 11](#) ~~Chapter 11~~ for information on maintenance of baffle oil/water separators.

1. The sizing procedures for the baffle oil/water separator ([Chapter 11](#) ~~(Chapter 11)~~) should be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wetvault size to match.
2. An oil retaining baffle shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
3. The vault shall have a minimum length-to-width ratio of 5:1.
4. The vault shall have a design water depth-to-width ratio of between 1:3 to 1:2.
5. The vault shall be watertight and shall be coated to protect from corrosion.
6. Separator vaults shall have a shutoff mechanism on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.
7. Wetvaults used as oil/water separators must be off-line and must bypass flows greater than the off-line WQ design flow multiplied by the off-line ratio indicated in [Figure 9.4.6b](#) ~~Figure 9.5b~~.

Intent: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

BMP T10.30: Stormwater Treatment Wetlands

Purpose and Definition

In land development situations, wetlands are usually constructed for two main reasons: to replace or mitigate impacts when natural wetlands are filled or impacted by development (mitigation wetlands), and to treat stormwater runoff (stormwater treatment wetlands). Stormwater treatment wetlands are shallow man-made ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figure

[10.3.7](#) and Figure [10.3.8](#).

Purpose and Definition

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Wetlands created to mitigate disturbance impacts, such as filling, may not also be used as stormwater treatment facilities. This is because of the different, incompatible functions of the two kinds of wetlands. Mitigation wetlands are intended to function as full replacement habitat for fish and wildlife, providing the same functions and harboring the same species diversity and biotic richness as the wetlands they replace. Stormwater treatment wetlands are used to capture and transform pollutants, just as wetponds are, and over time pollutants will concentrate in the sediment. This is not a healthy environment for aquatic life. Stormwater treatment wetlands are used to capture pollutants in a managed environment so that they will not reach natural wetlands and other ecologically important habitats. In addition, vegetation must occasionally be harvested and sediment dredged in stormwater treatment wetlands, further interfering with use for wildlife habitat.

In general, stormwater wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater wetlands is highly variable.

Applications and Limitations

This stormwater wetland design occupies about the same surface area as wetponds, but has the potential to be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. The most critical factor for a successful design is the provision of an adequate supply of water for most of the year. Careful planning is needed to be sure sufficient water will be retained to sustain good wetland plant growth. Since water depths are shallower than in wetponds, water loss by evaporation is an important concern. Stormwater wetlands are a good WQ facility choice in areas with high winter ground water levels.

Design Criteria

When used for stormwater treatment, stormwater wetlands employ some of the same design features as wetponds. However, instead of gravity settling being the dominant treatment process, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus when designing wetlands, water volume is not the dominant design criteria. Rather, factors which affect plant vigor and biomass are the primary concerns.

~~Applications and Limitations~~

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Sizing Procedure

Step 1: The volume of a basic wetpond is used as a template for sizing the stormwater wetland. The design volume is the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, ~~use the 91st percentile,~~ 24-hour runoff Water Quality Design Storm Volume estimated by an approved continuous runoff model ~~may be used.~~

Step 2: Calculate the surface area of the stormwater wetland. The surface area of the wetland shall be the same as the top area of a wetpond sized for the same site conditions. Calculate the surface area of the stormwater wetland by using the volume from Step 1 and dividing by the average water depth (use 3 feet).

Step 3: Determine the surface area of the first cell of the stormwater wetland. Use the volume determined from Criterion 2 under "Wetland Geometry", and the actual depth of the first cell.

Step 4: Determine the surface area of the wetland cell. Subtract the surface area of the first cell (Step 3) from the total surface area (Step 2).

Step 5: Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to Criterion 8 under "Wetland Geometry" below. Note: This will result in a facility that holds less volume than that determined in Step 1 above. This is acceptable.

Intent: The surface area of the stormwater wetland is set to be roughly equivalent to that of a wetpond designed for the same site so as not to discourage use of this option.

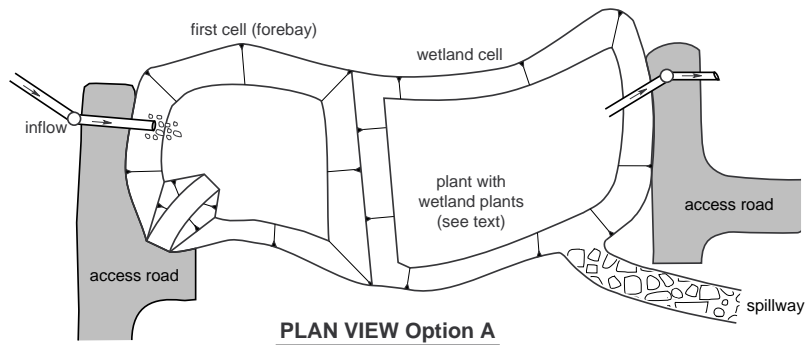
Step 6: Choose plants. See [Table 10.3.1](#) ~~Table 10.1~~ for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

Wetland Geometry

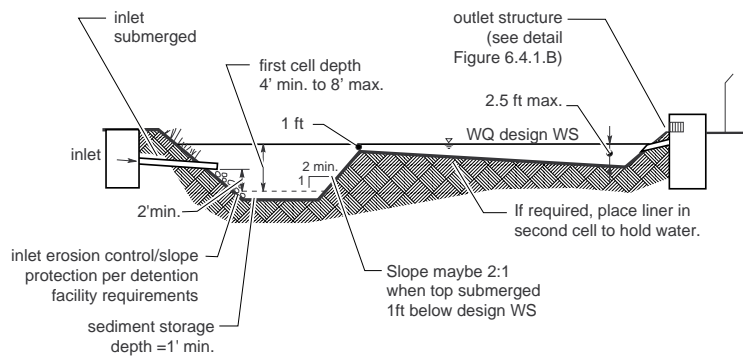
1. Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.

2. The presettling cell shall contain approximately 33 percent of the wetpool volume calculated in Step 1 above.
3. The depth of the presettling cell shall be between 4 feet (minimum) and 8 feet (maximum), excluding sediment storage.
4. One-foot of sediment storage shall be provided in the presettling cell.
5. The wetland cell shall have an average water depth of about 1.5 feet (plus or minus 3 inches).
6. The "berm" separating the two cells shall be shaped such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in [Figure 10.3.7](#)~~Figure 10.7~~). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).
7. The top of berm shall be either at the WQ design water surface or submerged 1-foot below the WQ design water surface, as with wetponds. Correspondingly, the side slopes of the berm must meet the following criteria:
 - a. ~~a.~~ If the top of berm is at the WQ design water surface, the berm side slopes shall be no steeper than 3H:1V.
 - b. If the top of berm is submerged 1-foot, the upstream side slope may be up to 2H:1V. If the berm is at the water surface, then for safety reasons, its slope should be not greater than 3:1, just as the pond banks should not be greater than 3:1 if the pond is not fenced. A steeper slope (2:1 rather than 3:1) is allowable if the berm is submerged in 1 foot of water. If submerged, the berm is not considered accessible, and the steeper slope is allowable.
8. Two examples are provided for grading the bottom of the wetland cell. One example is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see [Figure 10.3.7](#)~~Figure 10.7~~). The second example is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see [Figure 10.3.8](#)~~Figure 10.8~~). A distribution of depths shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged (see [Table 10.3.2](#)~~Table 10.2~~ below). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by the Local Plan Approval Authority.

Table 10.3.2 Distribution of Depths in Wetland Cell			
Dividing Berm at WQ Design Water Surface		Dividing Berm Submerged 1-Foot	
Depth Range (feet)	Percent	Depth Range (feet)	Percent
0.1 to 1	25	1 to 1.5	40
1 to 2	55	1.5 to 2	40
2 to 2.5	20	2 to 2.5	20

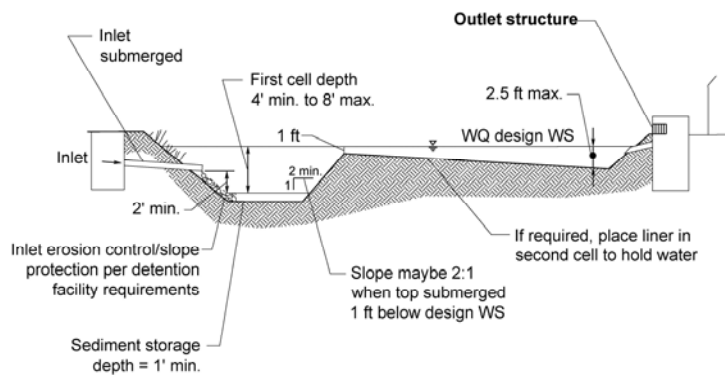
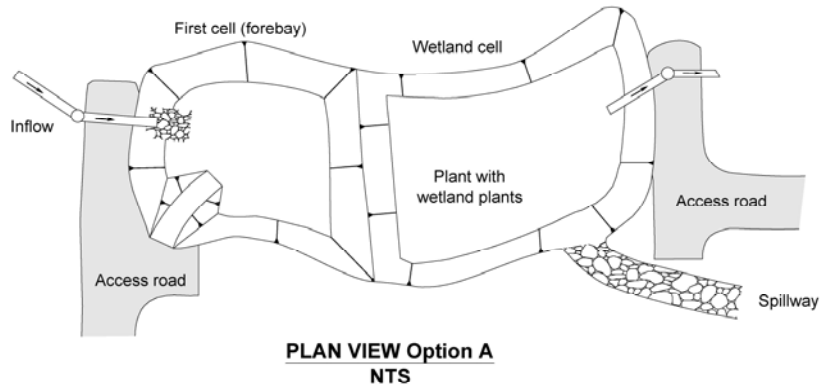


PLAN VIEW Option A
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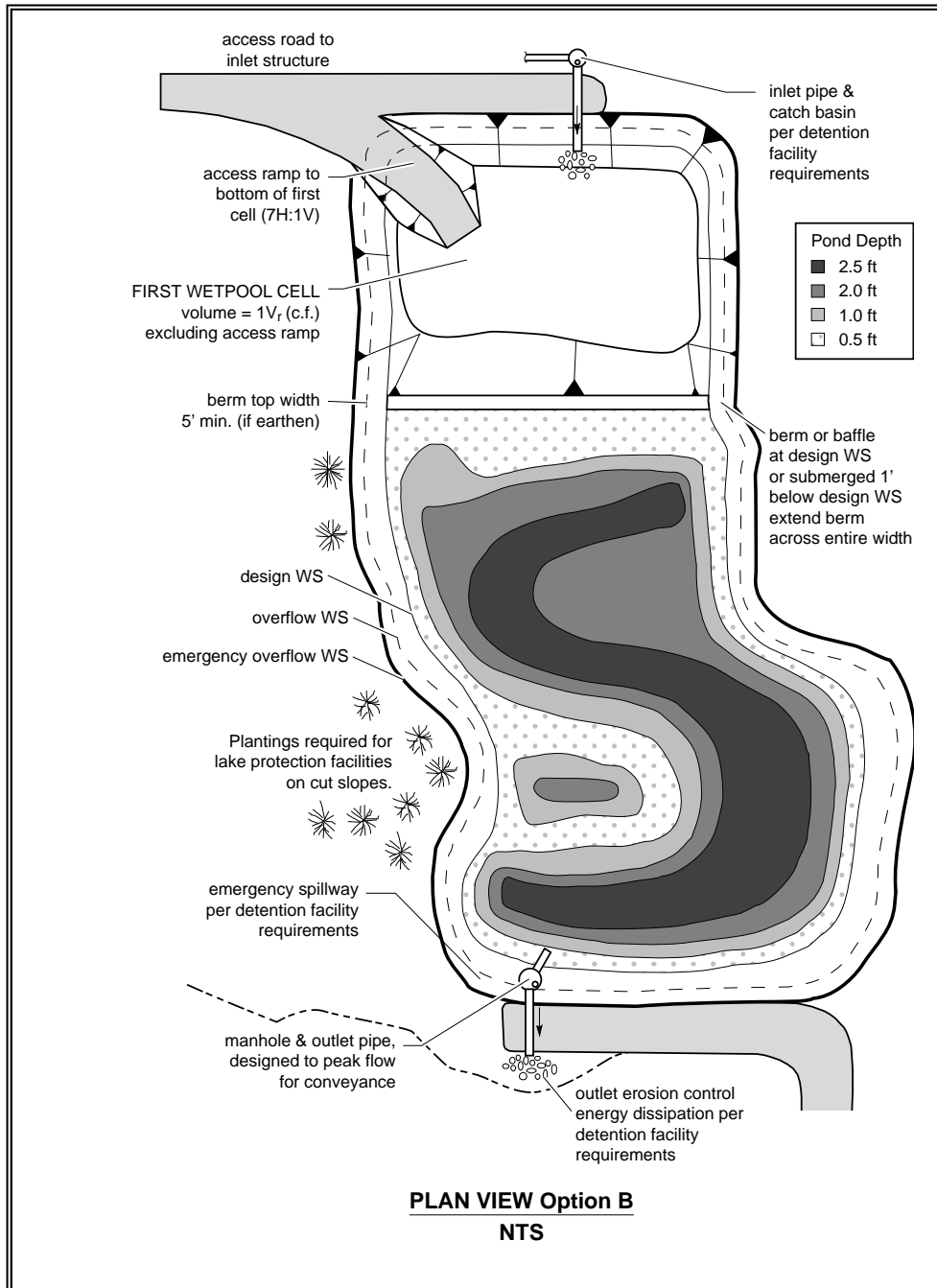
SECTION VIEW Option A
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Note: See detention facility requirements for location and setback requirements.



Note: See detention facility requirements for location and setback requirements.

Figure 10.3.7 – Stormwater Wetland — Option One



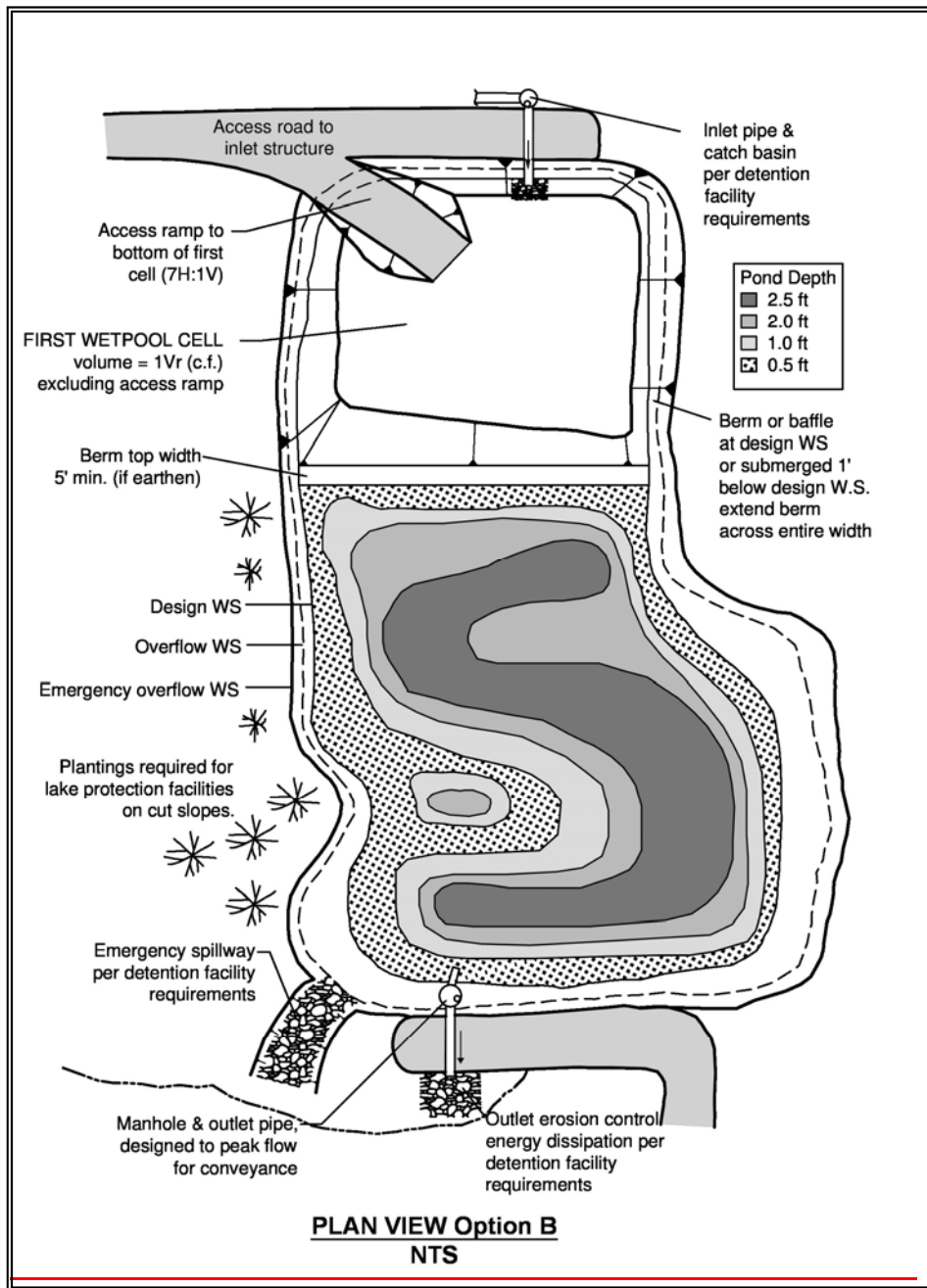


Figure 10.3.8 – Stormwater Wetland — Option Two

Lining Requirements

Constructed wetlands are not intended to infiltrate. In infiltrative soils, both cells of the stormwater wetland shall be lined. To determine whether a low-permeability liner or a treatment liner is required, determine whether the following conditions will be met. If soil permeability will allow sufficient water retention, lining may be waived.

