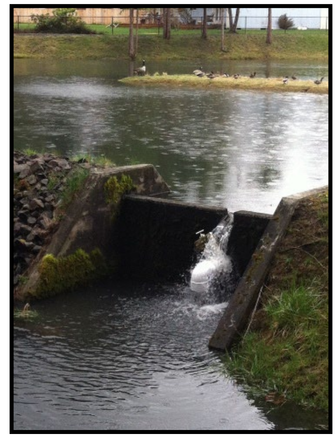
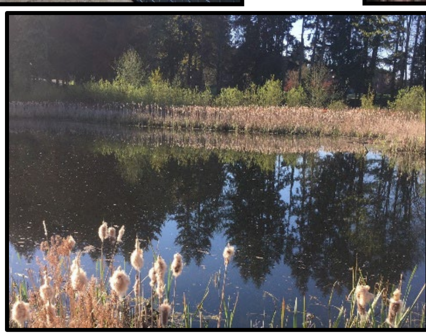
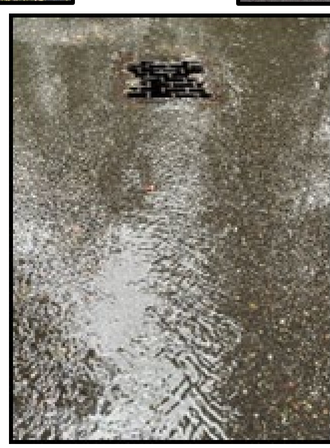
City of Lacey
2022 Stormwater Design Manual

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City of Lacey
2022 Stormwater Design Manual

Effective June 30, 2022

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Primary References

Washington State Department of Ecology,
2019 Stormwater Management Manual for Western Washington
Pierce County, *Stormwater Management and Site Development Manual*, 2021
Low Impact Development Technical Guidance Manual for Puget Sound, 2012

Table of Contents

Chapter 1 – Overview and Definitions

Table of Contents

Chapter 1 – Overview and Definitions

1.1 Background and Authority

This City of Lacey 2022 Stormwater Design Manual (SDM or "this manual") is a revised and updated replacement for the 2016 SDM. This 2022 SDM is based on the Washington State Department of Ecology *2019 Stormwater Management Manual for Western Washington* (2019 Ecology Manual). In creating this 2022 SDM, the City of Lacey Department of Public Works has retained the chapter format of the 2016 SDM, which is a reorganized version of the Ecology Manual. The reader is referred to the 2019 Ecology Manual for further background information and supporting details available on Ecology's website at: <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals>.

The City is required to regulate stormwater discharges to its municipal separate storm sewer system (MS4) and to waters of the state, in compliance with the Western Washington Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. Under the NPDES Municipal Stormwater Permit, the City must establish and apply the minimum requirements specified in the permit and provide design guidance for stormwater quality and quantity control for new development and redevelopment projects in the City. Through this manual, the City is complying with the Clean Water Act and the NPDES Municipal Stormwater Permit. Where requirements in this manual are also covered in any other law, ordinance, resolution, rule, or regulation of any kind the more restrictive law shall govern.

The SDM applies to virtually all land-disturbing activity, construction, new development, or redevelopment projects in the City. This manual has been adopted by local ordinance (Chapter 14.27 Lacey Municipal Code [LMC]) and has force of law. Failure to comply may trigger administrative or enforcement action, and result in project delays, fines, or penalties. For the purposes of interpreting and using this manual, the words "shall," "will," and "must" are always mandatory; the word "should" is situation-specific and not necessarily mandatory but strongly encouraged; and "may" is situation-specific and permissive. The City of Lacey Stormwater Design Manual Administrator (SDM Administrator) is authorized to determine if situation-specific requirements are applicable to any particular project.

The SDM Administrator is also authorized to request information or to impose requirements beyond those specified in this manual, which may occur for various reasons including but not limited to:

- To protect public safety, health, and welfare
- To prevent flooding, erosion, endangerment to property, habitat destruction, or water quality degradation
- To implement regulatory mandates such as a total maximum daily load (TMDL)

- To protect uninterruptible services
- To implement increases in requirements imposed by state or federal agencies or other pertinent factors
- To clarify, correct, augment, or update information in this manual

1.2 Objective

The objective of this manual is to provide guidance and requirements 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. Water quality standards include:

- Chapter 173-200 of the Washington Administrative Code (WAC), Water Quality Standards for Groundwaters 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 the minimum “core requirements” for stormwater control and site development requirements for all new development and redevelopment in the City and applies to all sites as detailed in Chapter 2 – Applicability and Core Requirements, and Chapter 3 – Stormwater Submittals. The core requirements outlined in Chapter 2 are based on the “Minimum Requirements” outlined in the 2019 Ecology Manual, but have been adapted for use in the City. Stormwater management requirements are satisfied by the application of best management practices (BMPs) identified in this manual, when they are selected and designed according to the procedures and criteria specified in this manual.

The requirements of this manual are applicable to all types of public and private land development projects in the City—including residential, commercial, industrial, and road projects. Stormwater management for road projects shall meet all the core requirements stated in this manual, although federally-funded road projects may be required (per Washington State Department of Transportation [WSDOT] Local Agency Guidelines) to design to WSDOT Highway Runoff Manual (HRM) standards, at a minimum. In this case, the more stringent stormwater requirements of this manual or the WSDOT HRM shall apply.

The intent and purpose of this manual is to:

- Establish criteria for submittal, review, and analysis of all development and other site-altering work
- Manage stormwater to minimize contact with contaminants

- Mitigate the impacts of increased runoff due to urbanization
- Manage runoff from developed property and property being developed
- Protect the health, safety, and welfare of the public

This manual is not intended to preclude alternative engineering solutions to design situations. It is expected that the professional engineer will bring to each project the best of their skills and abilities to see that the project is thoroughly analyzed and designed correctly, accurately, and in compliance with generally accepted engineering practices. Alternatives to the standard plans, specifications, and design details found in this manual may be accepted if they meet or exceed the performance of this manual's standards as determined by the City. Engineers are encouraged to be innovative; however, the burden of proof is on the engineer to document that their innovations meet or exceed the performance of the standards outlined in this manual.

This manual is based on the premise that development and redevelopment shall not negatively impact adjacent and/or downstream property owners nor degrade groundwater or the natural drainage system, including but not limited to streams, ravines, wetlands, potholes, and rivers. Further, development activities shall not impact adjacent and/or downstream property owners in a detrimental manner compared to the predeveloped condition. It is not the intent of this manual to make the City a guarantor or protector of public or private property with regard to land development activities.

1.3 Organization of this Manual

1.3.1 Overview of Manual Content

To accomplish the objective described in Section 1.2, this manual includes the following:

- **Core requirements** that cover a range of issues, such as submittal requirements, 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 core 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 core requirements. BMPs are 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. BMPs are divided into three groups: implementation of LID site design principles (Chapter 4, Section 4.3), short-term control of stormwater from construction sites (Chapter 5), and long-term management of stormwater at developed sites. Long-term BMPs are further subdivided into those covering flow control to manage the volume and timing of stormwater flows (Chapter 7), runoff treatment to remove sediment and other pollutants (Chapter 8), and source control to prevent pollution from potential sources (Chapter 9).

- **Requirements for preparing stormwater submittals**. Chapter 3 of this manual covers City stormwater-related submittals that may be required depending on the nature of the project or site characteristics.

1.3.2 Organization of this Manual

This manual is organized into ten chapters, briefly described below. See the subsections of each individual chapter for additional details on the contents of each chapter.

- **Chapter 2** presents the stormwater management core requirements (equivalent to the Ecology Manual's minimum requirements) for new development and redevelopment, information on any additional requirements, the project types and thresholds that trigger the various requirements, and information relating to exceptions and variances from these requirements.

- **Chapter 3** outlines the submittal requirements related to stormwater drainage reviews, including information on site assessment requirements, and submittal documentation requirement for various types of project submittals.

- **Chapter 4** describes the process for selecting BMPs for runoff treatment and flow control, in accordance with the core requirements, and includes LID site design BMPs for preserving native vegetation, restoring site vegetation, reducing effective impervious area, and improving site design.

- **Chapter 5** details the erosion and sediment control requirements and BMPs to be implemented during the construction phase of development projects.

- **Chapter 6** presents the hydraulic and hydrologic analytical methods to be used in developing the drainage design.

- **Chapter 7** addresses selection and design of BMPs intended to meet flow control requirements.

- **Chapter 8** addresses selection and design of BMPs intended to meet runoff treatment requirements.

- **Chapter 9** is devoted to source control of pollution and pollution prevention.

- **Chapter 10** describes the stormwater BMP maintenance process and standards.