1. ~~1.~~ The second cell must retain water for at least 10 months of the year.
2. ~~2.~~ The first cell must retain at least three feet of water year-round.
3. ~~3.~~ A complete precipitation record shall be used when establishing these conditions. Evapotranspiration losses shall be taken into account as well as infiltration losses.

Intent: Many wetland plants can adapt to periods of summer drought, so a limited drought period is allowed in the second cell. This may allow a treatment liner rather than a low permeability liner to be used for the second cell. The first cell must retain water year-round in order for the presettling function to be effective.

- If a low permeability liner is used, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner. For geomembrane liners, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.

The criteria for liners given in [Chapter 4](#) ~~Chapter 4~~ must be observed.

Inlet and Outlet

Same as for wetponds (see [BMP T10.10](#) ~~BMP T10.10~~).

Access and Setbacks

- Location of the stormwater wetland relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Volume III). See [Section 4.3](#) ~~Chapter 4~~ for typical setback requirements for ~~WQ~~ water quality facilities.
- Access and maintenance roads shall be provided and designed according to the requirements for detention ponds (see Volume III). Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the wetland side slopes.
- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Planting Requirements

The wetland cell shall be planted with emergent wetland plants following the recommendations given in [Table 10.3.1](#) ~~Table 10.1~~ or the recommendations of a wetland specialist. Note: Cattails (*Typha latifolia*) are not recommended. They tend to escape to natural wetlands and crowd out other species. In addition, the shoots die back each fall and will result in oxygen depletion in the wetpool unless they are removed.

Construction Criteria

- Construction and maintenance considerations are the same as for wetponds.

~~Construction Criteria~~

- ~~• Construction and maintenance considerations are the same as for wetponds.~~
- Construction of the naturalistic alternative (Option 2) can be easily done by first excavating the entire area to the 1.5-foot average depth. Then soil subsequently excavated to form deeper areas can be deposited to raise other areas until the distribution of depths indicated in the design is achieved.
- Wetlands should be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe plant species presence, abundance, and condition; bottom contours and water depths relative to plans; and sediment, outlet, and buffer conditions.

Operation and Maintenance

~~Operation and Maintenance~~

- ~~• Wetlands should be inspected at least twice per year during the first three years during both growing and non-growing seasons to observe plant species presence, abundance, and condition; bottom contours and water depths relative to plans; and sediment, outlet, and buffer conditions.~~
- Maintenance should be scheduled around sensitive wildlife and vegetation seasons.
- Plants may require watering, physical support, mulching, weed removal, or replanting during the first three years.
- Nuisance plant species should be removed and desirable species should be replanted.
- The effectiveness of harvesting for nutrient control is not well documented. There are many drawbacks to harvesting, including possible damage to the wetlands and the inability to remove nutrients in the below-ground biomass. If harvesting is practiced, it should be done in the late summer.

Resource Material

King County Surface Water Design Manual, September 1998.

Schueler, Thomas. Design of Stormwater Wetland Systems, Guidelines for Creating Diverse and Effective Stormwater Wetland Systems in the Mid-Atlantic Region, October, 1992.

Kadlec, Robert and Robert L. Knight. Treatment Wetlands. 1996.

BMP T10.40: Combined Detention and Wetpool Facilities

Purpose and Definition

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

Purpose and Definition

~~Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:~~

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals. See Chapter 3 for more information about treatment performance goals.

Applications and Limitations

Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Applications and Limitations

~~Combined detention and water quality facilities are very efficient for sites that also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the fluctuating water surface of the live~~

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The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume. For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the live storage component of the facility should be provided above the seasonal high water table.

Combined Detention and Wetpond (Basic and Large)

Typical design details and concepts for a combined detention and wetpond are shown in [Figures 10.3.9](#) and [10.3.10](#). The detention portion of the facility shall meet the design criteria and sizing procedures set forth in Volume 3.

Sizing Procedure

The sizing procedure for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. The wetpool volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, use the 91st percentile, 24-hour runoff Water Quality Design Storm Volume estimated by an approved continuous runoff model ~~may be used to size the wetpool.~~ Follow the standard procedure specified in Volume III and guidance documents for use of an approved continuous runoff model to size the detention portion of the pond.

Detention and Wetpool Geometry

- The wetpool and sediment storage volumes shall not be included in the required detention volume.
- The "Wetpool Geometry" criteria for wetponds (see [BMP T10.10](#) ~~BMP T10.10~~) shall apply with the following modifications/clarifications:

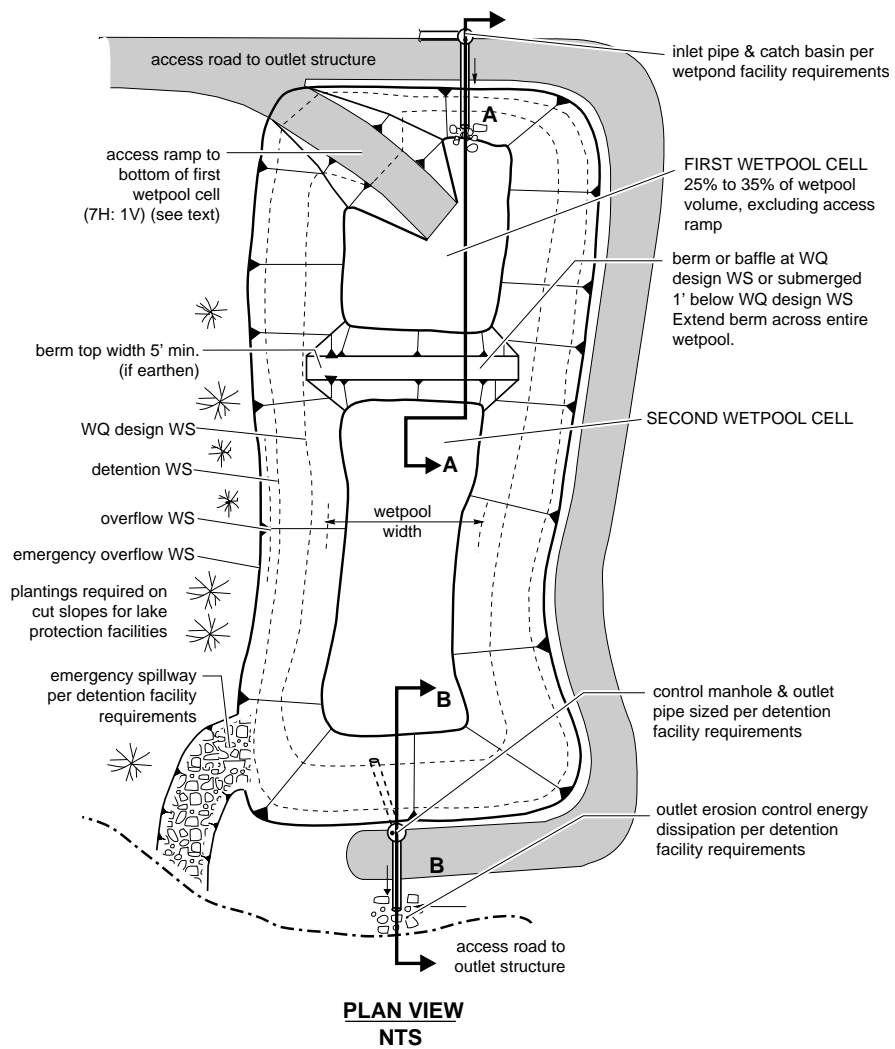
Criterion 1: The permanent pool may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met. See [Figure 10.3.11](#) ~~Figure 10.11~~ for two possibilities for wetpool cell placement.

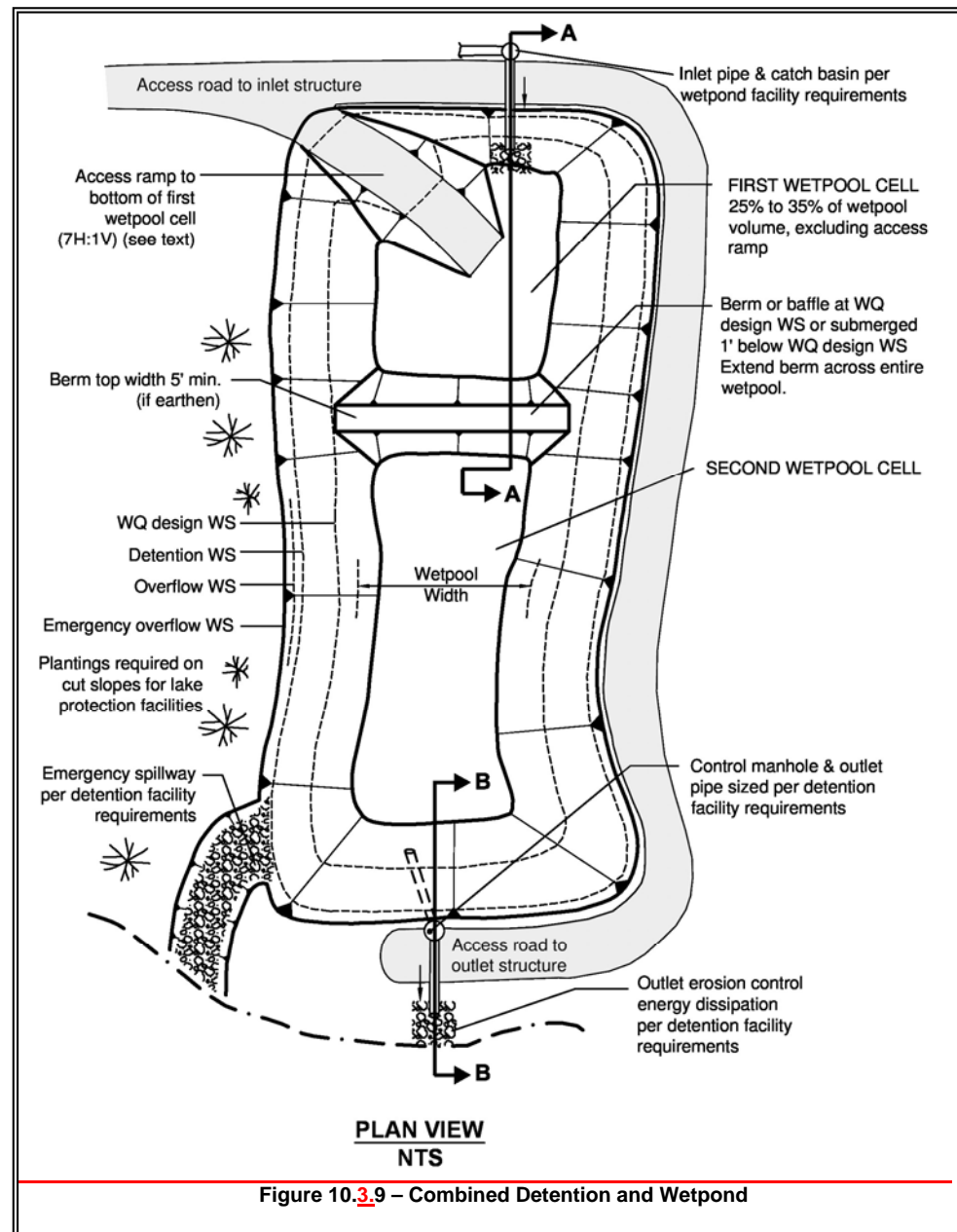
Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months.

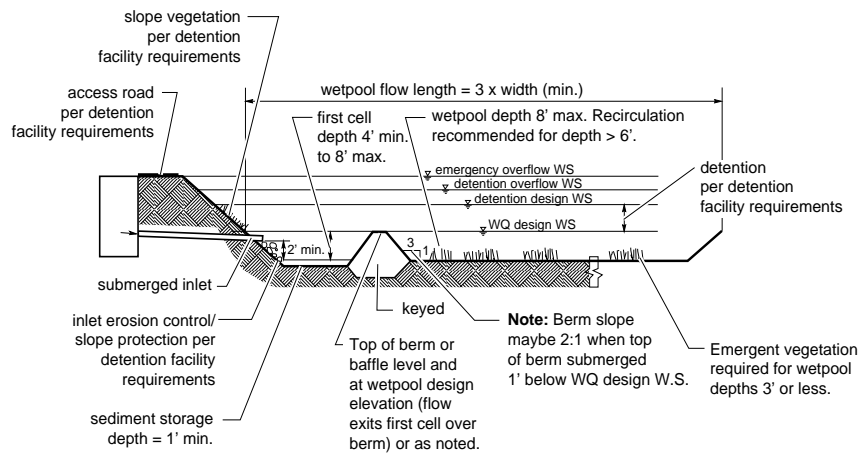
Criterion 2: The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

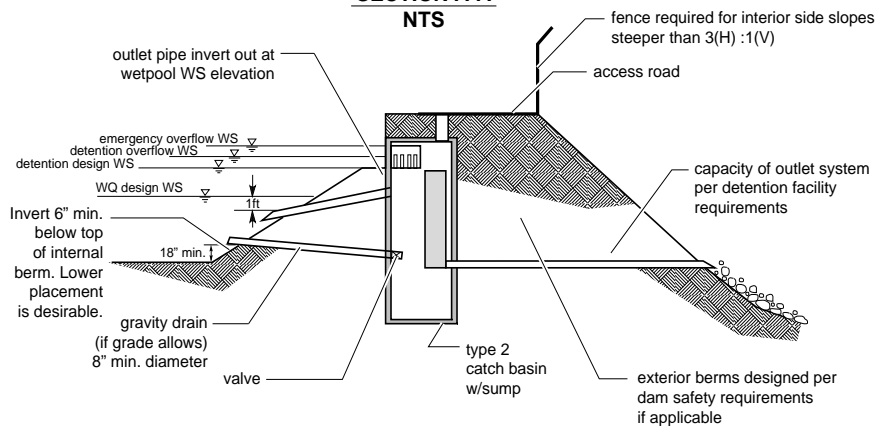
Same as for wetponds (see [BMP T10.10](#)~~BMP T10.10~~).





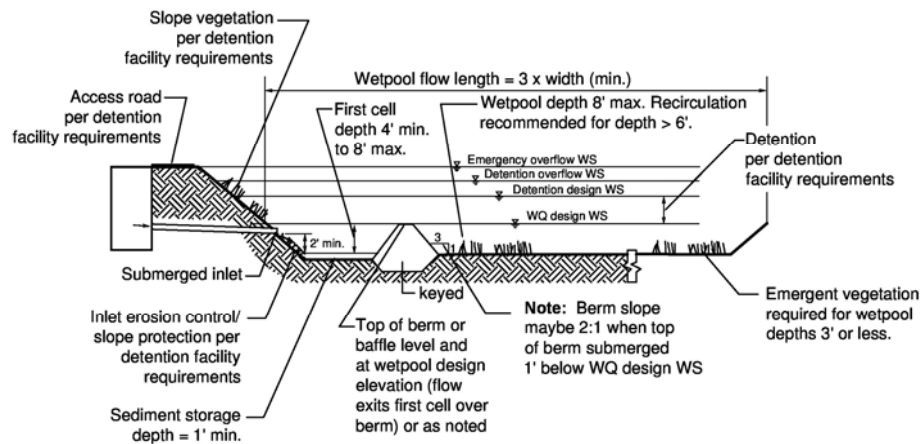


SECTION A-A NTS

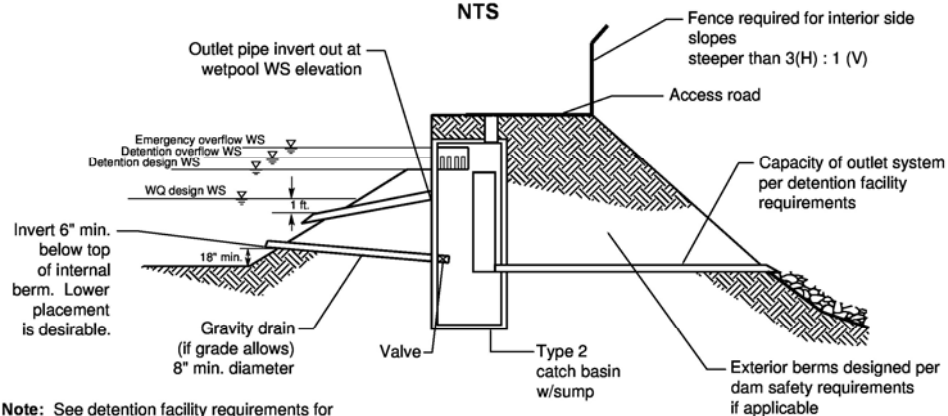


Note: See detention facility requirements for location, interior & exterior sideslopes, and setback requirements.