- **Appendices** to the chapters contain definitions, forms, checklists, maps, additional technical guidance, and other information relevant to the chapters and to the application of the core requirements.

- **Glossary** – Chapter 1 concludes with a glossary of terms.

1.4 Site Planning and Layout

The design professional is required to address the issue of stormwater management, both quantity and quality, in the early phases of the site planning process. Consideration of the natural characteristics of a site during the initial stages of project planning will help facilitate the site layout and drainage design. Existing topography, soils, vegetation, and drainage patterns can have a significant effect on the site drainage, and must be considered in designing the site and stormwater systems. Smart site planning and stormwater design includes adapting to a site's inherent characteristics rather than ignoring or working against them.

The approach to considering and minimizing stormwater impacts at the site layout stage is commonly referred to as low-impact development (LID). As described in Section 1.5.2, LID emphasizes protection and use of on-site natural features integrated with small-scale hydrologic controls to manage stormwater and simulate predevelopment watershed hydrologic functions. This is achieved by recognizing and focusing on the relationship among the overland and subsurface flow, infiltration, storage, and evapotranspiration characteristics of the site. LID strategies focus on evaporating, transpiring, and infiltrating stormwater on site through native or amended soils, vegetation, and bioengineering applications to reduce and treat overland flow.

Two primary site design strategies shall be considered in developing the site layout and stormwater drainage systems:

1. **Manage stormwater on site.** As stated in Chapter 2 under Core Requirement #5, one of this manual's main stormwater requirements is to employ on-site stormwater management BMPs to infiltrate, disperse, and retain stormwater runoff on site to the maximum extent feasible. This applies during construction (with temporary BMPs) and after development (with permanent BMPs). On an undeveloped (natural) site, stormwater is "managed" near where it falls, mainly by soaking into the ground and by plant interception. Through LID and on-site stormwater management, this approach can be applied on the developed site as well. Preserve large trees and native soils on site to the maximum extent possible. Determine if infiltration is feasible anywhere on the site, and if so, design the site layout to utilize well-drained soils. Keep stormwater dispersed and spread out as much as possible, and use small-scale LID drainage systems, rather than concentrating flows in larger common facilities.

2. **Minimize stormwater runoff by minimizing vegetation loss and reducing effective impervious areas.** This can be accomplished by using smart site design and use of a site's natural features. Site planning and layout strategies include: minimizing the use of impervious areas as much as possible (e.g., roofs; and non-permeable roadways, sidewalks, and parking), clustering buildings and preserving larger areas of open space; minimizing directly connected impervious areas (try to separate impervious surfaces and prevent runoff from concentrating by

disconnecting them and draining impervious surfaces overland to pervious areas); incorporating low maintenance landscaping that does not need frequent applications of fertilizers, herbicides, and pesticides; and minimizing the impact area and soil compaction during construction.

Additional details on LID approaches and requirements in the City are outlined in Chapters 2, 4, and 7.

1.5 Development of BMPs for Stormwater Management

1.5.1 Best Management Practices (BMPs)

BMPs are activities, restrictions, or constructed stormwater facilities that, when used singly or in combination, prevent or reduce the release of pollutants and other adverse impacts to waters of Washington. The types of BMPs include source control, runoff treatment, flow control, and LID (also referred to as on-site stormwater management BMPs). BMPs that involve construction of engineered structures are often referred to as facilities in this manual. For instance, the BMPs referenced in the runoff treatment menus in Chapter 8 are called runoff treatment BMPs.

The primary purpose of using BMPs is to protect beneficial uses of water resources through the reduction of pollutant loads and concentrations, 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 prescribed in this manual, beneficial uses are still threatened or impaired, additional controls may be required.

1.5.2 Low Impact Development BMPs (Chapters 4 and 7)

LID is 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. Certain on-site stormwater management BMPs and LID techniques are required as part of Core Requirement #5 (see Chapter 2), with additional techniques available to supplement or replace traditional stormwater approaches. Chapter 4 presents LID site design BMPs and Chapter 7 presents design guidelines for several of the most common on-site stormwater management (i.e., LID) BMPs. Given the evolving nature of LID approaches, the design standards for these BMPs may change before the next update to this manual. Users should check with the City and/or refer to the City’s website for any updates to the design criteria.

1.5.3 Construction Stormwater BMPs (Chapter 5)

Construction stormwater BMPs can provide source control, runoff treatment, or flow control during site construction. Examples include stabilized construction entrances, silt fences, check dams, and sediment traps. Chapter 5 contains construction stormwater BMPs.

1.5.4 Flow Control BMPs (Chapter 7)

Flow control BMPs typically control the volume, rate, frequency, and duration of stormwater surface runoff. The need to provide flow control BMPs depends on where the development site runoff is discharged to – e.g., a stream system, wetland, or closed depression—either directly or indirectly.

Construction of an infiltration facility is the preferred option for on-site flow control, but is feasible only where more permeable soils are available. Construction of a detention pond with controlled release is a common means of meeting flow control requirements when infiltration is not adequate.

Previous versions of the City and Ecology stormwater design guidelines and requirements (2005 and earlier) 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 predeveloped 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 will require significantly larger detention ponds than earlier City standards. The required size of a detention pond can be reduced by changing the extent of disturbance on a site. In addition, engineers and designers are encouraged to look for means to improve or restore natural conditions to complement, or to serve in lieu of, traditional flow control measures. The on-site stormwater management BMPs presented in Chapters 4, 7, and 8 will help accomplish this goal. See also Section 1.5.2.

1.5.5 Runoff Treatment BMPs (Chapter 8)

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

1.5.6 Source Control BMPs (Chapter 9)

Source control BMPs typically prevent pollution, or other adverse effects of stormwater, from occurring at a developed site (source control during construction activities is addressed by the construction BMPs in Chapter 5). Source control BMPs are classified 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 flow 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.

1.6 Maintenance of Stormwater Best Management Practices

The importance of maintenance for the proper functioning of stormwater control facilities cannot be overemphasized. Maintenance is crucial to performance of runoff treatment and flow control BMPs. A substantial portion of failures (clogging of filters, resuspension of sediments, loss of storage capacity, etc.) of such facilities results from inadequate maintenance. In addition, maintenance must be a basic consideration in design and in determination of cost. Therefore, provisions to facilitate maintenance operations must be built into the project when a BMP is installed.

Likewise, for both private and public facilities, it is important to include maintenance personnel early and throughout the design process. During discussions with maintenance personnel, describe the maintenance procedures that will need to be performed on the BMP. This will help ensure that future maintenance work and potential access needs are clearly understood.

The description of each BMP in subsequent chapters includes a brief section on facility maintenance. Chapter 3 outlines the specific elements to be addressed in the Maintenance and Source Control Manual, which is a required project submittal. Chapter 10 includes additional information on stormwater maintenance, including a detailed checklist of maintenance requirements for all drainage facilities.

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

This section describes some of the local, state, and federal regulations and permits that may apply to your project, depending on the nature of the project and site characteristics. City staff are available to help in determining which permits apply and in helping project applicants through the permitting process.

The City's website has information on the City's permitting process, including online permit information: <https://cityoflacey.org>. Permit information can also be obtained by calling the Community Development Department at (360) 491-5642.

The Joint Aquatic Resources Permit Application (JARPA) is another resource that can help to streamline the environmental permitting process. As noted in the following sections, several of the permits described in this section are included in the JARPA, so they can be covered under a single permit application. Refer to the Access Washington, one-stop e-permitting website for more information: <https://www.epermitting.wa.gov/site/alias__resourcecenter/9978/default.aspx>.

1.7.1 The Manual's Role as Technical Guidance and Requirements

This manual is to be used for identifying, selecting, and designing BMPs and completing submittal requirements to comply with City permits. The requirements of this manual apply to all areas of the City. These requirements also apply to cross-jurisdictional projects (e.g., county, state, or federal government entity) located totally, or in part, within the City, unless one of the following applies:

- Activity is exempted from submittal requirements (see Chapter 2, Section 2.1.3).
- Development/redevelopment and stormwater activities are conducted in accordance with a functionally equivalent stormwater management manual (e.g., WSDOT HRM or Pierce County Stormwater Management Manual and Site Development Manual).

This manual provides 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 groundwater). 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; Revised Code of Washington [RCW] 90.52.040 and RCW 90.48.010).

The state 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 and to protect groundwater that is used for public drinking water supplies. The state 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 WAC, Sediment Management Standards. However, compliance with the standards in this manual does not necessarily mitigate all probable and significant environmental impacts to aquatic biota. Thus, compliance with this manual should not be construed as mitigating all probable and significant stormwater impacts on aquatic biota in streams and wetlands; additional mitigation may be required.

In addition, this manual presents the City's minimum standards for planning and engineering for stormwater management. While the city believes these standards are appropriate for a wide range of development proposals, compliance solely with these requirements does not relieve the professional submitting stormwater plans of his or her responsibility to ensure drainage facilities provide adequate protection for natural resources and public and private property.

Severability

If any provisions of this manual, or their application to any person or property are amended or held to be invalid, the remainder of the provisions in this manual in their application to other persons or circumstances shall not be affected.

Penalties and Enforcement

Penalties and enforcement shall be per Chapter 14.27 LMC.

Appeals

Appeals shall be handled per Chapter 14.27 LMC.

1.7.2 More Stringent Measures

Other stormwater or water quality regulations—such as TMDLs or water cleanup plans—may identify more stringent measures needed to restore water quality in an impaired water body. For more information, see Chapter 8, Section 8.3.5, as well as the Ecology website: <https://ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Total-Maximum-Daily-Load-process>.

1.7.3 Retrofitting

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 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 such instances, the BMPs presented here can be modified using best professional judgment to provide reasonable improvements in stormwater management.

1.7.4 Presumptive Versus Demonstrative Approaches to Protecting Water Quality

Wherever a discharge permit or other water-quality-based project approval is required, project applicants 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 that supports the performance claims for the selected BMPs; and an assessment of how the selected BMP will comply with federal technology-based treatment requirements and state water quality standards, and will satisfy "all known available and reasonable methods by industries and others to prevent and control the pollution of the waters of the State of Washington." This statutory requirement is generally known by the acronym AKART.

The BMPs presented in this manual are approved by the city and are *presumed* to protect water quality and instream habitat—and meet the stated environmental objectives of the regulations described in this chapter— with the exception of deep UICs. Requirements and guidance specific to UICs and deep UICs is provided in Chapter 7, Appendix 7C. Project applicants always have the option of not following the stormwater management practices in this manual. However, if a project applicant chooses not to follow the practices in the manual, then the project applicant will 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. Project applicants interested in pursuing the demonstrative approach should contact the City of Lacey Department of Public Works early in the process.

If a project applicant wants to follow the demonstrative approach for a runoff treatment BMP, the 2019 Ecology Manual and Ecology website have more information on setting up an approved water quality monitoring plan to demonstrate that a project will protect water quality and satisfy state and federal laws. Additional city requirements will also apply. Contact the SDM Administrator for additional information.

1.7.5 Phase II – 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 (U.S. EPA) Phase II 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 certain medium- and large-sized cities and counties, including the City of Lacey.

The Western Washington NPDES Phase II Municipal Stormwater Permit was reissued on July 1, 2019 and is available on the Ecology website: <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Municipal-stormwater-general-permits/Western-Washington-Phase-II-Municipal-Stormwater>.

1.7.6 Industrial Stormwater General Permit

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 BMPs, including those BMPs identified as "required," for specific industrial activities in Chapters 8 and 9 of 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 BMPs for on-site pollution control.

Ecology's Industrial Stormwater web page <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Industrial-stormwater-permit> has a fill-in-the-blank Industrial SWPPP template for use by industrial facilities.

1.7.7 Construction Stormwater General Permit

Coverage under Ecology's Construction Stormwater General Permit (CSWGP) is generally required for any clearing, grading, or excavating if the project site:

- Discharges stormwater from the site into surface water(s) of the state, or
- Discharges into storm drainage systems that discharge to a surface water(s) of the state. "Surface waters of the state" are broadly defined by state law and include storm drains, ditches, wetlands, creeks, rivers, lakes, and marine waters.

And:

- Disturbs 1 or more acres of land area, or
- Disturbs less than 1 acre of land area, if the project or activity is part of a larger common plan of development or sale.

Any construction activity discharging stormwater that Ecology and/or the city 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 agencies.

The CSWGP 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 requirements for sedimentation and erosion control (Core Requirement #2) in Chapter 2 of this manual. Developers must file a Notice of Intent with Ecology and develop a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) prior to beginning construction. It is the responsibility of the project applicant to contact Ecology to determine if these or other requirements apply to their project. However, to minimize review time and effort by both the project applicant and the city, the Construction SWPPP required by the city has been structured to be consistent with Ecology's Construction SWPPP requirements.

The permit also requires construction sites within western Washington to implement stormwater BMPs contained in stormwater management manuals published or approved by Ecology, or BMPs that are demonstrably equivalent. Chapter 5 of this manual further describes the requirements and BMPs appropriate for managing construction site stormwater.

1.7.8 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 (ESA) affects many aspects of stormwater management. For example, the Mazama pocket gopher is another ESA-listed species that may affect projects in Lacey and the Lacey Urban Growth Area (UGA). Provisions of the ESA that can apply to stormwater management include the Section 4(d) rules, Section 7 consultations, and Section 10 Habitat Conservation Plans (HCPs).

The ESA can be of particular concern for construction sites because of potential adverse impacts from discharges of sediment, turbidity, or abnormal pH. Specific adverse impacts include:

- Suffocation of eggs or fry
- Displacement and elimination of aquatic invertebrates used for food
- Reduction in the biodiversity of aquatic invertebrates
- Reduction of foraging abilities in turbid water
- Irritation of gill tissue that can lead to disease or death
- 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 Oceanic and Atmospheric Administration Fisheries Service at: <https://www.fisheries.noaa.gov/topic/laws-policies#endangered-species-act> and the U.S. Fish and Wildlife Service at: <www.fws.gov/endangered/>.

1.7.9 Section 401 Water Quality Certifications (included in JARPA)

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 of Section 401 of the Clean Water Act. In order to make such a determination and issue a Section 401 Water Quality

Certification, 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 core requirements in this manual, or more stringent requirements.

1.7.10 Hydraulic Project Approvals (included in JARPA)

Under Chapter 77.55 RCW, the Hydraulics Act, the Washington Department of Fish and Wildlife (WDFW) 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 hydraulic project approval (HPA) permit. In exercising this authority, WDFW may require application of the core requirements in this manual, or more stringent requirements.

1.7.11 Aquatic Lands Use Authorizations (included in JARPA)

The Washington State Department of Natural Resources (WDNR), 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 79.90 through 96, Chapter 79.105-79.140 RCW, and in accordance with Chapter 332-30 WAC, WDNR may require application of the core requirements in this manual, or more stringent requirements.

1.7.12 Requirements Identified through Watershed or Basin Planning

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. In accordance with the Watershed Management Act (Chapter 90.82 RCW) or the basin planning option per Chapter 400-12 WAC, the state allows the City of Lacey to initiate its own watershed/basin planning processes to identify more stringent or alternative requirements. 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, 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.

1.7.13 Underground Injection Control – UIC Program

One of the provisions of the Safe Drinking Water Act is to protect underground sources of drinking water (USDW)). In 1984, Ecology received authority from the U.S. EPA to administer the Underground Injection Control (UIC) Program to protect USDW by regulating the discharges of fluids into the subsurface by UIC wells.

Ecology has adopted Chapter 173-218 WAC to implement the program; however, the UIC program rule protects all groundwater, not just USDW. The U.S. EPA organizes UIC wells into six classes. The Washington UIC program regulates Class I through Class V UIC wells, except for wells located on tribal land. UIC wells used to manage stormwater are considered Class V wells. For more information, visit Ecology's home page for the UIC program <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program> and "Guidance for UIC Wells that Manage Stormwater".

The UIC program has two requirements:

1. A non-endangerment performance standard must be met, prohibiting discharges that allow movement of fluids containing contaminants to reach groundwater.

2. All UIC facility owners/operators must complete online UIC well registration with Ecology.

The UIC program defines a UIC well as a well that is used to discharge fluids from the ground surface into the subsurface and is one of the following:

1. A bored, drilled, or driven shaft, or

2. A dug hole whose depth is greater than the largest surface dimension, or

3. An improved sinkhole; which is a natural crevice that has been modified, or

4. A subsurface fluid distribution system which contains perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground.

Examples of UIC wells or subsurface infiltration systems are the following:

- Drywells
- Drainfields
- Infiltration trenches with perforated pipe
- Storm chamber systems with the intent to infiltrate
- French drains
- Bioretention systems intending to infiltrate water from a perforated pipe below the treatment soil

Other similar devices that discharge into the ground

The following are not UIC wells:

- Buried pipe and/or tile networks that serve to collect water and discharge that water to a drainage system or to a receiving water

- Surface infiltration basins and flow dispersion stormwater facilities
- Infiltration trenches designed without perforated pipe or a similar mechanism
- Bioretention systems transporting water via a perforated pipe to a drainage system or to a receiving water

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. **UIC wells are required to be registered with Ecology** with the exception of UIC wells at single-family homes (or duplexes) that receive only residential roof runoff or for basement flooding control (WAC 173-218-070 (1)(e). The UIC rule (Chapter 173-218 WAC) applies to all Class V UIC wells that receive stormwater discharges. These wells must be sited, designed, constructed, managed, operated, and maintained according to the requirements throughout Chapter 7, Appendix 7C -Underground Injection Control (UIC) Program Guidelines.