SECTION B-B NTS



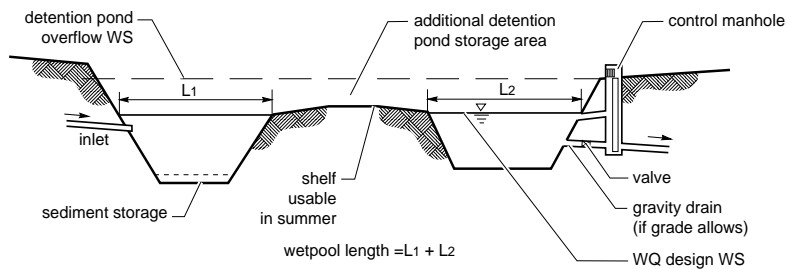
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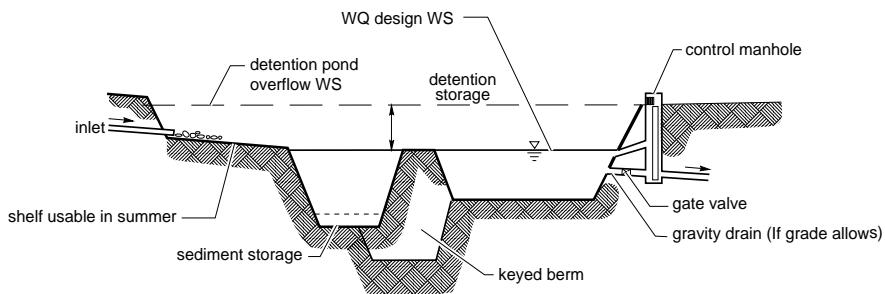
SECTION B-B NTS

Note: See detention facility requirements for location, interior & exterior sideslopes, and setback requirements.

Figure 10.3.10 – Combined Detention and Wetpond (Continued)

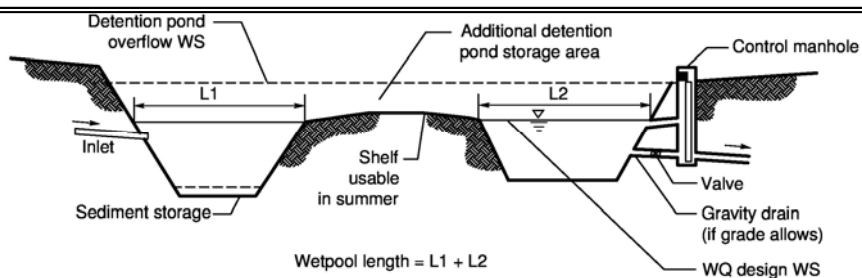


SECTION VIEW
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Note: These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.



SECTION VIEW
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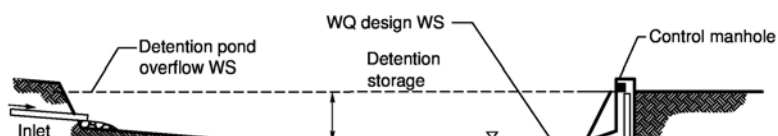


Figure 10.3.11 – Alternative Configurations of Detention and Wetpool Areas

Inlet and Outlet

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined ponds.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

Access and Setbacks

Same as for wetponds.

Planting Requirements

Same as for wetponds.

Combined Detention and Wetvault

The sizing procedure for combined detention and wetvaults is identical to those outlined for wetvaults and for detention facilities. The wetvault volume for a combined facility shall be equal to or greater than the total volume of runoff from the 6-month, 24-hour storm event. Alternatively, ~~use the 91st percentile, 24-hour runoff~~ Water Quality Design Storm Volume estimated by an approved continuous runoff model ~~may be used~~ to size the wetpool portion of vault. Follow the standard procedure specified in Volume 3 and guidance documents for use of an approved continuous runoff model to size the detention portion of the vault.

The design criteria for detention vaults and wetvaults must both be met, except for the following modifications or clarifications:

- The minimum sediment storage depth in the first cell shall average 1-foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
- The oil retaining baffle shall extend a minimum of 2 feet below the WQ design water surface.

Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

Note: If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults in ~~BMP T10.20~~ BMP T10.20. This is because the

added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

Combined Detention and Stormwater Wetland

The sizing procedure for combined detention and stormwater wetlands is identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in [BMP T10.30](#) ~~BMP T10.30~~ to determine the stormwater wetland size. Follow the standard procedure specified in Volume III to size the detention portion of the wetland.

The design criteria for detention ponds and stormwater wetlands must both be met, except for the following modifications or clarifications:

- The "Wetland Geometry" criteria for stormwater wetlands (see [BMP T10.30](#) ~~BMP T10.30~~) are modified as follows:
- The minimum sediment storage depth in the first cell is 1-foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

The "Inlet and Outlet" criteria for wetponds shall apply with the following modifications:

- A sump must be provided in the outlet structure of combined facilities.
- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Volume III).

The "Planting Requirements" for stormwater wetlands are modified to use the following plants which are better adapted to water level fluctuations:

Scirpus acutus (hardstem bulrush)	2 - 6' depth
Scirpus microcarpus (small-fruited bulrush)	1 - 2.5' depth
Sparganium emersum (burreed)	1 - 2' depth
Sparganium eurycarpum (burreed)	1 - 2' depth
Veronica sp. (marsh speedwell)	0 - 1' depth

In addition, the shrub *Spirea douglasii* (Douglas spirea) may be used in combined facilities.

Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The additional area may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.

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Chapter 11. - Oil and Water Separators

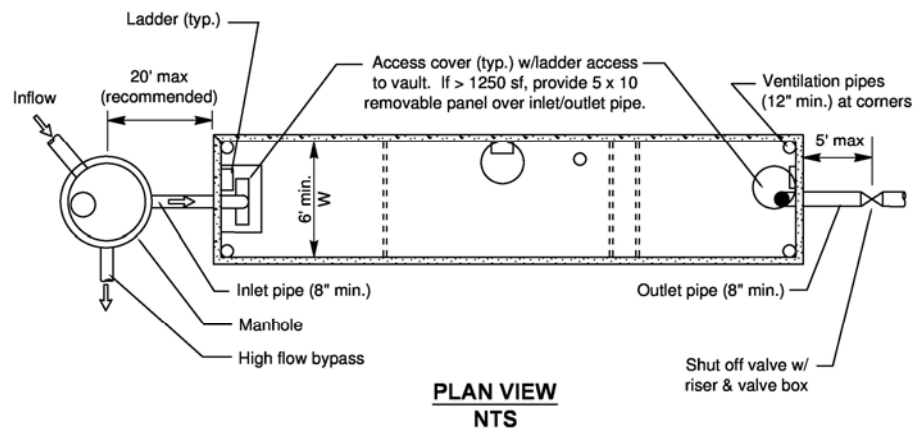
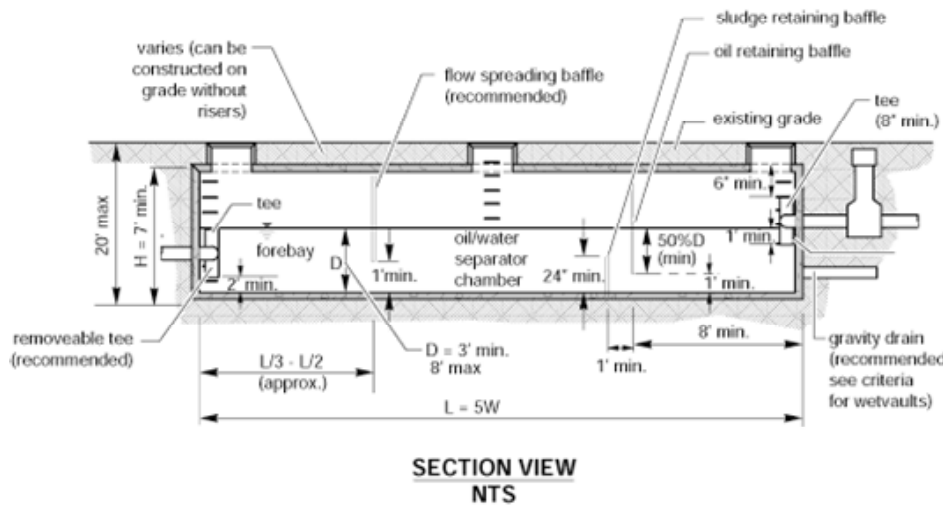
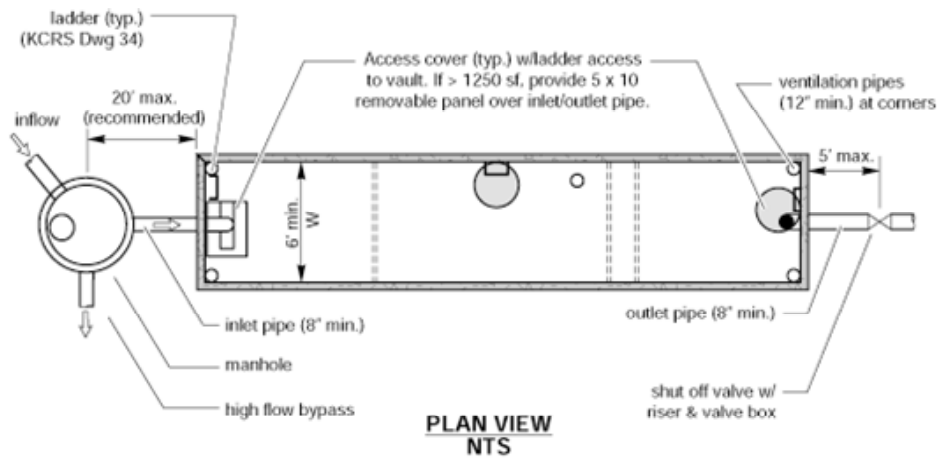
This chapter provides a discussion of oil and water separators, including their application and design criteria. BMPs are described for baffle type and coalescing plate separators.

11.1 Purpose of Oil and Water Separators

To remove oil and other water-insoluble hydrocarbons, and settleable solids from stormwater runoff.

11.2 Description

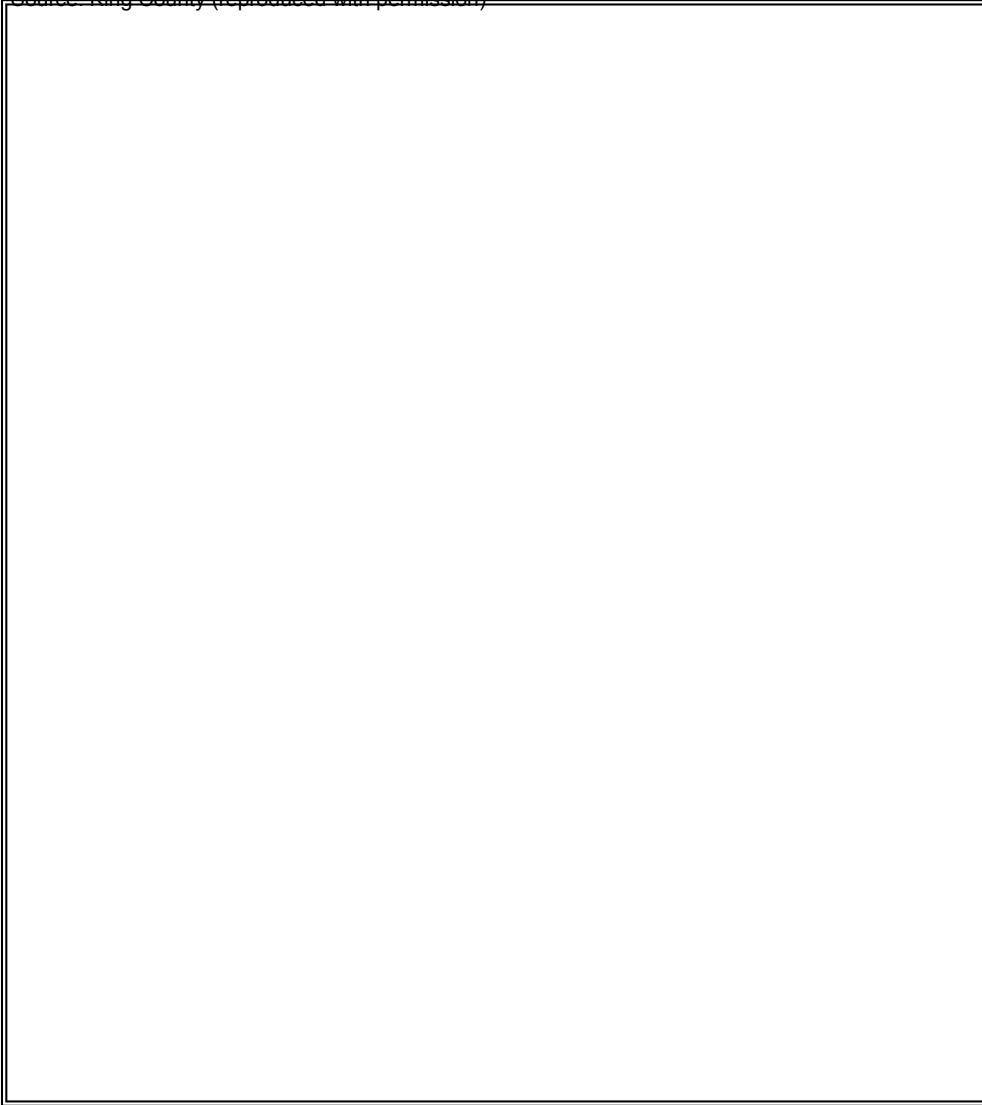
Oil and water separators are typically the American Petroleum Institute (API) (also called baffle type) (American Petroleum Institute, 1990) or the coalescing plate (CP) type using a gravity mechanism for separation. See Figures ~~11.2.1~~ and ~~11.2.2~~. Oil removal separators typically consist of three bays; forebay, separator section, and the afterbay. The CP separators need considerably less space for separation of the floating oil due to the shorter travel distances between parallel plates. A spill control (SC) separator (~~Figure 11.2.3~~) is a simple catchbasin with a T-inlet for temporarily trapping small volumes of oil. The spill control separator is included here for comparison only and is not designed for, or to be used for treatment purposes.