If all stormwater runoff from the project site discharges to a Class V UIC well, the Municipal Stormwater Permits do not pertain to the project, and the Minimum Requirements do not apply. The UIC rule (Chapter 173-218 WAC) applies in such cases. See Chapter 7, Appendix 7C – Underground Injection Control (UIC) Program Guidelines for details on the rules, registration requirements, regulations, non-endangerment standard, treatment requirements and operation guidelines.

This manual represents several BMPs to infiltrate stormwater. Additional information on underground injection control and how it applies to infiltration and stormwater management is included in Chapter 7 and Appendix 7C. For more information and for a listing on potential stormwater facilities that may have Class V classification, refer to the UIC Program available at Ecology's website:

<https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program>

Chapter 1 References

Novotny, V., and H. Olem. 1994. *Water Quality: Prevention, Identification, and Management of Diffuse Pollution*. Van Nostrand-Reinhold, New York, New York.

Washington State Department of Ecology (Ecology). 2019. *Stormwater Management Manual for Western Washington*. Publication Number 19-10-021. July.

Glossary and Abbreviations

Glossary

The following terms are provided for reference and use with this manual. They may be superseded by any other definitions for these terms adopted by City ordinance, unless the terms match the definitions provided by a Washington State WAC or RCW.

Term	Definition
2019 Ecology Manual	See Stormwater Management Manual for Western Washington.
Absorption	The penetration of a substance into or through another, such as the dissolving of a soluble gas in a liquid.
Adjustment	A variation in the application of a core requirement to a particular project. Adjustments provide substantially equivalent environmental protection.
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.
AKART	All known, available, and reasonable methods of treatment, prevention, and control. Under the NPDES Municipal Stormwater Permit, jurisdictions are to use AKART to prevent and control pollution of waters of the state of Washington. See also the State Water Pollution Control Act, Chapter 90.48.010 and 90.48.520 RCW.
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 Association of State Highway and Transportation Officials (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.
American Public Works Association (APWA)	The Washington State Chapter of the American Public Works Association.

Term	Definition
Anti-Seep Collar (or Device)	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.
Applicable BMPs	As used in this manual and in Volume IV of the 2019 Ecology Manual, 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 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 groundwater that can be withdrawn and used for human purposes.
Arterial	A road or street primarily for through traffic. Generally, 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, and a local access road connects individual properties to a collector.
As-Built Drawings	As-constructed engineering plans that include all changes made to a project during construction and submitted to the city. All drawing changes shall be made by a professional engineer or land surveyor. Also referred to as record drawings.
Assessed Value	The value of the existing improvements excluding land as listed in current records at the Thurston County Assessor's Office. Alternately, the applicant may provide current appraisal information and request that it be substituted for the Assessor's records.
Average Daily Traffic	Means the general unit of measurement for traffic defined as the total volume during a given time period (in whole days) greater than 1 day and less than 1 year divided by the number of days in that time period.
Average Annual Daily Traffic (AADT)	A measurement representing the total number of vehicles passing a given location, based upon 24-hour counts taken over an entire year. Mechanical counts are adjusted to an estimate of annual average daily traffic figures, taking into account seasonal variance, weekly changes, and other variables.
Backwater	Water upstream from an obstruction that is deeper than it would normally be without the obstruction.
Baffle	A device to check, deflect, or regulate flow.
Base Flow	The portion of stream discharge that is from groundwater seeping into the stream.
Basin	An area from which surface runoff is concentrated, usually to a single point such as the mouth of a stream.

Term	Definition
Basin Plan	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: • 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.
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.
Berm	A constructed barrier typically made of compacted earth, rock, or gravel. In a stormwater facility, a berm may serve as a vertical divider and is 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.
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 with vegetation or in combination with natural and synthetic construction materials.
Biofilter	A designed runoff treatment BMP using a combined soil and vegetation system for filtration, infiltration, adsorption, and biological uptake of pollutants in stormwater when runoff flows over and through the facility. Vegetation growing in these BMPs acts as both a physical filter, which causes gravity settling of particulates by regulating velocity of flow, and 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.

Term	Definition
Biofiltration	The process of reducing pollutant concentrations in water by filtering the polluted water through biological materials.
Bioretention Areas	Small-scale, shallow retention/detention facilities dispersed through the development site that utilize specific soil mixes and plant species to infiltrate and filter runoff from developed sites.
Bioretention BMP	Engineered BMPs that store and treat stormwater by passing it through a specified soil profile, and either retain or detain the treated stormwater for flow attenuation. See Chapter 7, Section 7.4.4 for bioretention BMP types and design specifications.
Biosolids	Municipal sewage sludge that is a primarily organic, semisolid product resulting from the wastewater treatment process that can be beneficially recycled and meets all applicable requirements under Chapter 173-308 WAC. Biosolids includes a material derived from biosolids and septic tank sludge, also known as septage, that can be beneficially recycled and meets all applicable requirements under Chapter 173-308 WAC. For the purposes of Chapter 173-308 WAC, semisolid products include biosolids or products derived from biosolids ranging in character from mostly liquid to fully dried solids.
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 all City of Lacey 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.
Catch Basin	An inlet box set into the ground, usually rectangular and made of concrete, with a sump in the bottom to catch sediment, and capped with a grate that allows stormwater to enter. Usually set at the curb line of a street, to admit surface runoff water to a sewer or subdrain.
Catch Line	The point where a steeper slope intercepts a different, gentler slope.
Catchment	Surface drainage area or basin.
Cation Exchange Capacity (CEC)	Cations are positively charged ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), and potassium (K^{+}), sodium (Na^{+}) hydrogen (H^{+}), aluminum (Al^{3+}), iron (Fe^{2+}), manganese (Mn^{2+}), zinc (Zn^{2+}) and copper (Cu^{2+}). The capacity of the soil to hold on to these cations called the cation exchange capacity (CEC). Units are milliequivalents per 100 grams of soil, typically abbreviated as meq.

Term	Definition
Certification	Means a written engineering opinion, stamped, signed, and dated by an engineer, concerning the progress or completion of work.
Certified Erosion and Sediment Control Lead (CESCL)	An individual who has current certification through an approved erosion and sediment control training program that meets the minimum training standards established by Ecology (see BMP C160 in the 2019 Ecology Manual). A CESCL is knowledgeable in the principles and practices of erosion and sediment control. A 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.
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/groundwater and have existed long enough to establish a stable route and/or biological community.
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 channel or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment.
Civil Engineer	See Professional Engineer.
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 humankind.
Clearing	The destruction and/or removal of vegetation by manual, mechanical, or chemical methods.
Closed Depression	An area that 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, non-spore-forming, rod-shaped bacteria that ferment lactose with gas formation within 48 hours at 35 degrees Celsius. 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 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.

Term	Definition
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.
Compost	Organic material that has undergone biological degradation and transformation under controlled conditions designed to promote aerobic decomposition at a solid waste facility in compliance with the requirements of Chapter 173-350 WAC, or biosolids composted in compliance with Chapter 173-308 WAC. Composting is a form of organic material recycling. Natural decay of organic solid waste under uncontrolled conditions does not result in composted material. (Note: Various BMPs have restrictions on the percentage of biosolids in compost, or do not allow biosolids in compost.)
Composted Material	Organic solid waste that has undergone biological degradation and transformation under controlled conditions designed to promote aerobic decomposition at a solid waste facility in compliance with the requirements of Chapter 173-350 WAC. Composting is a form of organic material recycling. Natural decay of organic solid waste under controlled conditions does not result in composted material.
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	A wetland intentionally created on non-wetland areas for the primary purpose of stormwater treatment and managed as such. Constructed wetlands are normally considered as part of the stormwater collection and treatment system and are subject to maintenance requirements. (These wetlands are not the same as wetlands created for mitigation purposes, which are viewed in the same manner as natural, regulated wetlands.)
Construction Stormwater Pollution Prevention Plan (SWPPP)	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.
Control Structure	A manhole or similar structure with an orifice or weir to control ponding depth and discharge flow rate from a detention facility.
Converted Vegetation Areas	The surfaces on a project site where native vegetation, pasture, scrub/shrub, or unmaintained nonnative 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 but not limited to, pipes, ditches, and channels.

Term	Definition
Conveyance System	The drainage BMPs/facilities, both natural and constructed, that 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 BMPs.
Cover	The depth of soil, rock, and paving materials over a utility pipe, vault or structure. The vertical distance between finished grade and the top of the pipe or structure.
Critical Areas	At a minimum, areas that 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 Tree Root Zone	The area surrounding a tree trunk where the roots of the tree should not be disturbed. The radius of the area is usually based on the trunk diameter at breast height and tree species.
CULD	Conditional Use Level Designation, a mid-level approval designation by Ecology for the assessment of new runoff treatment technologies. CULD allows use of a manufactured treatment system during its field testing period, subject to specific conditions.
Culvert	Pipe or concrete box structure that drains open channels, swales, or ditches under a roadway or embankment. Typically has no catch basins 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 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.
Cut and Fill	Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.
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)	Setting aside land for a specific use or function. More specifically, the deliberate appropriation of land by an owner for any general and public uses, reserving to him- or herself no other rights than such as are compatible with the full exercise and enjoyment of the public uses to which the property has been devoted. The intention to dedicate land within a subdivision or short subdivision shall be evidenced by the owner by the presenting for filing a final plat or short plat showing the dedication thereon; and the acceptance by the public shall be evidenced by the approval of such plat for filing by the appropriate governmental unit. See RCW 58.17.020(3).

Term	Definition
Degradation	The breakdown (biological or chemical) 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. The (geological) wearing down by erosion. 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.
Design Engineer	The professional civil engineer licensed in Washington State who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.
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 recurrence interval storm can be expected to occur on the average once every 10 years. Conveyances designed to handle flows that occur under such storm conditions would be expected to be surcharged by any storms of greater amount or intensity.
Design Storm (Design Event)	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.)
Design Year Average Daily Traffic	The planned average daily traffic 5 years after the road is scheduled to be built.
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 (detained) in temporary storage.
Detention BMP	An above or below ground BMP, 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 BMP system. There is little or no infiltration of stored stormwater.
Detention Pond	A detention BMP in the form of an open pond.
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).
Developer	The person or legal entity who holds title to the property or has a sufficient interest in the project to propose the project. The developer of the project.
Development	New development, redevelopment, or both. See definitions for each.

Term	Definition
Director	The Director of City of Lacey Public Works, or designee, as necessary to ensure compliance with the requirements of this manual (or its technical equivalent) unless explicitly referenced otherwise.
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 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	The release of surface and stormwater runoff 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.
Disturbed Area	An area inside project boundaries altered from its natural state.
Disturbed Soils	An area inside the project boundaries where the soils have reduced infiltration, retention, and soil permeability, compared to what would be present in a forested or prairie state, due to previous development or land use.
Ditch	A long narrow excavation dug in the earth for drainage with its top width less than 10 feet at design flow.
Drain	A buried pipe or other conduit (closed drain). A ditch (open drain) for carrying off surplus surface water or groundwater.
(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 Path	The route that surface and stormwater runoff follows downslope as it leaves any part of the site.
Drainage Review	An evaluation by City of Lacey staff of a proposed project's compliance with the drainage requirements in this manual (or its technical equivalent) and other applicable criteria.
Drainage System	Refers to the combination of BMPs, collection, conveyance, retention, detention, treatment, and outfall features or structures on a project.
Drawdown	Lowering of the water surface (in basins or open channel flow), water table, or piezometric surface (in groundwater flow) resulting from a withdrawal of water.

Term	Definition
Driveway	A vehicle driving surface within a single lot or parcel that connects a building or structure with a road, shared access facility, alley, or vehicle driving surface within an ingress/egress easement (or tract). A driveway begins at the right-of-way line, private road easement (or tract) line, shared access easement (or tract) line, alley easement (or tract) line, or ingress/egress easement (or tract) line, and extends to the building or structure.
Driveway Approach	A privately maintained vehicle driving surface that provides a transition between a road and a driveway, a road and a shared access facility, or a road and an alley.
Earth/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 D5268 specifications. See also Engineered Soil.
Earthwork	Means any operation involving the excavation, grading, filling, or moving of earth materials.
Easement	The legal right to use a described parcel of land for a particular purpose. It does not include fee ownership, but may restrict the owner's use of the land.
Ecology	Washington State Department of Ecology.
Effective Impervious Surface	Those impervious surfaces that are connected via sheet flow or discrete conveyance to a drainage system. See also Ineffective Impervious Surface.
Embankment	A structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road, building pad, or similar fill for a particular use.
Emergency Spillway	A channel used to safely convey flood discharges in excess of the capacity of the principal outlet, or in the event of a failure of the outlet to function as designed, e.g., a blockage.
Emergent Plants/ Vegetation	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.
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	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).
Engineer	A professional engineer currently licensed in Washington State in civil engineering, retained by and acting on behalf of the applicant. The term "engineer" also means design engineer and project engineer.

Term	Definition
Engineered Soil	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, and shall be planted and/or mulched as part of the installation. The engineered soil/plant system shall have the following characteristics: 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 D3385). D is less than 0.6 inch/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 D2974).
Engineering Geologist	A geologist who, by reason of his or her knowledge of engineering geology, acquired by education and practical experience, is qualified to engage in the practice of engineering geology, has met the qualifications in engineering geology established under Chapter 18.220 RCW, and has been issued a license in engineering geology (L.E.G.) by the Washington State geologist licensing board.
Engineering Plan	A plan prepared and stamped by a professional civil engineer.
Environmental Impact Statement	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.
Environmentally Sensitive Area (Sensitive Area)	See Chapter 16.54 LMC.
Erodible 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 NRCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated stream banks standing over 2 feet high above the base of the channel.
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.

Term	Definition
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 from 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 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 that 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 and Sediment 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.
Erosive	To permit or cause erosion; tending to erode.
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 core 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.

Term	Definition
Existing Site Conditions	Existing site conditions may be described as follows: • For previously developed sites with stormwater facilities that have been constructed to meet the standards of this manual, this shall mean the current conditions on the site. • For previously developed sites that do not have stormwater facilities that meet the standards of this manual, existing site conditions shall be considered under redevelopment regulations • For undeveloped sites, this shall mean the condition of the site prior to the influence of Euro-American settlement. The predeveloped condition shall be assumed to be forested land cover unless reasonable, historical information is provided that indicates the site was prairie prior to settlement. • Exception: If the site is located in a critical and/or sensitive area that affects drainage as defined by city ordinances, the Director may require that a more restrictive definition of existing site conditions be utilized for calculating runoff characteristics.
Fertilizer	Any material or mixture used to supply one or more of the essential plant nutrient elements.
Fill	“Fill or fill material” means the deposit of organic or inorganic material by human or mechanical means.
Filter Fabric	A woven or non-woven, water-permeable material generally made of synthetic products, such as polypropylene, and used in stormwater management and erosion and sedimentation control applications to trap sediment or prevent the clogging of aggregates by fine soil particles.
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 that eventually settle out of suspension. This process occurs naturally but can also be caused by such chemicals as alum.
Flood	“Flood” or “flooding” means a general and temporary condition of partial or complete inundation of normally dry land areas from: 1) the overflow of inland or tidal waters, and/or 2) the unusual and rapid accumulation of runoff of surface waters from any source.
Flood Control	Methods or facilities for reducing flood risks and the extent of flooding.
Flood Hazard Areas	Those areas subject to inundation by the base flood. Includes, but is not limited to streams, lakes, wetlands, and closed depressions. Also referred to as special flood hazard areas.
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 Stage	The stage at which overflow of the natural banks of a stream begins.
Floodplain	The total area subject to inundation by a flood including the flood fringe and floodway.

Term	Definition
Flow Control BMP	A drainage BMP designed to mitigate the impacts of increased surface and stormwater runoff flow rates generated by development. Flow control BMPs 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 percent of the 2-year recurrence interval 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 recurrence interval flow.
Flow Path	The route that surface water 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: road and trail construction, harvesting, final and intermediate, precommercial thinning, reforestation, fertilization, prevention and suppression of diseases and insects, salvage of trees, brush control.
Freeboard	The vertical distance between the highest designed water surface elevation and the elevation of the crest of the facility. For example, in pond design, freeboard is the vertical distance between the emergency overflow water surface and the crest of the facility.
Functions (Wetland)	The ecological (physical, chemical, and biological) processes or attributes of a wetland. Functions are often defined in terms of the processes that provide value to society, 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 recharge and discharge, water quality improvement, and soil stabilization.
Gabion	A rectangular or cylindrical wire mesh cage filled with rock and used as a protecting agent, revetment, etc., against erosion. Soft gabions, often used in stream bank stabilization, are made of geotextiles filled with dirt, in between which cuttings are placed.
Gauge	A measure of the thickness of metal. Also, a measuring device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc.
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 5 years of experience as a practicing geologist or 4 years of experience and at least 2 years of post-graduate study, research, or teaching. The practical experience shall include at least 3 years of work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers. Per RCW 18.220.010, a “geologist” is a person who, by reason of his or her knowledge of geology, mathematics, the environment, and the supporting physical and life sciences, acquired by education and practical experience, has met the qualifications established under Chapter 18.220 RCW, and has been issued a certificate of licensing as a geologist (L.G.) by the Washington State geologist licensing board.