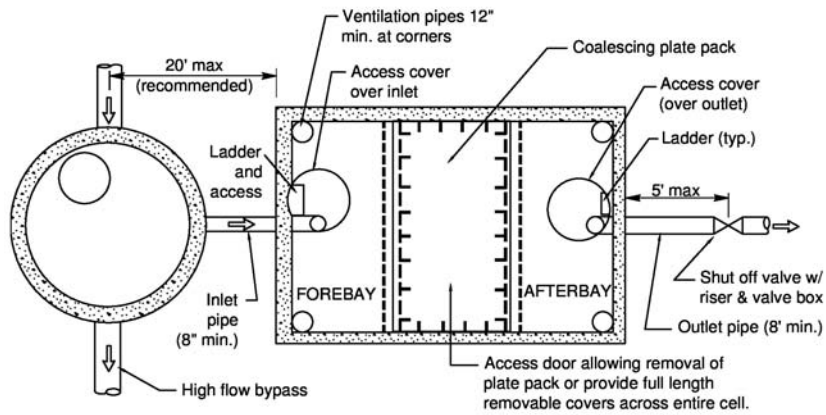


— Sludge retaining baffle

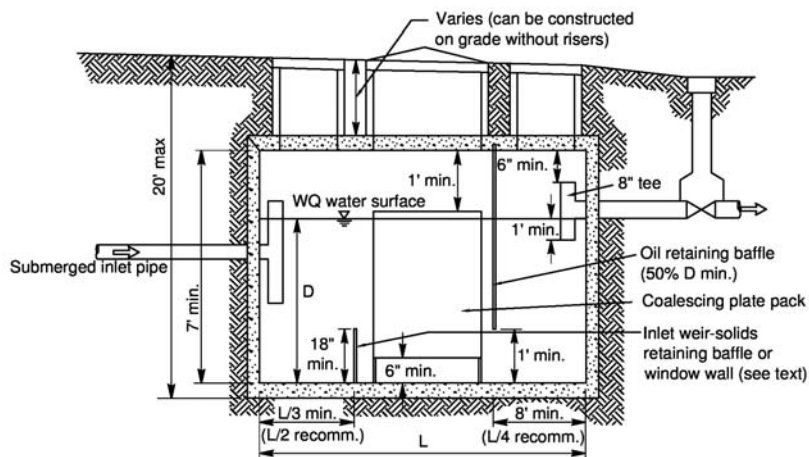
Figure 11.2.1 – API (Baffle Type) Separator

Source: King County (reproduced with permission)



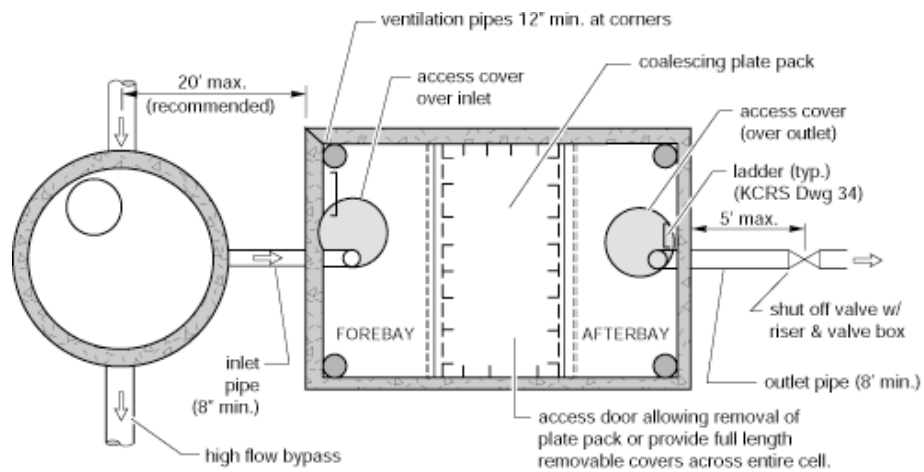


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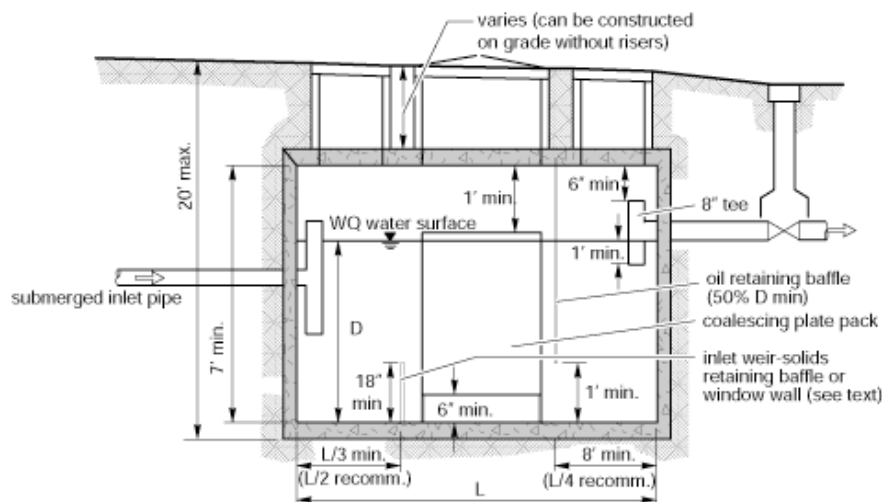


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Figure 11.2.2 – Coalescing Plate Separator



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Source: King County (reproduced with permission)

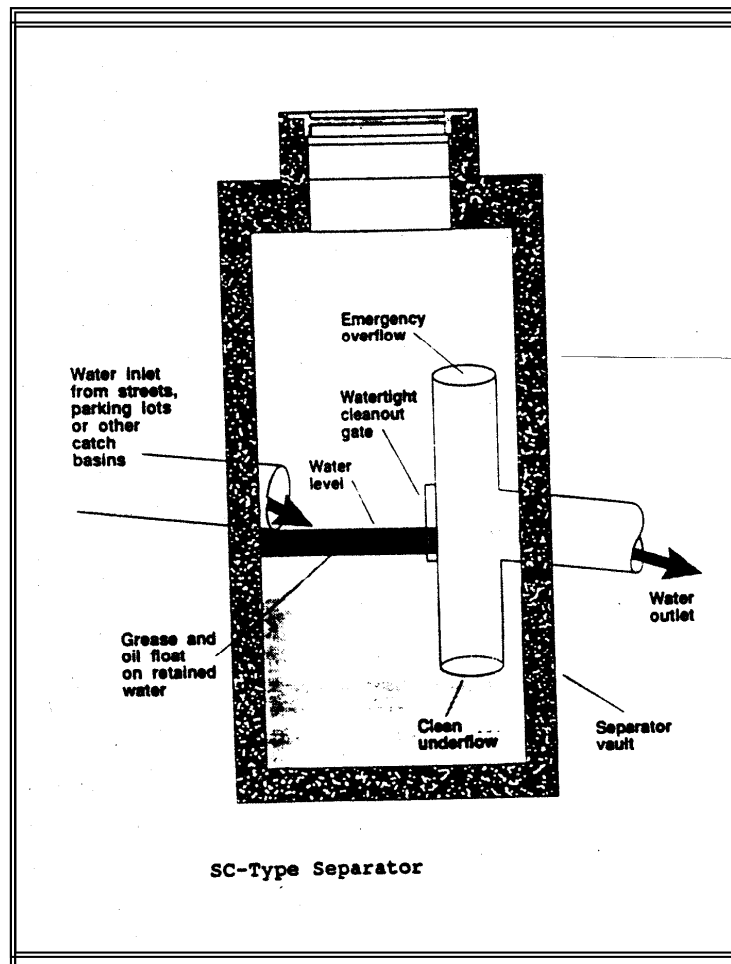


Figure 11.2.3 – Spill Control Separator (not for oil treatment)

Source: 1992 Ecology Manual

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11.3 Performance Objectives

Oil and water separators should be designed to remove oil and TPH down to 15 mg/L at any time and 10 mg/L on a 24-hr average, and produce a discharge that does not cause an ongoing or recurring visible sheen in the stormwater discharge, or in the receiving water. (See also [Chapter 3](#))

11.4 Applications/Limitations

The following are potential applications of oil and water separators where free oil is expected to be present at treatable high concentrations and sediment will not overwhelm the separator. (Seattle METRO, 1990; Watershed Protection Techniques, 1994; King County Surface Water Management, 1998) For low concentrations of oil, other treatments may be more applicable. These include sand filters and emerging technologies.

- Commercial and industrial areas including petroleum storage yards, vehicle maintenance facilities, manufacturing areas, airports, utility areas (water, electric, gas), and fueling stations. (King County Surface Water Management, 1998)
- Facilities that would require oil control BMPs under the high-use site threshold described in [Chapter 2](#) including parking lots at convenience stores, fast food restaurants, grocery stores, shopping malls, discount warehouse stores, banks, truck fleets, auto and truck dealerships, and delivery services. (King County Surface Water Management, 1998)
- Without intense maintenance oil/water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels.
- Pretreatment should be considered if the level of TSS in the inlet flow would cause clogging or otherwise impair the long-term efficiency of the separator.
- For inflows from small drainage areas (fueling stations, maintenance shops, etc.) a coalescing plate (CP) type separator is typically considered, due to space limitations. However, if plugging of the plates is likely, then a new design basis for the baffle type API separator may be considered on an experimental basis. (See [11.6 Design Criteria](#))

11.5 Site Suitability

Consider the following site characteristics:

- Sufficient land area
- Adequate TSS control or pretreatment capability
- Compliance with environmental objectives
- Adequate influent flow attenuation and/or bypass capability

Sufficient access for operation and maintenance (O & M)

11.6 Design Criteria-General Considerations

There is concern that oil/water separators used for stormwater treatment have not performed to expectations. (Watershed Protection Techniques, 1994; Schueler, Thomas R., 1990) Therefore, emphasis should be given to proper application (see [Section 11.4](#) ~~Section 11.4~~), design, O & M, (particularly sludge and oil removal) and prevention of CP fouling and plugging. (US Army of Engineers, 1994) Other treatment systems, such as sand filters and emerging technologies, should be considered for the removal of insoluble oil and TPH.

The following are design criteria applicable to API and CP oil/water separators:

- If practicable, determine oil/grease (or TPH) and TSS concentrations, lowest temperature, pH; and empirical oil rise rates in the runoff, and the viscosity, and specific gravity of the oil. Also determine whether the oil is emulsified or dissolved. (Washington State Department of Ecology, 1995) ~~Do not use oil/water separators for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols, and alcohols.~~
- Locate the separator off-line and bypass the incremental portion of flows that exceed the off-line 15-minute, Water Quality design flow rate multiplied by the ratio indicated in [Figure 9.4.6b](#) ~~Figure 9.5b~~ of this Volume. If it is necessary to locate the separator on-line, try to minimize the size of the area needing oil control, and use the on-line water quality design flow rate multiplied by the ratio indicated in [Figure 9.4.6a](#) ~~Figure 9.5a~~.
- Use only impervious conveyances for oil contaminated stormwater.
- Specify appropriate performance tests after installation and shakedown, and/or certification by a professional engineer that the separator is functioning in accordance with design objectives. Expedient corrective actions must be taken if it is determined the separator is not achieving acceptable performance levels.

- Add pretreatment for TSS that could cause clogging of the CP separator, or otherwise impair the long-term effectiveness of the separator.

Criteria for Separator Bays:

- Size the separator bay for the Water Quality design flow rate (15 minute time step) x a correction factor ratio indicated in [Figure 9.4.6b](#) ~~Figure 9.5b~~ of this Volume (assuming an off-line facility). (See [Chapter 4](#) ~~Chapter 4~~ of this Volume for a definition of the Water Quality Design Flow Rate.)
- To collect floatables and settleable solids, design the surface area of the forebay at $\geq 20 \text{ ft}^2$ per 10,000 ft^2 of area draining to the separator ⁽⁶⁾. The length of the forebay should be 1/3-1/2 of the length of the entire separator. Include roughing screens for the forebay or upstream of the separator to remove debris, if needed. Screen openings should be about 3/4 inch.
- Include a submerged inlet pipe with a turn-down elbow in the first bay at least two feet from the bottom. The outlet pipe should be a Tee, sized to pass the design peak flow and placed at least 12 inches below the water surface.
- Include a shutoff mechanism at the separator outlet pipe. (King County Surface Water Management, 1998)
- Use absorbents and/or skimmers in the afterbay as needed.

Criteria for Baffles:

- Oil retaining baffles (top baffles) should be located at least at 1/4 of the total separator length from the outlet and should extend down at least 50% of the water depth and at least 1 ft. from the separator bottom.
- Baffle height to water depth ratios should be 0.85 for top baffles and 0.15 for bottom baffles.

11.7 Oil and Water Separator BMPs

Two BMPs are described in this section. ~~BMP T11.10~~ ~~BMP T11.10~~ for baffle type separators, and ~~BMP T11.11~~ ~~BMP T11.11~~ for coalescing plate separators.

~~BMP T11.10~~ API (Baffle type) Separator Bay

Design Criteria The criteria for small drainages is based on V_h , V_t , residence time, width, depth, and length considerations. As a correction factor API's turbulence criteria is applied to increase the length.

~~Design Criteria~~

~~The criteria for small drainages is based on V_h , V_t , residence time, width, depth, and length considerations. As a correction factor API's turbulence criteria is applied to increase the length.~~

Ecology is modifying the API criteria for treating stormwater runoff from small drainage area (fueling stations, commercial parking lots, etc.) by using the design hydraulic horizontal velocity, V_h , for the design V_h/V_t ratio rather than the API minimum of $V_h/V_t = 15$. The API criteria appear applicable for greater than two acres of impervious drainage area. Performance verification of this design basis must be obtained during at least one wet season using the test protocol referenced in Chapter 12 for new technologies.

The following is the sizing procedure using modified API criteria:

- Determine the oil rise rate, V_t , in cm/sec, using Stokes Law (Water Pollution Control Federation, 1985), or empirical determination, or 0.033 ft./min for 60 μ oil. The application of Stokes' Law to site-based oil droplet sizes and densities, or empirical rise rate determinations recognizes the need to consider actual site conditions. In those cases the design basis would not be the 60 micron droplet size and the 0.033 ft/min. rise rate.
- Stokes Law equation for rise rate, V_t (cm/sec):

$$V_t = \frac{[(g(\sigma_w - \sigma_o)D^2) / (\rho_w - \rho_o)(d^2)]}{[(18\eta_w) * \mu_w]}$$

Where:

~~g = gravitational constant (981 cm/sec²)~~

~~D = diameter V_t = the rise rate of the oil particle in droplet (cm/s or ft/sec)~~

~~g = acceleration due to gravity (cm-/s² or ft/s²)~~

~~Use~~

~~oil particle size diameter, D = 60 microns (0.006 cm)~~

~~σ_w = 0.999 gm/cc. at 32° F~~

~~σ_o = Select conservatively high oil density,~~

For example, if diesel oil @ $\sigma_o = 0.85$ gm/cc and motor oil @ $\sigma_o = 0.90$ can be present then use $\sigma_o = 0.90$ gm/cc

$\eta_w = 0.017921$ poise, ρ_w = density of water at the design temperature (g/cm³ or lbm/ft³)

ρ_o = density of oil at the design temperature (g/cm³ or lbm/ft³) at $T_w = 32^\circ\text{F}$, (See API Publication 421, February, 1990³ or lbm/ft³)

d = oil droplet diameter (cm or ft)

μ_w = absolute viscosity of the water (g/cm³ or lbm/ft³)

Use the following separator dimension criteria:

Separator water depth, $d \geq 3 \leq 8$ feet (to minimize turbulence)
(American Petroleum Institute, 1990; US Army Corps of Engineers, 1994).

Separator width, 6-20 feet (WEF & ASCE, 1998; King County Surface Water Management, 1998)

Depth/width (d/w) of 0.3-0.5 (American Petroleum Institute, 1990)

For Stormwater Inflow from Drainages under 2 Acres:

1. Determine V_t and select depth and width of the separator section based on above criteria.
2. Calculate the minimum residence time (t_m) of the separator at depth d :

$$t_m = d/V_t$$

3. Calculate the horizontal velocity of the bulk fluid, V_h , vertical cross-sectional area, A_v , and actual design V_h/V_t (American Petroleum Institute, 1990; US Army Corps of Engineers, 1994).

$V_h = Q/dw = Q/A_v$ (V_h maximum at < 2.0 ft/min.)(American Petroleum Institute, 1990)

$Q = (k)$ the ratio indicated in [Figure 9.4.5](#) ~~Figure 9.5b~~ for the site location multiplied by ~~the~~ 15-minute Water Quality design flow rate in ft³/min, at minimum residence time, t_m

At V_h/V_t determine F , turbulence and short-circuiting factor ([Appendix V-D](#) ~~(Appendix V-D)~~) API F factors range from 1.28-1.74. (American Petroleum Institute, 1990)

4. Calculate the minimum length of the separator section, $l(s)$, using:

$$l(s) = FQt_m/wd = F(V_h/V_t)d$$

$$l(t) = l(f) + l(s) + l(a)$$

$$l(t) = l(t)/3 + l(s) + l(t)/4$$

Where:

$l(t)$ = total length of 3 bays = “L” in [Figure 11.2.1](#) ~~Figure 11.1~~

$l(f)$ = length of forebay

$l(a)$ = length of afterbay

5. Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

V = minimum hydraulic design volume

A_h = minimum horizontal area of the separator

For Stormwater Inflow from Drainages > 2 Acres: Use $V_h = 15 V_t$ and $d = (Q/2V_h)^{1/2}$ (with $d/w = 0.5$) and repeat above calculations 3- 5.

BMP T11.11: Coalescing Plate (CP) Separator Bay

Design Criteria Calculate the projected (horizontal) surface area of plates needed using the following equation:

~~Design Criteria~~

~~Calculate the projected (horizontal) surface area of plates needed using the following equation:~~

$$A_p = A_h = Q/Vt = [Q/0.1] / [(0.00386(\sigma_w - \sigma_o/\eta_w)) * ((S_w - S_o)/(\mu_w))]$$

$$A_p = A_a(\cosine b)$$

Where:

~~Q = k (the ratio appropriate for the project location) indicated by Figure 9.5b x the 15 minute water quality design flow rate;~~

~~A_h = horizontal surface area of the plates (ft³/min²)~~

~~Vt = rise rate of 0.033 ft/min, or empirical determination, or Stokes Law based the oil droplet (ft/min)~~

~~A_p = projected surface area of the plate in ft²; 0.00386 is unit conversion constant~~

~~σ_w = density Q = design flowrate (ft³/min)~~

~~S_w = specific gravity of water at 32° F~~

~~σ_o = density the design temperature~~

~~S_o = specific gravity of oil at 32° F~~

~~A_a = actual plate area in ft² (one side only) the design temperature~~

~~b = angle of the plates with the horizontal in degrees (usually varies from 45-60 degrees).~~

~~$\eta_w = \mu_w$ = absolute viscosity of the water at 32° F (poise)~~

~~The above equation is based on an oil droplet diameter of 60 microns.~~

- Plate spacing should be a minimum of 3/4 in (perpendicular distance between plates) ~~or as determined by the manufacturer.~~ (WEF & ASCE, 1998; US Army Corps of Engineers, 1994; US Air Force, 1991; Jaisinghani, R., 1979)
- Select a plate angle between 45° to 60° from the horizontal.
- Locate plate pack at least 6 inches from the bottom of the separator for sediment storage
- Add 12 inches minimum head space from the top of the plate pack and the bottom of the vault cover.
- Design inlet flow distribution and baffles in the separator bay to minimize turbulence, short-circuiting, and channeling of the inflow especially through and around the plate packs of the CP separator. The

Operation and Maintenance

Reynolds Number through the separator bay should be <500 (laminar flow).