Term	Definition
Geology	The science of the Earth's physical properties, composition, history, and processes by which it evolves. The science of geology includes: the origin and history of the Earth; the investigation of the Earth's constituent rocks, minerals, solids, and fluids, including surface and underground waters, gases, and other materials; and the study of the natural agents, forces and processes that cause changes in the Earth.
Geometrics	The mathematical relationships between points, lines, angles, and surfaces used to measure and identify areas of land.
Geotechnical Professional	A person with experience and training in analyzing, evaluating, and mitigating any of the following: landslide, erosion, seismic, and/or mine hazards, or fluvial geomorphology and river dynamics. A geotechnical professional shall be licensed in Washington State as an engineering geologist or professional engineer. Per WAC 308-15-140 and 196-27-020, engineering geologists and professional engineers shall affix their signatures or seals only to plans or documents dealing with subject matter in which they are qualified by training or experience.
Geotechnical Engineer	A civil engineer who has specialized in the design and construction aspects of earth materials. A practicing geotechnical/civil engineer licensed as a professional civil engineer with Washington State who has at least 4 years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.
Glacial Till	A glacial deposit consisting of a poorly-sorted, unstratified mixture of clay, silt, sand, gravel, and cobbles that has been deposited under glacial ice. As "basal till," compressed under glacial weight, and commonly found in the Lacey area as a shallow subsurface layer having an extremely low permeability. See also Hardpan.
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 ditch, 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.
Grading	Any excavating, filling, clearing, or creating of hard surfaces or combination thereof.
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.
Groundwater	Water in a saturated zone or stratum beneath the land surface or a surface water body.
Groundwater Recharge	Inflow to a groundwater reservoir.

Term	Definition
Groundwater Table	The free surface of the groundwater, 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.
Grubbing	Means the removal and disposing of all unwanted vegetative matter from underground, such as sod, stumps, roots, buried logs, or other debris.
GULD	General Use Level Designation, the highest-level approval designation by Ecology for the assessment of new runoff treatment technologies. GULD allows use of a manufactured treatment system under specific conditions of approval.
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.
Hard Surface	An impervious surface, a permeable pavement, or a vegetated roof.
Hardpan	A layer of soil that has become relatively hard and impermeable, and impenetrable by roots, usually through the decomposition of minerals. Sometimes used in casual reference to glacial till.
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. Examples include cadmium, chromium, cobalt, copper, lead, mercury, nickel, and zinc.
High-Use Site	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 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 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.

Term	Definition
Hydraulic Conductivity	The quality of saturated soil that enables water or air to move through it; a permeability coefficient, related to the fluid density and viscosity, describing the rate at which water can move through a permeable medium. The coefficient, K, has units of length/time, or velocity.
Hydraulic Gradient	Slope of the potential head relative to a fixed datum. The change in total head per change in distance, in the direction of decreasing head. Also referred to as the hydraulic grade line.
Hydrogeology	The study of the interrelationships of geologic materials and processes with water, especially groundwater. Hydrogeology is a science that involves the study of the waters of the Earth, including the occurrence, circulation, distribution, chemistry, and quality of water, and its role as a natural agent that causes changes in the Earth, and the collection of data concerning waters and their interaction with other materials in the atmosphere, on the Earth's surface, or in the interior of the Earth.
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 NRCS 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 (Novotny and Olem 1994).
Hydrological Simulation Program—Fortran (HSPF)	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 that represent the rainfall-runoff process at some conceptual level.
Hydrology	The science of the behavior of water in the atmosphere, on the surface of the earth, and underground.

Term	Definition
Hydroperiod	A seasonal occurrence of flooding and/or soil saturation, generally used in reference to wetlands; it encompasses depth, frequency, duration, and seasonal pattern of inundation.
Hyetograph	A graph of rainfall intensity (often in inches per hour) over time at a single point.
Illicit Connection	Any infrastructure connection to the MS4 that is not intended, permitted, or used for collecting and conveying stormwater or non-stormwater discharges allowed as specified in the city's NPDES Municipal Stormwater Permit.
Illicit Discharge	All non-stormwater discharges to stormwater drainage systems that cause or contribute to a violation of state water quality, sediment quality or groundwater quality standards, including but not limited to sanitary sewer connections, industrial process water, interior floor drains, car washing, and greywater systems.
Impermeable Liner (or Low-Permeability Liner)	A layer of compacted till or clay, or a synthetic geomembrane, intended to restrict infiltration.
Impervious	A surface that cannot be easily penetrated. For instance, rain does not readily penetrate paved surfaces.
Impervious Surface	A 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 non-vegetated surface area that 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, rooftops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam or other surfaces that 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 core requirements are exceeded. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling.
Impoundment	A natural or constructed 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 wastewaters; 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.

Term	Definition
Ineffective Impervious Surfaces	Impervious surfaces are considered ineffective if: 1. The runoff is dispersed through at least 100 feet of native vegetation in accordance with Full Dispersion as described in Chapter 7, Section 7.4.2; 2. Residential roof runoff is infiltrated in accordance with Downspout Infiltration Systems Chapter 7, Section 7.4.10; or 3. Approved continuous runoff modeling methods indicate that the entire runoff file is infiltrated.
Infiltration	The downward movement of water from the land surface into and through the upper soil layers 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 MS4 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 where portions flow continuously only at certain times of the year, for example, when it receives water from a spring, groundwater source, or surface source, such as melting snow (i.e., seasonal). At low flow there may be dry segments alternating with flowing segments.
International Building Code (IBC)	The most recent version of the International Building Code adopted by the City of Lacey.
Invasive Species	Opportunistic plant species (either native or nonnative) that colonize disturbed ecosystems and come to dominate the plant community in ways that are commonly viewed 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.
Invert	The lowest point on the inside of a pipe 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 and duration.

Term	Definition
Junction	Point where two or more drainage pipes or channels converge (e.g., manhole).
Lake	An area permanently inundated by water in excess of 2 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.
Landscaping	The improvement or installation on a parcel or portion thereof of objects or vegetation for decorative or ornamental effect. Examples include trees, bushes, shrubs, flowers, grass, weeds, ornamental rocks or figures, low-lying ground cover, sprinkler systems, sidewalks, and lighting fixtures.
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 this manual, 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.
Leaching	Water or other liquid that has been contaminated by dissolved or suspended materials due to contact with solid waste or gases.
Legume	A member of the legume or pulse family, *Leguminosae*, one of the most important and widely distributed plant families. 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 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.
Live Storage	The amount of storage in a stormwater facility that is intended to completely drain after a storm event.
Local Government	Any county, city, town, or special purpose district having its own incorporated government for local affairs, such as the City of Lacey.
Lot	A designated parcel, tract, or area of land established by plat, subdivision, or as otherwise permitted by law, to be used, developed, or built upon as a unit.

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Low Impact Development (LID)</td><td>A stormwater and land use management strategy that strives to mimic predisturbance 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.</td></tr>
<tr><td>Low Impact Development Best Management Practices (LID BMPs)</td><td>Distributed stormwater management practices, integrated into a project design, that emphasize predisturbance 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, post-construction soil quality and depth, minimal excavation foundations, vegetated roofs, and rainwater harvesting.</td></tr>
<tr><td>Maintenance</td><td>Activities conducted on currently serviceable structures, facilities, and equipment that involves no expansion or use beyond that previously existing and resulting in no significant adverse hydrologic impact. Maintenance includes those usual activities taken to prevent a decline, lapse, or cessation in the use of structures and systems. Those usual activities may include replacement of dysfunctional facilities, including cases where environmental permits require replacing an existing structure with a different type of 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 checklists of Chapter 10.</td></tr>
<tr><td>Manning’s Equation</td><td>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.</td></tr>
<tr><td>Manual, The</td><td>The City of Lacey Stormwater Design Manual including all amendments, corrections, and changes made through subsequent city ordinance.</td></tr>
<tr><td>Material</td><td>Any solid or semi-solid substance that displaces volume.</td></tr>
<tr><td>Maximum Extent Practicable</td><td>Refers to a paragraph of the federal Clean Water Act, which reads (in part): “Permits for discharges from municipal storm sewers shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques, and system, design and engineering methods … for the control of such pollutants.”</td></tr>
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Term	Definition
Metals	Elements, such as mercury, lead, nickel, zinc and cadmium, which are of environmental concern because they can be toxic to life in high enough concentrations and do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain. Some 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: 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.
MS4	Municipal separate storm sewer system. A system of conveyances (including streets, curbs, gutters, catch basins, pipes and ditches) owned or operated by a city or other public entity, that is used for collecting or conveying stormwater (excluding combined sewers).
Mulch	A layer of organic material or aggregate applied to the surface of soil. Its purpose is any or all of the following: • To conserve soil moisture or temperature • To improve the fertility and health of the soil • To reduce weed growth • To hold fertilizer, seed, and soil in place • To enhance the visual appeal of the area. Types of mulches used in this manual include: Chipped site vegetation, compost, hydromulch, wood-based or wood straw, wood strand, straw, and aggregate.