- Include forebay for floatables and afterbay for collection of effluent. (WEF & ASCE, 1998)
- The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 in. (King County Surface Water Management, 1998).
- Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.
- Prepare, regularly update, and implement an O & M Manual for the oil/water separators.

Operation and Maintenance

- ~~Prepare, regularly update, and implement an O & M Manual for the oil/water separators.~~
- Inspect oil/water separators monthly during the wet season of October 1-April 30 (WEF & ASCE, 1998; Woodward-Clyde Consultants) to ensure proper operation, and, during and immediately after a large storm event of ≥ 1 inch per 24 hours.
- Clean oil/water separators regularly to keep accumulated oil from escaping during storms. They must be cleaned by October 15 to remove material that has accumulated during the dry season (Woodward-Clyde Consultants), after all spills, and after a significant storm. Coalescing plates may be cleaned in-situ or after removal from the separator. An eductor truck may be used for oil, sludge, and washwater removal. (King County Surface Water Management, 1998) Replace wash water in the separator with clean water before returning it to service.
- Remove the accumulated oil when the thickness reaches 1-inch. Also remove sludge deposits when the thickness reaches 6 inches (King County Surface Water Management, 1998).
- Replace oil absorbent pads before their sorbed oil content reaches capacity.
- Train designated employees on appropriate separator operation, inspection, record keeping, and maintenance procedures.

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Chapter 12. - Emerging Technologies

~~This Chapter addresses emerging (new) technologies that have not been evaluated in sufficient detail to be acceptable for general usage in new development or redevelopment situations.~~

12.1 Background

~~It has become clear that the treatment Traditional best management practices (BMPs described in Ecology's 1992 Stormwater Manual, in some situations, are either not applicable or do not provide reliable) such as wetponds and cost effective removal of filtration swales may not be appropriate in many situations due to size and space restraints or their inability to remove target pollutants. For these reasons a need Because of this, the stormwater treatment industry emerged to develop new stormwater treatment technologies has emerged in this State as well as nationwide devices.~~

~~Emerging technologies are new technologies that have not been evaluated using approved protocols, but for which preliminary data indicate that they may provide a desirable level of stormwater pollutant removal. Some emerging technologies have already been installed in Washington as parts of treatment trains or as stand alone systems for specific applications. In some cases, emerging technologies are necessary to remove metals, hydrocarbons, and nutrients. Emerging technologies can also be used for retrofits and where land availability is unavailable for larger natural systems. stormwater treatment devices that are new to the stormwater treatment marketplace. These devices include both permanent and construction site treatment technologies. Many of these devices have not undergone complete performance testing so their performance claims cannot be verified.~~

12.2 Ecology Role in Evaluating Emerging Technologies

~~Ecology currently participates in a process to evaluate emerging technologies for permanent and construction site stormwater runoff applications and to convey judgments made by local jurisdictions and others on their acceptance. Based on recommendations from Ecology's Volume V Stormwater Technical Advisory Committee (TAC), Ecology has implemented the following process:~~

~~Operating a web site for publishing To aid local governments in selecting new stormwater treatment technologies Ecology developed the Technology Assessment Protocol – Ecology (TAPE) and Chemical Technology Assessment Protocol Ecology (CTAPE) protocols. These protocols provide manufacturers with guidance on stormwater monitoring so they may verify their performance claims.~~

As a part of this process Ecology:

- Posts information on emerging technologies ~~for permanent and construction site stormwater applications and protocols (TAPE and CTAPE) used in their evaluation at the emerging technologies website:~~ <http://www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html>
- ~~Participating-Participates~~ in ~~meetings of all~~ Technical Review Committee (TRC) and Chemical Technical Review Committee (CTRC) ~~which will be asked to evaluate emerging technologies activities which include reviewing manufacturer performance data and providing recommendations on use level designations.~~
- Grants use level designations based on performance and other pertinent data ~~from submitted by the manufacturers and vendors and manufacturers and recommendations by the review committees~~ Ecology assesses levels of developments of emerging technologies and posts relevant decisions and supporting documentation at its stormwater web site.
- Provides oversight and analysis of all submittals to ensure consistency with this manual.

12.3 Evaluation of Emerging Technologies

Local governments should consider the following as they make decisions concerning the use of new stormwater treatment technologies in their jurisdictions:

Remember the Goal:

The goal of any stormwater management program or BMP is to treat and release stormwater in a manner that does not harm beneficial uses.

~~Compliance with water quality standards is one measure of determining whether beneficial uses will be harmed.~~

Exercise Reasonable Caution:

- ~~It is important to be cautious with the use of emerging, unproven, technologies for new development and for retrofits.~~ Before allowing ~~the use of~~ a new technology ~~for a limited application~~, the local government should review evaluation information based on ~~acceptable protocols such as Ecology's~~ the TAPE and/or CTAPE.

An emerging technology ~~must not~~cannot be used for new ~~development sites or redevelopment~~ unless ~~there are data indicating this technology has a use level designation~~. Having a use level designation means that ~~its Ecology and the TRC or CTRC reviewed system performance is expected to be reasonably equivalent to the performance goals listed in Chapter 3 for data and believe the technology has the ability to provide the level of treatment type applicable to the site: Basic, Enhanced, Phosphorus, or Oil Treatment. It may also receive approval as part of a treatment train to help achieve the applicable performance goal.~~ Local governments can refer to Ecology's web site to obtain claimed by the latest performance verification of an emerging technology.

~~Local governments are encouraged to:~~

- ~~Require a monitoring program, using an acceptable protocol, of those emerging technologies that have not been verified for limited or full scale statewide use at Ecology's web site.~~
- ~~Look for achieving acceptable performance objectives as specified in Chapter 3~~ manufacturer.
- To achieve the goals of the Clean Water Act and the Endangered Species Act, local governments may find it necessary to retrofit stormwater pollutant control systems for many existing stormwater discharges. In retrofit situations, the use of any ~~BMPs~~ BMP that ~~make~~ makes substantial progress toward these goals is a step forward and ~~is~~ encouraged by Ecology. To the extent practical, the performance of ~~these~~ BMPs used in retrofit situations should be evaluated, using ~~approved~~ the TAPE or CTAPE protocols.

12.4 Acceptable Evaluation Protocols (TAPE and CTAPE)

To properly evaluate new technologies, performance data must be obtained using the Ecology approved Technology Assessment Protocol-Ecology (TAPE) and the chemical TAPE (CTAPE) or other accepted protocols. Ecology published these protocols at its web site for use by local governments, suppliers of new technologies, and consultants. They can be downloaded at: [Other acceptable protocols may also be added to Ecology's web site. Such protocols may be developed by local, state, or federal agencies.](#)

12.512.4 Assessing Levels of Development of Emerging Technologies

Ecology developed use level designations to assess levels of development for emerging technologies. The use level designations are based upon the quantity, quality, and type of performance data. There are three use level designations: pilot use level designation, conditional use level designation, and general use level designation.

Pilot Use Level Designation (PULD)

For technologies that have limited performance data, the pilot use level designation allows limited use to conduct field-testing. Ecology may give Pilot use level designations based solely on laboratory performance data. Pilot use level designations apply for a specified time period only. During this time period, the proponent must complete all field testing and submit a technology evaluation report (TER) to Ecology.

PULD technologies may be installed at sites that are pre-approved by Ecology and the local government with jurisdiction provided that the vendor and/or developer agree to conduct field testing based on TAPE requirements. Ecology will limit the number of installations to five during the pilot use level period and the manufacture must monitor all five sites. Local governments should not approve technologies that have a PULD for a new or redevelopment project unless Ecology has concurred in the use of the technology at that project site.

Please note: Government entities covered by a municipal stormwater NPDES permit must [notify Ecology](#) when a PULD technology is proposed (form is available in [TAPE guidance document](#), at: www.ecy.wa.gov/biblio/1110061.html). Ecology has received many submittals from vendors to approve their new technologies for statewide applications. Technologies have been proposed for permanent and construction site applications that include cartridge filtration, vortex enhanced sedimentation, manufactured storm drain structures,

electrocoagulation, chemical flocculants and upgrades of catchbasin insert technologies. Because the submittals demonstrated various stages of development Ecology decided to classify technologies depending on the adequacy of the verification testing.

To assess and classify levels of developments, Ecology is using the classification criteria given below. These criteria are included in the TAPE and CTAPE posted at Ecology's web site. Emerging technologies shall be used only within the application criteria and performance limits listed at Ecology's web site. *Pilot Level (PLD)*—Pilot studies could typically be conducted at roadway, commercial and residential sites, or specific land uses for which the system is marketed. Runoff at each site should be tested at full flow (design flow) conditions using the TAPE or CTAPE before deciding on a limited or general statewide use of the technology. The pilot studies should be conducted during dry and wet seasons.

- *General Statewide Use (GULD)*. To obtain general statewide acceptance the performance criteria as specified in Chapter 3 must be verified using the TAPE or CTAPE, or other acceptable protocol. Final application, design and O&M criteria, and costs must be determined. Approvals may include application as part of a treatment train and/or as a stand-alone BMP.

)

Conditional Use Level Designation (CUD)—A CUD may be granted by Ecology under the following circumstances: CULD)

- An Ecology established the CULD for emerging technology is in widespread use in the Pacific Northwest and/or on a national basis, and the manufacturer has technologies that have considerable performance data that does not meet approved protocols, or,
- An emerging technology is in limited use has limited data and is deemed to be functionally equivalent to another emerging technology for which the TRC or CTRC has recommended a Conditional or General Use Designation, and, it is likely that after completing additional laboratory and/or field testing meeting collected per the TAPE protocol. Ecology may give a conditional use level designation if a manufacture collected field data through a protocol reasonably consistent with but not fully meeting the TAPE protocol. The field data must meet the statistical goals set out in the TAPE guidelines (See www.ecy.wa.gov/pubs/1110061.pdf/CTAPE criteria, the technology will be awarded a GULD.

) Manufactures may use laboratory data to supplement field data. Ecology will allow the use of Technologies that are granted receive a CUD may

~~continue to be sold subject to CUD conditions~~ CULD for a specified time period, during which the manufacture must complete the field and laboratory testing necessary to obtain a general use ~~Designation must be completed~~ level designation (GULD) and must submit a TER to Ecology and the TRC. Ecology limits the number of installations to ten during the CULD period.

General Use Level Designation (GULD)

The general use level designation (GULD) confers a general acceptance for the specified applications (land uses). Technologies with a GULD may be used for new development, re-development, or retrofit situations anywhere in Washington, subject to conditions that Ecology places within the Use Designation document.

12.6 ~~Examples of 5~~ Emerging Technologies for Stormwater Treatment and Control Options

Ecology's Emerging Technologies website:

www.ecy.wa.gov/programs/wq/stormwater/newtech/index.html

lists technologies that have obtained a use level designation through the Technology Assessment Protocol – Ecology (TAPE) process. Ecology's website also provides additional guidance regarding the TAPE process and application forms.

In addition to Ecology certification, local jurisdiction approval is required for installation of treatment technologies with Pilot (PULD), Conditional (CULD), or General (GULD) Use Level Designations. Local jurisdictions may choose not to accept products approved through TAPE, or may require additional testing prior to consideration for local approval.

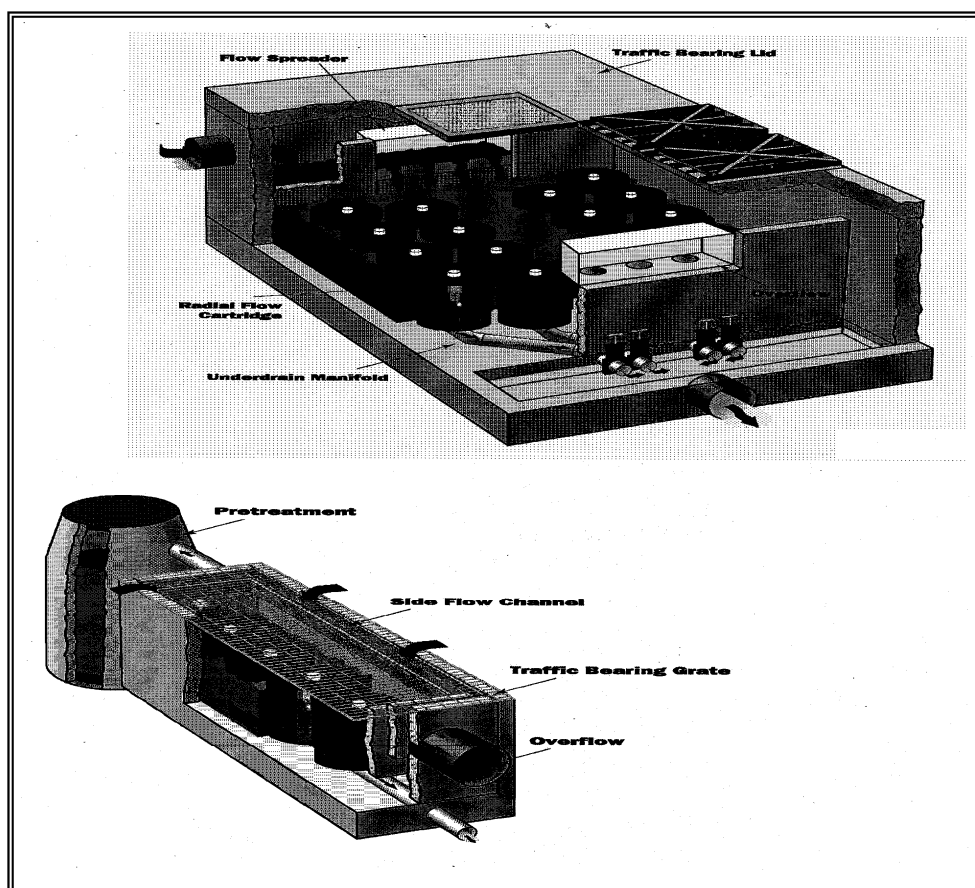
In addition to other requirements, Ecology uses the goals below to evaluate emerging stormwater treatment technologies. Proponents attempting to obtain a GULD for a stormwater treatment technology must demonstrate the achievement of applicable performance goals by monitoring the water quality parameters listed in [Table 12.5.1](#).

The following subheadings link to menus of emerging treatment technologies that have completed or are engaged in the TAPE program.

[Pretreatment](#)*Note: The descriptions and other supplier information provided in this section should not be construed as approvals by Ecology of any of the technologies. Download information on technologies that are under review and development levels with supporting data at*

12.6.1—Media Filters

Introduction—The media filter technology has been under development in the Pacific Northwest since the early 1990s. During the early stages of development, a leaf compost medium was used in fixed beds. Continued development of this technology is based on placing the media in filter cartridges (vertical media filters) instead of fixed beds, and amending the media (Varner, Phyllis, City of Bellevue, 1999) with constituents that will improve effectiveness (See Figure 12.1). Many systems have been installed in the U.S. The target pollutants for removal are: TSS, total and soluble phosphorous, total nitrogen, soluble metals, oil & grease and other organics.



Courtesy of Stormwater Management Inc.

Figure 12.1—Vertical Media Filter

Description:	The media can be housed in cartridge filters enclosed in concrete vaults, or in fixed beds such as the sand filters described in Chapter 8. An assortment of filter media are available including leaf compost, pleated fabric, activated charcoal, perlite, amended sand and perlite, and zeolite. The system functions by routing the stormwater through the filtering or sorbing medium, which traps particulates and/or soluble pollutants. (Leif, Bill, 1999; Stormwater Management Inc., 1999)
Performance Objectives	Media can be selected for removal of TSS, oil/grease or total petroleum hydrocarbons, soluble metals, nutrients and organics. (See Chapter 4 for performance objectives)
Applications and limitations:	<p>Typical applications and limitations include:</p> <ul style="list-style-type: none"> • Pretreatment is required for high TSS and/or hydrocarbon loadings and debris that could cause premature failures due to clogging • Media filtration, such as amended sand, (Varner, Phyllis, City of Bellevue, 1999) should be considered for some enhanced treatment applications to remove soluble metals and soluble phosphates • These systems may be designed as on-line systems for small drainage areas, or as off-line systems. • For off-line applications, flows greater than the design flow shall be bypassed.
Site Suitability	<p>Consider:</p> <ul style="list-style-type: none"> • Space requirements • Design flow characteristics • Target pollutants • O & M requirements • Capital and annual costs
Design Criteria for TSS Removal)	<ul style="list-style-type: none"> • Determine TSS loading and peak design flow rate. • TSS loading capacity per cartridge based on manufacturer's loading and flow design criteria to determine number and size of cartridges. • Evaluate for pre-treatment needs. Typically, roadways, single family dwellings, and developments with steep slopes and erodible soils need pretreatment for TSS. Developments producing sustained oil and grease loads should be evaluated for oil and grease pretreatment needs. • Select media based on pollutants of concern which are typically based on land use and local agency guidelines.
Pretreatment and Bypassing:	<ul style="list-style-type: none"> • Use source control where feasible, including gross pollutant removal, sweeping, and spill containment

	<ul style="list-style-type: none"> • Maintain catchbasins as needed to minimize inlet debris that could impair the operation of the filter media. • Sedimentation vaults/ponds/tanks, innovative more efficient catchbasins, oil/water separators for oil > 25 ppm, or other appropriate pre-treatment system to improve and maintain the operational efficiency of the filter media • Bypassing of flows above design flows should be included
<i>Construction</i>	<ul style="list-style-type: none"> • A precast or cast-in-place vault is typically installed over an underdrain manifold pipe system. This is followed by installation of the cartridges. • Prior to cartridge installation construction sites must be stabilized to prevent erosion and solids loading.
<i>Maintenance</i>	<ul style="list-style-type: none"> • Follow manufacturers O & M guidelines to maintain design flows and pollutant removals • Based on TSS loading and cartridge capacity calculate maintenance frequency <p><i>Additional Applications, Limitations, Design, Construction, and Maintenance Criteria</i> (See Ecology web site).</p>

12.6.2—Amended Sand Filters

Description

The addition of media to improve the pollutant removal capabilities of basic sand filters.

Recent Performance Results

In a thorough study (Varner, Phyllis, City of Bellevue, 1999) of the performance of sand filters amended with processed steel fiber (95% sand and 5% processed steel fiber by volume), and crushed calcitic limestone (90% sand and 10% crushed calcitic limestone by volume), the City of Bellevue reported significant reductions in total phosphorus and dissolved zinc in runoff from the Lakemont residential area. Because the Lakemont filter study was a detailed, well-documented, and reviewed analysis of a full scale operation, Ecology considers this technology as sufficiently advanced in development to allow its use as an option under the Enhanced Treatment Menu and the Phosphorus Treatment Menu. Sand filters amended with one of these media should be sized using the design criteria for a basic sand filter. Ecology prefers that these amendments be tested at another location to confirm the performances achieved by the Lakemont study and to further refine the design criteria.

Bellevue experienced some reduction in infiltration in the sand filter amended with processed steel fiber due to formation of a cemented layer of ferrie oxide. Filters amended with processed steel fiber may require more frequent rototilling and removal of top layers to prevent formation of a cemented layer.

12.6.3—Catch Basin Inserts (CBI)

Introduction

CBIs have been under development for many years in the Puget Sound Basin. They function similarly to media filtration except that they are typically limited by the size of the catchbasin. They also are likely to be maintenance intensive.

Description

Catch basin inserts typically consist of the following components:

- A structure (screened box, brackets, etc.) which contains a pollutant removal medium
- A means of suspending the structure in a catch basin
- A filter medium such as sand, carbon, fabric, etc.
- A primary inlet and outlet for the stormwater
- A secondary outlet for bypassing flows that exceed the design flow rate

Applications and Limitations

By treating runoff close to its source, the volume of flow is minimized and more effective pollutant removal is therefore possible. Depending on the insert medium, removals of TSS, organics (including oils), and metals can be achieved. The main drawbacks are the limited retention capacities

and maintenance requirements on the order of once per month in the wet season to clean or replace the medium. Based on two studies of catch basin inserts, (Koon, John, Interagency Catchbasin Insert Committee, 1995; Leif, William, Snohomish County 1998) the following are potential limitations and applications for specifically designated CBIs:

- CBIs are not recommended as a substitute for basic BMPs such as wet ponds, vaults, constructed wetlands, grass swales, sand filters or related BMPs.
- CBIs can be used as temporary sediment control devices and pretreatment at construction sites.
- CBIs can be considered for oil control at small sites where the insert medium has sufficient hydrocarbon loading capacity and rate of removal, and the TSS and debris will not prematurely clog the insert.
- CBIs can be used in unpaved areas and should be considered equivalent to currently accepted inlet protection BMPs.
- CBIs can be used when an existing catch basin lacks a sump or has an undersized sump.
- CBIs can cause flooding when plugged.
- CBIs may be considered in specialized small drainage applications for specific target pollutants where clogging of the medium will not be a problem.

12.6.4 — Manufactured Storm Drain Structures

Most of these types of systems marketed thusfar are cylindrical in shape and are designed to fit into or adjacent to existing storm drainage systems or catch basins. The removal mechanisms include vortex enhanced sedimentation, circular screening, and engineered designs of internal components, for large particle TSS and large oil droplets.

1. Vortex-enhanced Sedimentation

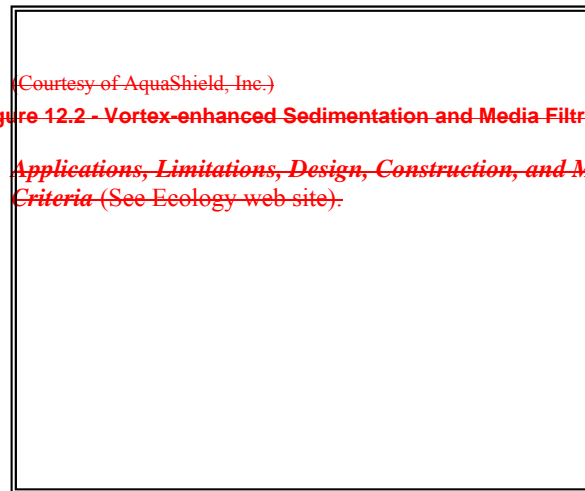
Description

Vortex-enhanced Sedimentation consists of a cylindrical vessel with tangential inlet flow which spirals down the perimeter, thus causing the heavier particles to settle. It uses a vortex enhanced settling mechanism (swirl concentration) to capture settleable solids, floatables, and oil and grease. This system includes a wall to separate TSS from oil. An assessment of a vortex technology with designation levels is provided at Ecology's web site at —

2. Vortex-enhanced Sedimentation and Media Filtration

Description

This system uses a two-stage approach which includes a Swirl Concentrator followed by a filtration chamber. See Figure 12.3.



(Courtesy of AquaShield, Inc.)

Figure 12.2 - Vortex-enhanced Sedimentation and Media Filtration

Applications, Limitations, Design, Construction, and Maintenance Criteria (See Ecology web site).

3. Cylindrical Screening System

Description

This system is comprised of a cylindrical screen and appropriate baffles and inlet/outlet structures to remove debris, large particle TSS, and large oil droplets. It includes an overflow for flows exceeding the design flow. Sorbents can be added to the separation chamber to increase pollutant removal efficiency. See Figure 12.4.

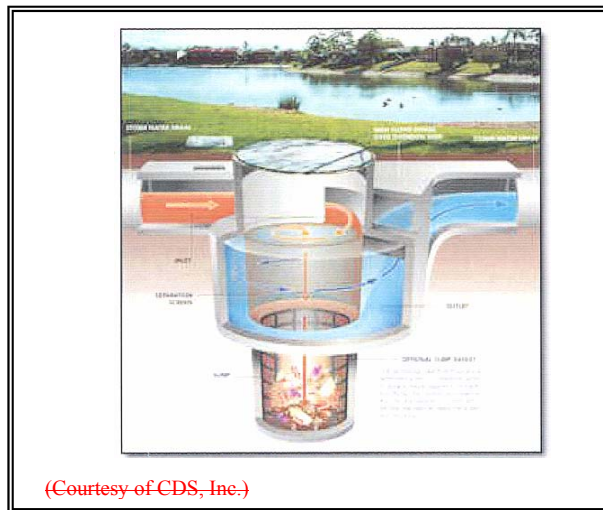
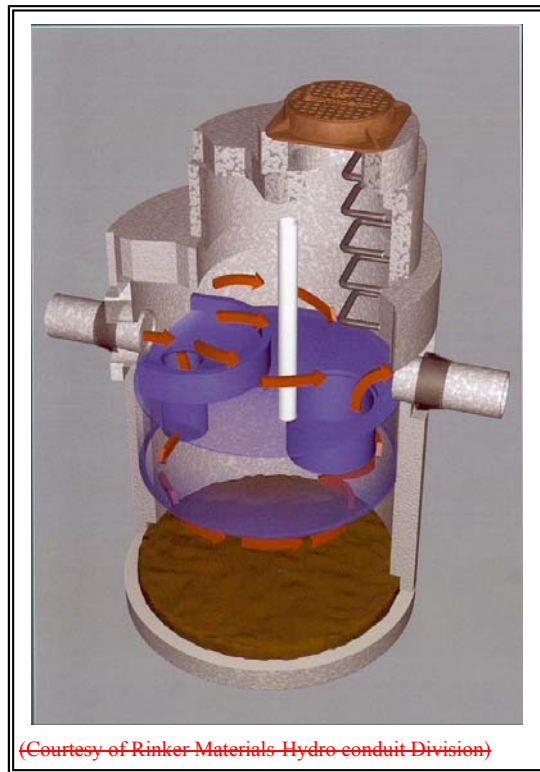


Figure 12.3 – Screen Separator

4. Engineered Cylindrical Sedimentation

Description:

This system is comprised of an engineered internal baffle arrangement and oil/TSS storage compartment designed to provide considerably better removals of large particle TSS and oil droplets than the standard catchbasins. It includes a bypass of flows higher than design flows, thus preventing scouring of collected solids and oils during the bigger storms. See Figure 12.5.



(Courtesy of Rinker Materials Hydro-conduit Division)

Figure 12.4 – Engineered Cylindrical

12.6.5 High Efficiency Street Sweepers


Description:

A new generation of street sweepers has been developed that utilize strong vacuums to pick up small particulates. They include mechanical sweeping and air filtration to control air emissions to acceptable levels. At least two manufacturers market what is referred to as a "high efficiency" street sweeper.

Application

High efficiency street sweepers are being marketed for roadways that are sufficiently accessible, need fine particulate removal (<250 microns), and for which a sufficient frequency of sweeping can be maintained to achieve proper removals of street dirt.

Limitations:

- Limited field data and dependence on modeling projections
- May not be sufficiently effective during wet conditions
- More expensive than traditional sweepers — the cost of alternative BMPs should be compared.
- Increased storm frequency, with short intervals between storms, results in 

May depend on its availability, particularly during the wet season, and the need for a minimum in-place backup

Pretreatment is generally applied to:

- Project sites using infiltration treatment.
- Treatment systems needed to assure and extend performance of the downstream basic or enhanced treatment facility.

Pretreatment Performance Goal: For influent concentrations ranging:

- Less than 100 mg/L: achieve effluent goals of 50 mg/L of fine and 20 mg/L of coarse total suspended solids.
- Greater than 100 mg/L, but less than 200 mg/L: achieve 50% removal of fine (50 micron-mean size) and 80% removal of coarse (125-micron-mean size) total suspended solids.

Oil Treatment

Oil treatment Performance Goal: Achieve no ongoing or recurring visible sheen and a daily average total petroleum hydrocarbon concentration no greater than 10 mg/L with a maximum of 15 mg/L for discrete (grab) samples.

Basic Treatment

Basic treatment Effluent Goals: For influent concentrations ranging:

- Less than 100mg/L: achieve an effluent of 20mg/L total suspended solids.
- From 100mg/L to 200 mg/L: achieve 80% removal of total suspended solids.
- Greater than 200mg/L: achieve more than 80% removal of total suspended solids.

Ecology has also approved technologies listed in this section with a GULD for Pre-treatment in accordance with [Section 6.2](#).

Enhanced Treatment

Enhanced Performance Treatment Goal: Achieve a higher level of treatment than basic treatment. For influent concentrations ranging:

- Dissolved copper 0.005 - 0.02 mg/L: meet basic treatment goal and better than basic treatment currently defined as > 30% dissolved copper removal.
- Dissolved zinc 0.02 - 0.3 mg/L: meet basic treatment goal and better than basic treatment currently defined as > 60% dissolved zinc removal.

Phosphorous Treatment

Phosphorus Performance Treatment Goal: Achieve 50% total phosphorus removal for an influent concentration range of 0.1 to 0.5 mg/L and achieve basic treatment goals.

Construction Site Treatments

Construction Performance Treatment Goal: Achieve a maximum of 5 NTUs above background (background of 50 NTUs or less), not more than 10% increase in turbidity where background is greater than 50 NTUs, pH of 6.5-8.5 in freshwater and 7.0-8.5 in marine water, and no visible oil sheen.

Table 12.5.1 TAPE Treatment Goals and Water Quality Parameters

Performance Goal	Influent Range	Criteria	Required Water Quality Parameters
Basic Treatment	20-100 mg/L TSS	Effluent goal \leq 20 mg/L TSS ^a	TSS
	100-200 mg/L TSS	\geq 80% TSS removal ^b	
	> 200 mg/L TSS	> 80% TSS removal ^b	
Dissolved Metals Treatment ^c	Dissolved copper 0.005 – 0.02 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 30% dissolved copper removal ^{b,d}	TSS, hardness, total and dissolved Cu and Zn
	Dissolved zinc 0.02 – 0.3 mg/L	Must meet basic treatment goal and better than basic treatment currently defined as > 60% dissolved zinc removal ^{b,d}	
Phosphorus Treatment	Total phosphorus (TP) 0.1 to 0.5 mg/L	Must meet basic treatment goal and exhibit \geq 50% TP removal ^b	TSS, TP, orthophosphate
Oil Treatment	Total petroleum hydrocarbons (TPH) > 10 mg/L ^e	1) No ongoing or recurring visible sheen in effluent 2) Daily average effluent TPH concentration < 10 mg/L ^{a,e} 3) Maximum effluent TPH concentration of 15 mg/L ^{a,e} for a discrete (grab) sample	NWTPH-Dx, visible sheen
Pretreatment ^f	50-100 mg/L TSS	Effluent goal \leq 50 mg/L TSS ^a	TSS
	\geq 100 mg/L TSS	> 50% TSS removal ^b	

mg/L – milligrams per liter

Cu – copper

NWTPH-Dx – Northwest Total Petroleum Hydrocarbons-Motor Oil and Diesel fractions

TP – total phosphorus

TPH – total petroleum hydrocarbons

TSS – total suspended solids

Zn – zinc

^a The upper one-sided 95 percent confidence interval around the mean effluent concentration for the treatment system being evaluated must be lower than this performance goal to meet the performance goal with the required 95 percent confidence.

^b The lower one-sided 95 percent confidence interval around the mean removal efficiency for the treatment system being evaluated must be higher than this performance goal to meet the performance goal with the required 95 percent confidence.

^c Referred to as Enhanced Treatment in the *Stormwater Management Manual for Western Washington* (Ecology 2005) and Metals Treatment in the *Stormwater Management Manual for Eastern Washington* (Ecology 2004b). Must meet the removal goal for both dissolved copper and dissolved zinc in order to achieve a Dissolved Metals Treatment GULD. Meeting the removal goal for only one of these dissolved metals is not sufficient.

^d This percent removal was determined based on an analysis of basic treatment BMP dissolved metals removal data from the International Stormwater BMP database to define performance goals for dissolved metals treatment (Washington Stormwater Center and Herrera 2011). Data from the International Stormwater BMP database was reviewed and screened based on influent concentrations, geographic location, data quality, BMP design, and monitoring problems to develop a subset of data that was representative and suitable for determining BMP performance.

^e This performance goal should be evaluated based on the motor oil fraction of TPH-Dx only.

^f Pretreatment technologies generally apply to (1) project sites using infiltration treatment and (2) treatment systems where pretreatment is needed to ensure and extend performance of the downstream basic or dissolved metals treatment facilities.

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Appendix V-A Basic Treatment Receiving Waters

1. All salt waterbodies

2. <u>Rivers</u>	<u>Upstream Point for Exemption</u>
Baker	Anderson Creek
Bogachiel	Bear Creek
Cascade	Marblemount
Chehalis	Bunker Creek
Clearwater	Town of Clearwater
Columbia	Canadian Border
Cowlitz	Skate Creek
Elwha	Lake Mills
Green	Howard Hanson Dam
Hoh	South Fork Hoh River
Humptulips	West and East Fork Confluence
Kalama	Italian Creek
Lewis	Swift Reservoir
Muddy	Clear Creek
Nisqually	Alder Lake
Nooksack	Glacier Creek
South Fork Nooksack	Hutchinson Creek
North River	Raymond
Puyallup	Carbon River
Queets	Clearwater River
Quillayute	Bogachiel River
Quinault	Lake Quinault
Sauk	Clear Creek
Satsop	Middle and East Fork Confluence
Skagit	Cascade River
Skokomish	Vance Creek
Skykomish	Beckler River
Snohomish	Snoqualmie River
Snoqualmie	Middle and North Fork Confluence
Sol Duc	Beaver Creek
Stillaguamish	North and South Fork Confluence
North Fork Stillaguamish	Boulder River
South Fork Stillaguamish	Canyon Creek
Suiattle	Darrington
Tilton	Bear Canyon Creek
Toutle	North and South Fork Confluence
North Fork Toutle	Green River
Washougal	Washougal
White	Geenwater River
Wind	Carson
Wynoochee	Wishkah River Road Bridge

3.	<u>Lakes</u>	<u>County</u>
	Washington	King
	Sammamish	King
	Union	King
	Whatcom	Whatcom
	Silver	Cowlitz

Note: Local governments may petition for the addition of more waters to this list. The initial criteria for this list are rivers whose mean annual flow exceeds 1000 cfs, and lakes whose surface area exceeds 300 acres. Additional waters do not have to meet these criteria, but should have sufficient background dilution capacity to accommodate dissolved metals additions from build-out conditions in the watershed under the latest Comprehensive Land Use Plan and zoning regulations.