Term	Definition
Multifamily	Three or more living units under the same ownership where land has not been divided (i.e., triplex, quadraplex, condominiums, housing cooperatives and apartment units).
National Pollutant Discharge Elimination System (NPDES)	The part of the Clean Water Act that requires point source dischargers to obtain permits. These permits are referred to as NPDES permits and, in Washington, are administered by Ecology.
Native Growth Protection Easement	An easement granted for the protection of native vegetation within a sensitive area or its associated buffer. The native growth protection easement shall be recorded on the appropriate documents of title and filed with the Thurston County Records Division.
Native Vegetation	Vegetation comprising plant species, other than noxious weeds, that are indigenous to the coastal region of the Pacific Northwest and that 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 Channel	Stream, creek, river, lake, wetland, estuary, gully, swale, ravine, or any open conduit where water will concentrate and flow intermittently or continuously. Only includes constructed channels designed to mimic natural systems.
Natural Hydrologic Function	Refers to the processing of precipitation over and through the landscape in a forest or prairie condition. Includes evapotranspiration by on-site vegetation, storage of rainfall in the soil structure or on the soil surface within depressions in the topography, and the release of stormwater through either infiltration, interflow, or surface flow off the site.
Natural Location	The location of those channels, swales, and other non-constructed conveyance systems as defined by the first documented topographic contours existing for the subject property, from either 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.
Natural Resources Conservation Service (NRCS)	Formerly the Soil Conservation Service (SCS), NRCS is an agency of the United States Department of Agriculture (USDA) that provides technical and financial assistance to farmers and other private landowners and managers.
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 hard surfaces; and subdivision, short subdivision, and binding site plans, as defined and applied in Chapter 58.17 RCW. Projects meeting the definition of redevelopment shall not be considered new development.

Term	Definition
New Hard Surface	Hard surface created on or added to a site or structural development including construction, installation, or expansion of a building or other structure. Includes the addition of a hard or compacted surface like roofs, pavement, gravel, or dirt; or 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. New hard surface may also include existing hard surface that is removed and replaced. To be considered new, the removal and replacement activity must result in significant changes in hard surface locations, grade, and/or drainage system features, and/or must involve construction, installation, or expansion of a building or structure after complete or substantial intentional demolition thereof by or for the benefit of the applicant.
New Impervious Surface	A surface that is: • changed from a previous surface to an impervious surface (e.g., resurfacing by upgrading from dirt to gravel, a bituminous surface treatment ("chip seal"), asphalt, concrete, or an impervious structure); or • upgraded from gravel to chip seal, asphalt, concrete, or an impervious structure; or • upgraded from chip seal to asphalt, concrete, or an impervious structure. Note that if asphalt or concrete has been overlaid by a chip seal, the existing condition should be considered as asphalt or concrete.
Nitrate	A form of nitrogen that 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.
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 water body 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.
Notice of Intent	The application for coverage under a general stormwater permit in Washington State.
NPDES	The National Pollutant Discharge Elimination System as established by the Clean Water Act.
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. 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.

Term	Definition
NWTPH-Dx and NWTPH-Gx	Northwest Total Petroleum Hydrocarbon Analytical Methods used for compliance with the MTCA. NWTPH-Dx is a qualitative and quantitative method (extended) for semi-volatile (Diesel-range organics and heavy oils) petroleum products in water. NWTPH-Gx is a qualitative and quantitative method (extended) for volatile (gasoline-range organics) in water. See Ecology publication number ECY 97-602.
Off-Line Facilities	Runoff treatment facilities to which stormwater runoff is restricted to some maximum flow rate or volume by a flow-splitter.
Off Site (adverb)	Any area lying upstream of the (project) site that drains onto the site and any area lying downstream of the site to which the site drains. (Note: When used as an adjective, off site is hyphenated. For example: off-site storage.)
Oil-Water Separator	A vault, usually underground, designed to provide a quiescent environment to separate oil from water. See Chapter 8 for design criteria.
On-Line Facilities	Runoff treatment BMPs that 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 (adverb)	The entire property that includes the proposed development. (Note: When used as an adjective, on site is hyphenated. For example: on-site vegetation.)
On-Site Stormwater Management BMPs	As used in this manual, a synonym for LID 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 cleanup, 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 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 mark on all lakes, streams, and tidal water that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued 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 ordinary high water mark adjoining fresh water shall be the line of mean high water.

Term	Definition
Organic Matter	Organic matter is decomposed animal or vegetable matter. It is measured by ASTM D2974. 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 artificial structures, such as terraces, tile lines, and diversions.
Outwash Soils	Soils formed from highly permeable sands and gravels deposited by glacial meltwater.
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 that can be handled by interceptor sewer lines and pumping and treatment facilities to be carried by and to such water pollution control structures.
Overtopping	Flowing over the limits of a containment or conveyance element.
Parcel	Any portion, piece, or division of land. Fractional part or subdivision of block, according to plat or survey; portion of platted territory measured and set apart for individual and private use and occupancy.
Particle Size	The effective diameter of a particle as measured by sedimentation, sieving, or micrometric methods.
Pasture	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.
Paved Road	A road that has been treated or covered with asphalt to create an oil mat surface; a road that has a bituminous surface treatment, asphalt, or cement concrete surface.
Peak Discharge	The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.
Percolation	The movement of water through soil.
Percolation Rate	The rate, often expressed in inches/hour, 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).

Term	Definition
Permanent Stabilization	Permanent site stabilization is the covering of exposed surfaces through paving, gravels, landscaping materials, sodding, seeding, etc., but shall not mean the temporary use of erosion/sediment control materials unless used in conjunction with the above measures to aid in seed or landscaping vegetation establishment.
Permanent Stormwater Control Plan	A plan that includes permanent BMPs for the control of pollution from stormwater runoff after construction and/or land-disturbing activity has been completed.
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.
Permeable Soils	Soil materials with a sufficiently rapid infiltration rate to greatly reduce or eliminate surface and stormwater runoff. These soils are generally classified as NRCS 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.
Pervious Surface	A surface material that allows stormwater to infiltrate into the ground. Examples include lawn, landscape, pasture, native vegetation areas, and permeable pavements.
Pesticide	A general term used to describe any substance—usually chemical—used to destroy or control organisms; includes herbicides, insecticides, rodenticides, 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 that is based on measuring the concentration of hydrogen ions in the substance. A pH of 7.0 indicates neutral water. A 6.5 reading is slightly acid.
Planned Unit Development (PUD)	A special classification authorized in some zoning ordinances, in which 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, short subdivision, large lot or binding site plan, showing thereon the division of a tract or parcel of land into lots, blocks, streets and alleys, or other divisions and dedications.
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.
Polishing	Additional treatment of a waste stream that has already received one or more stages of treatment by other means. 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.

Term	Definition
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, or 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 that receive direct rainfall or run-on or blow-in of rainfall and are subject to: vehicular use; industrial activities (as further defined in this glossary); or storage of erodible or leachable materials, wastes, or chemicals. In addition, 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 are considered 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 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, restricted access fire lanes, and infrequently used maintenance access roads.
Pollution-Generating Pervious Surface (PGPS)	Any pervious surface subject to any of the following: • vehicular use, • industrial activities (as further defined in this glossary), • 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).
Postproject	For use with Appendix I-C of the 2019 Ecology Manual. The conditions present across a landscape after a specific stormwater management project (e.g., raising the outlet, building an outlet control structure) is completed that will potentially affect wetlands.
Postdevelopment Condition	The condition of site after the project has been constructed.
Pothole	A closed basin. See also Closed Depression.
Preproject	For use with Appendix I-C of the 2019 Ecology Manual. The conditions present across a landscape before a specific project is constructed.