Appendix V-B (Also published as Appendix III-D) Procedure for Conducting a Pilot Infiltration Test

The Pilot Infiltration Test (PIT) consists of a relatively large-scale infiltration test to better approximate infiltration rates for design of stormwater infiltration facilities. The PIT reduces some of the scale errors associated with relatively small-scale double ring infiltrometer or “stove-pipe” infiltration tests. It is not a standard test but rather a practical field procedure recommended by Ecology’s Technical Advisory Committee.

Infiltration Test

- The horizontal surface area of the bottom of the test pit should be approximately 100 square feet. For small drainages and where water availability is a problem smaller areas may be considered as determined by the site professional.
- Accurately document the size and geometry of the test pit.
- Install a vertical measuring rod (minimum 5 ft. long) marked in half-inch increments in the center of the pit bottom.
- Use a rigid 6-inch diameter pipe with a splash plate on the bottom to convey water to the pit and reduce side-wall erosion or excessive disturbance of the pond bottom. Excessive erosion and bottom disturbance will result in clogging of the infiltration receptor and yield lower than actual infiltration rates.
- Add water to the pit at a rate that will maintain a water level between 3 and 4 feet above the bottom of the pit. A rotameter can be used to measure the flow rate into the pit.

Note: A water level of 3 to 4 feet provides for easier measurement and flow stabilization control. However, the depth should not exceed the proposed maximum depth of water expected in the completed facility.

Every 15–30 min, record the cumulative volume and instantaneous flow rate in gallons per minute necessary to maintain the water level at the same point (between 3 and 4 feet) on the measuring rod.

Add water to the pit until one hour after the flow rate into the pit has stabilized (constant flow rate) while maintaining the same pond water level. (usually 1–7 hours)

After the flow rate has stabilized, turn off the water and record the rate of infiltration in inches per hour from the measuring rod data, until the pit is empty.

Data Analysis

Calculate and record the infiltration rate in inches per hour in 30 minutes or one-hour increments until one hour after the flow has stabilized.

Note: Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

Apply appropriate correction factors for site heterogeneity, anticipated level of maintenance and treatment to determine the site-specific design infiltration rate (see Table 7.3).

Example

The area of the bottom of the test pit is 8.5 ft. by 11.5 ft.

Water flow rate was measured and recorded at intervals ranging from 15 to 30 minutes throughout the test. Between 400 minutes and 1,000 minutes the flow rate stabilized between 10 and 12.5 gallons per minute or 600 to 750 gallons per hour, or an average of $(9.8 + 12.3) / 2 = 11.1$ inches per hour.

Applying a correction factor of 5.5 for gravelly sand in table 6.3 the design long-term infiltration rate becomes 2 inches per hour, anticipating adequate maintenance and pre-treatment.

Appendix V-G

Appendix V-B Recommended Modifications to ASTM D 2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes

Developed by the City of Seattle in cooperation with local soils laboratories.

Proctor method ASTM D1557 Method C (6-inch mold) shall be used to determine maximum dry density values for compaction of bioretention soil sample. Sample preparation for the Proctor test shall be amended in the following ways:

- 1) Maximum grain size within the sample shall be no more than ½ inches in size.
- 2) Snip larger organic particles (if present) into ½ inch long pieces.
- 3) When adding water to the sample during the Proctor test, allow the sample to pre-soak for at least 48 hours to allow the organics to fully saturate before compacting the sample. This pre-soak ensures the organics have been fully saturated at the time of the test.

ASTM D2434 shall be used and amended in the following ways:

1) Apparatus:

- a. 6-inch mold size shall be used for the test.
- b. If using porous stone disks for the testing, the permeability of the stone disk shall be measured before and after the soil tests to ensure clogging or decreased permeability has not occurred during testing.
- c. Use the confined testing method, with 5- to 10-pound force spring
- d. Use de-aired water.

2) Sample:

- a. Maximum grain size within the sample shall not be more than ½ inch in size.
- b. Snip larger organic particles (if present) into ½-inch long pieces.
- c. Pre-soak the sample for at least 48 hours prior to loading it into the mold. During the pre-soak, the moisture content shall be higher than optimum moisture but less than full saturation (i.e., there shall be no free water). This pre-soak ensures the organics have been fully saturated at the time of the test.

3) Preparation of Sample:

- a. Place soil in cylinder via a scoop.
- b. Place soil in 1-inch lifts and compact using a 2-inch-diameter round tamper. Pre-weigh how much soil is necessary to fill 1-inch lift at 85% of maximum dry density, then tamp to 1-inch thickness. Once mold is full, verify that density is at 85% of maximum dry density (+ or – 0.5%). Apply vacuum (20 inches Hg) for 15 minutes before inundation.
- c. Inundate sample slowly under a vacuum of 20 inches Hg over a period of 60 to 75 minutes.

d. Slowly remove vacuum (> 15 seconds).

e. Sample shall be soaked in the mold for 24 to 72 hours before starting test.

4) Procedure:

a. The permeability test shall be conducted over a range of hydraulic gradients between 0.1 and 2.

b. Steady state flow rates shall be documented for four consecutive measurements before increasing the head.

c. The permeability test shall be completed within one day (one-day test duration).

Appendix V-C Geotextile Specifications

Table C.1
Geotextile Properties for Underground Drainage
Geotextile Property Requirements¹

Geotextile Property	Test Method	Low Survivability	Moderate Survivability
		Woven/Nonwoven	Woven/Nonwoven
Grab Tensile Strength, in machine and x-machine direction	ASTM D4632	180 lbs/115 lbs min.	250 lbs/160 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	<50%/>=50%	<50%/>=50%
Seam Breaking Strength (if seams are present) with seam located in the center of 8-inch-long specimen oriented parallel to grip faces	ASTM D4632	160 lbs/100 lbs min.	220 lbs/140 lbs min.
Puncture Resistance	ASTM D6241	370 lbs/220 lbs min.	495 lbs/310 lbs min.
Tear Strength, in machine and x-machine direction	ASTM D4533	67 lbs/40 lbs min.	80 lbs/50 lbs min.
Ultraviolet (UV) Radiation stability	ASTM D4355	50% strength retained min., after 500 hrs. in a xenon arc device	50% strength retained min., after 500 hrs. in a xenon arc device

¹ All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

Table C-2 Geotextile for Underground Drainage Filtration Properties				
Geotextile Property Requirements ¹				
Geotextile Property	Test Method	Class A	Class B	Class C
AOS ²	ASTM D4751	No. 40 max.	No. 60 max.	No. 80 max.
Water Permittivity	ASTM D4491	0.5 sec ⁻¹ min.	0.4 sec ⁻¹ min.	0.3 sec ⁻¹ min.

¹ All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

² Apparent Opening Size (measure of diameter of the pores in the geotextile)

Table C-3 Geotextile Strength Properties for Impermeable Liner Protection		
Geotextile Property	Test Method	Geotextile Property Requirements ¹
Grab Tensile Strength, min. in machine and x-machine direction	ASTM D4632	250 lbs min.
Grab Failure Strain, in machine and x-machine direction	ASTM D4632	>50%
Seam Breaking Strength (if seams are present)	ASTM D4632 and ASTM D4884 (adapted for grab test)	220 lbs min.
Puncture Resistance	ASTM D4833	125 lbs min.
Tear Strength, min. in machine and x-machine direction	ASTM D4533	90 lbs min.
Ultraviolet (UV) Radiation	ASTM D4355	50% strength stability retained min., after 500 hrs. in weatherometer

¹ All geotextile properties are minimum average roll values (i.e., the test result for any sampled roll in a lot shall meet or exceed the values shown in the table).

Applications

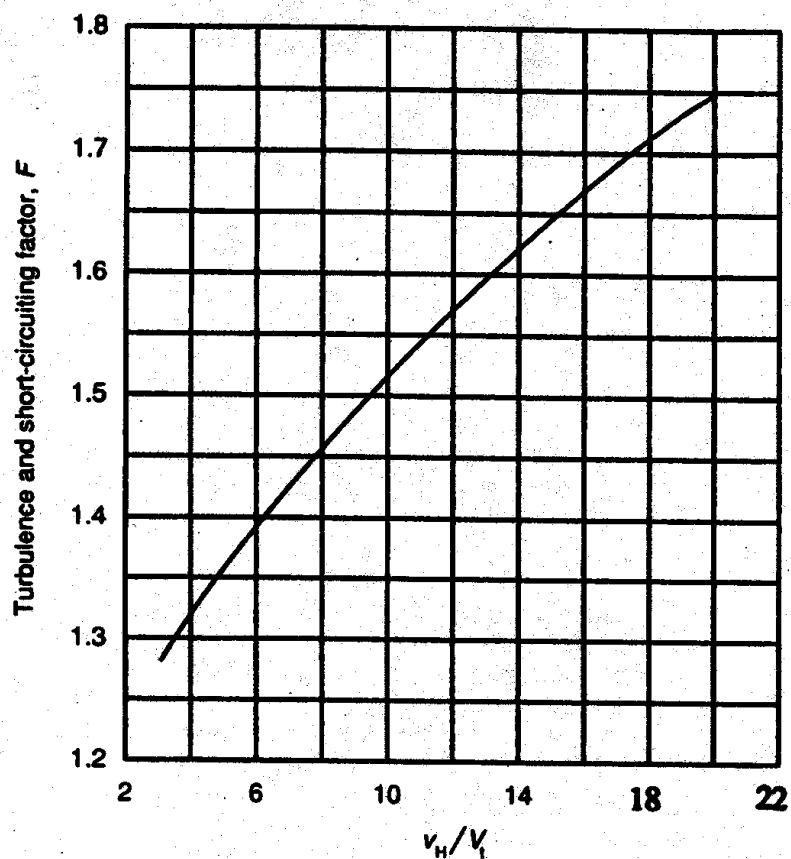
1. For sand filter drain strip between the sand and the drain rock or gravel layers specify Geotextile Properties for Underground Drainage, moderate survivability, Class A, from ~~Tables C-1~~ and ~~C-2~~ in the Geotextile Specifications.
2. For sand filter matting located immediately above the impermeable liner and below the drains, the function of the geotextile is to protect the impermeable liner by acting as a cushion. The specification provided ~~below~~ in ~~Table C-3~~ ~~Table 3~~ should be used to specify survivability properties for the liner protection application. Table 2, Class C should be used for filtration properties. Only nonwoven geotextiles are appropriate for the liner protection application.
3. For an infiltration drain specify Geotextile for Underground Drainage, low survivability, Class C, from Tables ~~C-1~~ and ~~C-2~~ in the Geotextile Specifications.
4. For a sand bed cover a geotextile fabric is placed exposed on top of the sand layer to trap debris brought in by the storm water and to protect the sand, facilitating easy cleaning of the surface of the sand layer. However, a geotextile is not the best product for this application. A polyethylene or polypropylene geonet would be better. The geonet material should have high UV resistance (90% or more strength retained after 500 hours in the weatherometer, ASTM D4355), and high permittivity (ASTM D4491, 0.8 sec. -1 or more) and percent open area (CWO-22125, 10% or more). Tensile strength should be on the order of 200 lbs grab (ASTM D4632) or more.

Courtesy of Tony Allen, Geotechnical Engineer-WSDOT

Reference for Tables ~~C-1~~ and ~~C-2~~: Section 9-33.2 “Geotextile Properties,” ~~1998~~ ~~2012~~ Standard Specifications for Road, Bridge, and Municipal Construction.

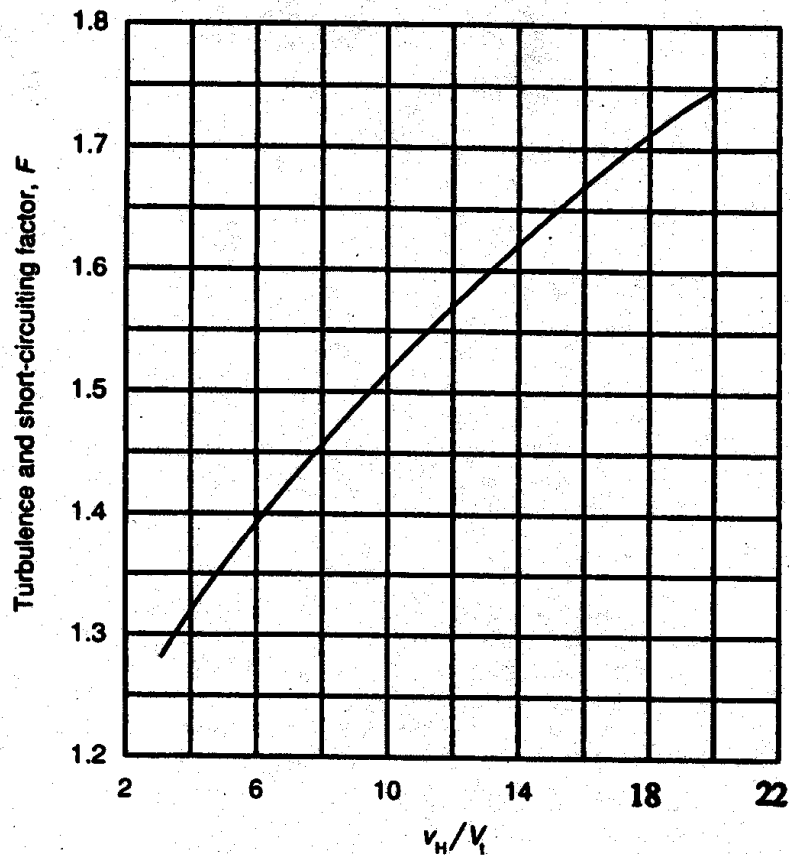
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v_H/V_t	Turbulence Factor (F_t)	$F = 1.2(F_t)$
20	1.45	1.74
15	1.37	1.64
10	1.27	1.52
6	1.14	1.37
3	1.07	1.28

Appendix V-D Turbulence and Short-Circuiting Factor



v_H/V_t	Turbulence Factor (F_t)	$F = 1.2(F_t)$
20	1.45	1.74
15	1.37	1.64
10	1.27	1.52
6	1.14	1.37
3	1.07	1.28

Figure D.1 – Recommended Values of F for Various Values of v_H/V_t

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Appendix V-E Recommended Newly Planted Tree Species for Flow Control Credit

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Green Factor Trees (Sorted according to criteria)

Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
Large												
	<i>Abies grandis</i>	Grand Fir	100	35		0		<input type="checkbox"/>		Grows at 0-1500 m in moist conifer forests	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Abies procera</i>	Noble Fir	90	30		0		<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>
	<i>Acer freemanii</i> 'Autumn Blaze'	Autumn Blaze M	50	40		37700	6	<input type="checkbox"/>	Orange		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer macrophyllum</i>	Big Leaf Maple	100	80	Rounded	0		<input type="checkbox"/>	yellow / brown	Very large native	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Acer platanoides</i> 'Emerald Queen'	Emerald Queen	50	40		50300	6	<input type="checkbox"/>	Yellow		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer saccharum</i> 'Bonfire'	Bonfire Sugar Ma	50	40	Oval	50300	6	<input type="checkbox"/>	Bright orange red	Fastest growing sugar maple.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer saccharum</i> 'Commemorat	Commemoration	50	35		38500	6	<input type="checkbox"/>	Orange to orange-red	Resistant to leaf tatter.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer saccharum</i> 'Legacy'	Legacy Sugar Ma	50	35		38500	5	<input type="checkbox"/>	Yellow or orange/red	Limited use - where sugar maple is desired in standard planting strips	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Aesculus flava</i>	Yellow Buckeye	70	40		0		<input type="checkbox"/>	yellow / orange	yellow flowers - least susceptible to leaf blotch - large fruit	<input type="checkbox"/>	<input type="checkbox"/>
	<i>Alnus rubra</i>	Red Alder	70	35	Broadly con	0		<input type="checkbox"/>	yellow / brown	nitrogen fixing	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Cercidiphyllum japonicum</i>	Katsura Tree	40	40	Oval	37700	6	<input type="checkbox"/>	Yellow to orange	Needs lots of water when young	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Fagus sylvatica</i>	Green Beech	50	40	Oval	50300	6	<input type="checkbox"/>	Bronze	Silvery-grey bark.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Fagus sylvatica</i> 'Asplenifolia'	Fernleaf Beech	60	60		0	6	<input type="checkbox"/>	golden / brown	Beautiful cut leaf	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Fraxinus latifolia</i>	Oregon Ash	60	35		0		<input type="checkbox"/>	yellow / brown	Only native ash in PNW	<input type="checkbox"/>	<input checked="" type="checkbox"/>

Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
	<i>Fraxinus pennsylvanica</i> 'Urban	Urbanite Ash	50	40	Pyramidal	50300	6	<input type="checkbox"/>	Deep bronze	Tolerant of city conditions	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Gymnocladus dioica</i> 'Espress	Espresso Kentuc	50	35		0	6	<input type="checkbox"/>	yellow	very coarse branches - extremely large bi-pinnately compound leaf -	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Liriodendron tulipifera</i>	Tulip Tree	60	30	Oval	35400	8	<input type="checkbox"/>	Yellow	Fast-growing tree.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Nothofagus antarctica</i>	Antarctic Beech	50	35		38500	6	<input type="checkbox"/>	None	Rugged twisted branching and petite foliage.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Picea sitchensis</i>	Sitka Spruce	100	30		0		<input type="checkbox"/>	Evergreen	Native environment is characterized by a cool, moist maritime climate	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Pinus monticola</i>	Western White Pi	100	35		0		<input type="checkbox"/>	Evergreen	Occurs in lowland fog forests or on moist mountain soils - primary host	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Platanus x acerifolia</i> 'Bloodgoo	Bloodgood Londo	50	40	Pyramidal	63700	8	<input type="checkbox"/>	Red	More anthracnose resistant - needs space	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Platanus x acerifolia</i> 'Yanwood'	Yanwood London	50	40		50300	8	<input type="checkbox"/>	Yellow-brown	High resistance to powdery mildew.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Pseudotsuga menziesii</i>	Douglas Fir	150	35		0		<input type="checkbox"/>	Evergreen		<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Quercus bicolor</i>	Swamp White Oa	45	45		55700	8	<input type="checkbox"/>	Varies.	Shaggy peeling bark	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus coccinea</i>	Scarlet Oak	50	40	Upright	50300	6	<input type="checkbox"/>	Red	Best oak for fall color	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus garryana</i>	Oregon Oak	45	40	Oval	43960	6	<input type="checkbox"/>		Native to Pacific Northwest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus imbricaria</i>	Shingle Oak	60	50		0	6	<input type="checkbox"/>	golden / brown	nice summer foliage - leaves can persist	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus muhlenbergii</i>	Chestnut Oak	60	50		0	6	<input type="checkbox"/>	brown / yellow	coarsely toothed leaf	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus robur</i>	English Oak	50	40	Rounded	50300	8	<input type="checkbox"/>	Yellow-brown	Large, sturdy tree	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Quercus rubra</i>	Red Oak	50	45	Rounded	63600	8	<input type="checkbox"/>	Red	Fast growing oak - needs space	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
	<i>Quercus velutina</i>	Black Oak	60	50		0	6	<input type="checkbox"/>	rusty red		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Thuja plicata</i>	Western Red Ce	125	40	Pyramidal	0		<input type="checkbox"/>	Evergreen	growth is stunted on dry soils	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Tsuga heterophylla</i>	Western Hemloc	130	30		0		<input type="checkbox"/>	Evergreen		<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Ulmus</i> 'Homestead'	Homestead Elm	60	35		48100	6	<input type="checkbox"/>	Yellow		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Ulmus</i> 'Pioneer'	Pioneer Elm	60	50		98200	6	<input type="checkbox"/>	Yellow	Resistant to Dutch elm disease.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Ulmus parvifolia</i> 'Emer II'	Allee Elm	50	35	Vase	38500	5	<input type="checkbox"/>	Yellow-orange	Exfoliating bark and nice fall color	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Zelkova serrata</i> 'Greenvase'	Green Vase Zelk	50	40		50300	5	<input type="checkbox"/>	Orange	Vigorous	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Medium / Large												
	<i>Acer campestre</i>	Hedge Maple	30	30		14100	5	<input type="checkbox"/>	Yellow		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer campestre</i> 'Evelyn'	Queen Elizabeth	35	30		17700	5	<input type="checkbox"/>	Yellow	More upright branching than the species.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer miyabei</i> 'Morton'	State Street Mapl	45	30		0	5	<input type="checkbox"/>	yellow		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer platanoides</i> 'Parkway'	Parkway Norway	40	25		14700	6	<input type="checkbox"/>	Yellow	tolerant of verticillium wilt	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer pseudoplatanus</i> 'Atropurp	Spaethii Maple	40	30		21200	5	<input type="checkbox"/>	Not significant	Leaves green on top purple underneath.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Acer saccharum</i> 'Green Mount	Green Mountain	45	35	Oval	33700	6	<input type="checkbox"/>	Red to orange.	Reliable fall color	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Aesculus x carnea</i>	'Briotii' Red Hors	30	35		18200	5	<input type="checkbox"/>	No	Resists heat and drought better than other horsechestnuts.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Betula albosinensis</i> var <i>septe</i>	Chinese Red Birc	45	35		0	5	<input type="checkbox"/>	yellow	pink/ white peeling bark	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Betula jacquemontii</i>	Jacquemontii Bir	40	30	Oval	21200	5	<input type="checkbox"/>	Yellow	White bark makes for good winter interest - best for aphid resistance	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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	Betula papyrifera	Paper Birch	60	35		0		<input type="checkbox"/>	Yellow / brown	High susceptibility to aphid infestation	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Chamaecyparis pisifera	Sawara Cypress	45	25	Pyramidal	17200	6	<input type="checkbox"/>	Evergreen	Special site approval needed - many cultivars available	<input type="checkbox"/>	<input type="checkbox"/>
	Corylus columa	Turkish Filbert	40	25	Pyramidal	14800	5	<input type="checkbox"/>	Yellow	Tight, formal, dense crown - not for high pedestrian areas	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Eucommia ulmoides	Hardy Rubber Tr	50	40		0	5	<input type="checkbox"/>		Dark green shiny leaves	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Fagus sylvatica 'Rohanii'	Purple Oak Leaf	50	30		0	6	<input type="checkbox"/>		Attractive purple leaves with wavy margins.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Fraxinus americana 'Autumn A	Autumn Applaus	40	25	Oval	14700	5	<input type="checkbox"/>	Purple	Compact tree - reportedly seedless	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Fraxinus americana 'Empire'	Empire Ash	50	25	Columnar	17900	5	<input type="checkbox"/>	Rusty Orange	Use for areas adjacent to taller buildings when ash is desired	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Fraxinus pennsylvanica 'Patmo	Patmore Ash	45	35	Oval	33700	5	<input type="checkbox"/>	Yellow	Extremely hardy, may be seedless.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Ginkgo biloba 'Autumn Gold'	Autumn Gold Gin	45	35	Pyramidal	33700	6	<input type="checkbox"/>	Yellow	Narrow when young	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Healesia monticola	Mountain Silverb	45	25		0	5	<input type="checkbox"/>	yellow	attractive, small white flower	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Koeleruteria paniculata	Goldenrain Tree	30	30		14100		<input checked="" type="checkbox"/>	Yellow	Midsummer blooming.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Liquidambar styraciflua 'Rotun	Rotundiloba Swe	45	25		17200	6	<input type="checkbox"/>	Purple orange	Only sweetgum that is entirely fruitless. Smooth rounded leaf	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Magnolia denudata	Yulan Magnolia	40	40		0	5	<input type="checkbox"/>		6" inch, fragrant, white blossoms in spring	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Metasequoia glyptostroboides	Dawn Redwood	50	25	Narrow	19625	6	<input type="checkbox"/>	Rusty	Fast growing deciduous conifer	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Nyssa sylvatica	Tupelo	60	20		18800	5	<input type="checkbox"/>	Apricot > bright red	Handsomely chunky bark.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Phellodendron amurense 'Mac	Macho Cork Tree	40	40		0	5	<input type="checkbox"/>	yellow	Male selection - fruitless - another good variety is 'His Majesty'	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
	Pinus nigra	Austrian Pine	45	25	Pyramidal	17200	6	<input type="checkbox"/>	Evergreen	Special site approval needed - fairly tolerant of heat, pollution, urban	<input type="checkbox"/>	<input type="checkbox"/>
	Pinus pinea	Italian Stone Pin	40	30	Pyramidal	21200	6	<input type="checkbox"/>	Evergreen	Special site approval needed	<input type="checkbox"/>	<input type="checkbox"/>
	Populus tremuloides	Quaking Aspen	50	30		0		<input type="checkbox"/>	yellow / orange		<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Pyrus calleryana 'Aristocrat'	Aristocrat Pear	40	30		21200	5	<input type="checkbox"/>	Red	Good branch angles - one of the tallest pears	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Quercus trainetto	Italian Oak	50	30	Oval	28300	6	<input type="checkbox"/>	Yellow-Brown	Drought resistant	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Quercus robur 'fastigiata'	Skyrocket Oak	40	15		17200	6	<input type="checkbox"/>	Yellow-brown	Columnar variety of oak.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Salix lasiandra	Pacific Willow	40	30		0		<input type="checkbox"/>	yellow		<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Sophora japonica 'Regent'	Japanese Pagod	50	40		0	6	<input type="checkbox"/>	yellow	can have trunk canker or twig blight	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Taxodium distichum	Bald Cypress	55	30	Pyramidal	31800	6	<input type="checkbox"/>	Rusty red	A deciduous conifer	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Taxodium distichum 'Mickelson	Shawnee Brave	55	20	Narrow/pyr.	14100	6	<input type="checkbox"/>	Orange/bronze	Deciduous conifer - tolerates city conditions	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Tilia americana 'Redmond'	Redmond Linden	45	30	Pyramidal	21200	8	<input type="checkbox"/>	Yellow	Pyramidal, needs water.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Tilia cordata 'Greenspire'	Greenspire Linde	40	30		21200	5	<input type="checkbox"/>	Yellowish	Symmetrical, pyramidal form.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Zelkova serrata 'Village Green'	Village Green Zel	40	38		34000	5	<input type="checkbox"/>	Rusty Red		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Medium / Small												
	Acer nigrum 'Green Column'	Green Column Bl	50	10		12600	5	<input type="checkbox"/>	Yellow to orange	Good close to buildings.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Acer platanoides 'Columnar'	Columnar Norwa	40	15		5300	5	<input type="checkbox"/>	Yellow	Good close to buildings.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Acer rubrum 'Bowhall'	Bowhall Maple	40	15		5300	5	<input type="checkbox"/>	Yellow orange		<input checked="" type="checkbox"/>	<input type="checkbox"/>

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Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
	Acer rubrum 'Karpick'	Karpick Maple	35-40	20		8800	5	<input type="checkbox"/>	Yellow to orange	May work under very high powerlines with arborist's approval.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Acer rubrum 'Scarsen'	Scarlet Sentinel	40	20		9400	5	<input type="checkbox"/>	Yellow orange		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Acer truncatum x A. platanoides	Norwegian Sun	35	25		12300		<input checked="" type="checkbox"/>	Yellow-orange/red	Limited use under wires	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Acer truncatum x A. platanoides	Pacific Sunset M	30	25		9800	5	<input checked="" type="checkbox"/>	Yellow-orange/red	Limited use under wires	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Alnus sinuata	Sitka Alder	40	25		0		<input type="checkbox"/>		Prefers a heavy moist soil - usually found above 3000' feet - can be	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Carpinus betulus	'Fastigiata' Pyra	35	15	Pyramidal	12300	5	<input type="checkbox"/>	Yellow	Broadens when older	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Cladrastis kentuckia	Yellowwood	40	40		0	5	<input type="checkbox"/>	yellow / orange	white flowers in spring, resembling wisteria flowers	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Cornus controversa 'June Snow	Giant Dogwood	40	30		0	5	<input type="checkbox"/>	red / orange	Large white flower clusters that appear in June	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Crataegus crus-galli 'Inermis'	Thornless Cocks	25	30		10600		<input checked="" type="checkbox"/>	Orange to scarlet	Red persistent fruit.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Crataegus phaenopyrum	Washington Haw	25	20		4700		<input checked="" type="checkbox"/>	Scarlet	Thorny.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Crataegus sukadoffii	Sukadoff's Hawth	30	25		0		<input type="checkbox"/>		Shorter spines than C. Douglasii	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Crataegus x lavalli	Lavalle Hawthorn	28	20		5600		<input checked="" type="checkbox"/>	Bronze	Thorns on younger trees.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Davidia involucreata	Dove Tree	40	30		0	5	<input type="checkbox"/>		large, unique white flowers in May	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Ginkgo biloba 'Princeton Sentry	Princeton Sentry	40	15	Columnar	5300	6	<input type="checkbox"/>	Yellow	Very narrow growth.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Halesia tetraptera	Carolina Silverbell	35	30	Irregular	0	5	<input type="checkbox"/>	Yellow	Attractive bark for seasonal interest	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Libocedrus decurrens	Incense Cedar	35	20	Pyramidal	7850	6	<input type="checkbox"/>	Evergreen	Special site approval needed	<input type="checkbox"/>	<input type="checkbox"/>

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	Liquidambar styraciflua	Moraine Sweetgum	40	20		9400	6	<input type="checkbox"/>	Yellow, orange/red	Light green foliage. More compact than other varieties	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Maackia amurensis	Amur Maackia	30	20		0	5	<input checked="" type="checkbox"/>	none	attractive bark and summer flowers - grows in tough conditions	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Magnolia 'Elizabeth'	Elizabeth Magnol	30	20		0	5	<input checked="" type="checkbox"/>		yellow flowers	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Magnolia 'Galaxy'	Galaxy Magnolia	35	25	pyramidal	0	5	<input checked="" type="checkbox"/>	yellow/brown	reddish-purple flowers in spring.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Magnolia grandiflora 'Victoria'	Victoria Evergreen	25	20		4700	5	<input checked="" type="checkbox"/>	Evergreen		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Magnolia Kobus	Wada's Memory	35	20	Round	7900	5	<input checked="" type="checkbox"/>	Brown	Does not flower well when young	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Ostrya virginiana	Ironwood	40	25		0	5	<input type="checkbox"/>	yellow	hop like fruit	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Parrotia persica	Persian Parrotia	30	20		6300	5	<input checked="" type="checkbox"/>	Yellow - orange red	Select or prune for single stem; can be multi-trunked.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Pinus densiflora 'Umbraculifera	Umbrella Pine	25	20	Oval	4810	8	<input checked="" type="checkbox"/>	Evergreen	Special site approval needed	<input type="checkbox"/>	<input type="checkbox"/>
	Prunus x yedoensis 'Akebono'	Akebono Flower	25	25		7400	6	<input checked="" type="checkbox"/>	Yellow		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Pterocarya hispidula	Fragrant Epaulett	40	30		0	5	<input type="checkbox"/>	yellow / brown	Pendulous creamy white flowers - fragrant	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Pyrus calleryana 'Cambridge'	Cambridge Pear	40	15	Pyramidal	5300	5	<input type="checkbox"/>	Reddish purple	Narrow tree with good branch angles and form	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Pyrus calleryana 'Glen's Form'	Chanticleer or Cl	40	15		5300	5	<input type="checkbox"/>	Scarlet	Vigorous.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Pyrus calleryana 'Redspire'	Redspire Pear	35	25		12300		<input type="checkbox"/>	Yellow to red	Pyramidal.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Quercus 'Crimschmidt'	Crimson Spire O	45	15		6200		<input type="checkbox"/>		Hard to find.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	Robinia x ambigua	Pink Idaho Locust	35	25		12300	5	<input type="checkbox"/>	Yellow	Fragrant flowers.	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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Group	Botanical Name	Common Name	Height	Spread	Shape	Volume	Strip Width	Wires	Fall Color	Comments	Street Tree	Native Tree
	<i>Sciadopitys verticillata</i>	Japanese Umbrel	30	20	Pyramidal	6300	8	✓	Evergreen	Grows slowly - pristine evergreen foliage - special site approval	<input type="checkbox"/>	<input type="checkbox"/>
	<i>Sorbus alnifolia</i>	Korean Mountain	40	30		0	5	<input type="checkbox"/>	orange	Simple leaves. Beautiful pink-red fruit - may be short lived	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Sorbus aucuparia</i> 'Mitchred'	Cardinal Royal M	35	20		7900	5	✓	Rust	Bright red berries.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Sorbus x hybrida</i>	Oakleaf Royal Mt	30	20		6300	5	✓	Rust		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Stewartia monodelpha</i>	Orange Bark Ste	30	20		0	5	✓	orange	orange peeling bark - white flowers in spring	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Taxus brevifolia</i>	Pacific Yew	40	25		0		<input type="checkbox"/>	Evergreen	typically occurs as an understory tree 3-5 m tall west of the Cascades	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<i>Tilia cordata</i> 'De Groof'	De Groot Littlelea	30	20		6300	5	✓	Yellow	Compact, suckers less than other Lindens.	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	<i>Tilia cordata</i> 'Chancellor'	Chancellor Linden	35	20		7900	5	<input type="checkbox"/>	Yellow	Pyramidal.	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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