Term	Definition
Predeveloped Condition	The native vegetation and soils that existed at a site prior to the influence of Euro-American settlement. The predeveloped condition shall be assumed to be forested land cover unless reasonable, historical information is provided that indicates the site was prairie prior to settlement.
Preliminary Plat	A neat and approximate drawing of a proposed subdivision showing the general layout of streets, alleys, lots, blocks, and restrictive covenants to be applicable to the subdivision, which shall furnish a basis for the approval or disapproval of the general layout of a subdivision.
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.
Private Road	A roadway facility in private ownership providing private access and used for travel of vehicles by the owner(s) or those having express or implied permission from the owner(s), but not by other persons.
Professional Engineer (PE)	A person currently licensed and registered in Washington State 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.
Project Engineer	Professional Engineer.
Project Site	That portion of a property, properties, or right-of-way subject to land-disturbing activities, new hard surfaces, or replaced hard surfaces.
Rain Garden	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. See Chapter 7, Section 7.4.5 of this manual for design criteria.
Rational Method	A means of computing storm drainage flow rates (Q) by use of the formula Q = CIA, where <u>C</u> is a coefficient describing the physical drainage area, <u>I</u> is the rainfall intensity and <u>A</u> is the area. This method is only allowed for sizing conveyances in certain small basins.
Reach	A length of channel with uniform characteristics.
Receiving Waters (or Receiving Water Body)	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.
Recharge	The addition of water to the zone of saturation (i.e., an aquifer).
Recommended BMPs	As used in reference to Source Control (Chapter 9 of this manual, and Volume IV of the 2019 Ecology Manual, 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.

Term	Definition
Redevelopment	On a site that is already substantially developed (i.e., has 35 percent or more of existing hard surface coverage), the creation or addition of 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 hard surface that is not part of a routine maintenance activity; and land-disturbing activities.
Regional	An action or facility (for stormwater management purposes) that involves more than one discrete property.
Regional Detention (or Retention) Facility	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. This term is also used when a detention or retention facility is sited to detain or infiltrate stormwater runoff from a number of new developments or areas within a catchment.
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 impervious surfaces down to the foundation. For other impervious surfaces, the removal down to bare soil or base course and replacement.
Restoration	Actions performed to re-establish 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 Pond	A retention facility that is an open pond.
Retention/Detention BMP	A type of drainage BMP 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 stormwater drainage 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).
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.
Riparian	Pertaining to the banks of streams, wetlands, lakes, or tidewater.
Riparian Areas	Transition zones between water bodies and upland areas that exhibit vegetation or soil characteristics reflective of permanent surface or subsurface water influence. Lands along, adjacent to, or contiguous with perennially and intermittently flowing rivers and streams, glacial potholes, and the shores of lakes and reservoirs with stable water levels are typical riparian areas.

Term	Definition
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.
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.
Roadway Width	The sum of the traveled way width and the shoulder width measured at its narrowest location.
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 groundwater. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.
Runoff Treatment BMP	A BMP that is intended to remove pollutants from stormwater. A few examples of runoff treatment BMPs are wet ponds, wet vaults, oil-water separators, biofiltration swales, and constructed wetlands.
Salmonid	A member of the fish family *Salmonidae*. Chinook, coho, chum, pink, and sockeye salmon; cutthroat, brook, brown, rainbow, and steelhead trout; Dolly Varden, kokanee, and char are examples of salmonid species.
Sand Filter	A constructed depression or basin with a layer of sand that treats stormwater as it percolates through the sand.
Scour	Erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.
SCS	Soil Conservation Service (now the Natural Resources Conservation Service), United States Department of Agriculture.
SCS Method	See NRCS Method.
SDM Administrator	City of Lacey Stormwater Design Manual Administrator. See Director.
Seasonal High Groundwater Level	The upper level at which the groundwater table normally is located during the season of the year when such levels are at their highest (typically December 1 through April 30).
Section 401; Section 404	Section 401 and Section 404 of the Clean Water Act. Under Section 401, an activity involving a discharge into waters of the U.S. authorized by a federal permit must receive water quality certification from the appropriate certifying agency (Ecology), indicating the activity will comply with applicable water quality standards. Under Section 404, the USACE regulates the discharge of dredged or fill material into waters of the U.S., including wetlands.
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 Area	Those areas designated by resolution or ordinance of the Lacey City Council pursuant to WAC 197-11-908 and Chapter 16.54 LMC or the most recent amendments thereto. See Environmentally Sensitive Area.
Settleable Solids	Those suspended solids in stormwater that separate by settling when the stormwater is held in a quiescent condition for a specified time.

Term	Definition
Shared Access Facility	A privately-owned drivable surface that serves up to and including four lots in the rural area or two lots in the urban area for access to single-family and two-family dwelling units.
Sheet Flow	Runoff that flows over the ground surface as a thin, even layer, not concentrated in a channel.
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 water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful salmon spawning.
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.
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-degree slope being vertical (maximum) and 45-degree 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 and Engineered Soil.
Soil Group, Hydrologic	A classification of soils by the NRCS 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 Permeability	The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.
Soil Profile	A vertical section of the soil from the surface through all horizons, including C horizons.
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 Structure	The relation of particles or groups of particles that impart to the whole soil a characteristic manner of breaking; types include crumb structure, block structure, platy structure, and columnar structure.
Soil Texture Class	The relative proportion, by weight, of particle sizes, based on the USDA soil textural class 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.
Soils Professional	A person certified by the Soil Science Society of America (or an equivalent national program); a locally licensed on-site sewage designer; or a suitably trained person working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in Washington State.

Term	Definition
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. 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 Chapter 9 of this manual for details.
Spill Control Device	A T-section or turned-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 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)	The Washington law (RCW 43.21c) 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.
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 Sewer	A sewer that carries stormwater and surface water, street wash, and other washwaters or drainage, but excludes sewage and industrial wastes. Also called a storm drain. Local storm sewers may flow to stormwater treatment ponds, but they do not flow to sewage treatment plants (as sanitary sewers do).
Stormwater	Surface runoff due to precipitation or snowmelt. 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 the stormwater drainage system to a surface water body or constructed stormwater BMP.
Stormwater Drainage System	Constructed and natural features that function together as a system to collect, convey, channel, hold, inhibit, retain, detain, infiltrate, divert, treat, or filter stormwater.
Stormwater BMP/Facility	A constructed component of a stormwater drainage system designed or constructed to perform a particular function, or multiple functions. Stormwater BMPs/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, bioretention, permeable pavement, and biofiltration swales.
Stormwater Management Manual for Western Washington	The stormwater manual issued by Ecology to provide guidance on measures necessary in western Washington to control the quantity and quality of stormwater runoff from new development and redevelopment. The current manual is the 2019 *Stormwater Management Manual for Western Washington*, also referred to as the 2019 Ecology Manual.

Term	Definition
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. It includes a Construction Stormwater Pollution Prevention Plan (Construction SWPPP) and a Permanent Stormwater Control Plan. Guidance on preparing a Stormwater Site Plan is contained in Chapter 3 of this manual.
Stream Banks	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 constructed 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.
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: • 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 runoff treatment BMPs.
Structure	A catch basin or manhole in reference to a storm drainage system.
Stub-Out	A short length of pipe provided for future connection to a stormwater drainage system.
Subbasin	A drainage area that drains to a point contained within a larger basin.
Subgrade	A layer of stone or soil used as the underlying base for a BMP or road.
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.

Term	Definition
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 groundwater.
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 1 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.
Threatened or Endangered Species	Plant or animal species that 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.
Threshold Discharge Area	An area within a project site draining to a single natural discharge location or multiple natural discharge locations that combine within 0.25 mile downstream (as determined by the shortest flowpath). The examples in Chapter 4, Figure 4.1 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.
Till	See Glacial Till.
Time of Concentration	The time 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	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.
Total Maximum Daily Load (TMDL) – Water Cleanup Plan	A calculation of the maximum amount of a pollutant that a water body 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 or water quality improvement program) 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 water body 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 water body, 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.

Term	Definition
Total Suspended Solids	That portion of the solids carried by stormwater that can be captured on a standard glass filter.
Toxic	Poisonous, carcinogenic, or otherwise directly harmful to life.
Total Phosphorus	A water quality parameter.
TPH	Total petroleum hydrocarbons. A water quality parameter.
TR-55	Technical Release No. 55 of the USDA Natural Resources Conservation Service, Conservation Engineering Division, June 1986, titled *Urban Hydrology for Small Watersheds*, which describes procedures for estimating runoff and peak discharges. See NRCS Method.
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.
Traveled Way	That portion of the roadway used for the movement of vehicles exclusive of the portion of the roadway width that is used, or available for parking of vehicles. The traveled way does not include curbs and gutters.
Treatment Liner	A layer of soil that is designed to slow the rate of infiltration and provide sufficient pollutant removal to protect groundwater 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.
U.S. EPA	The United States Environmental Protection Agency.
UIC	Underground injection control. Used in reference to an Ecology program regulating injection wells and specific types of infiltration systems.
UIC Well	A UIC well is defined as a structure built to discharge fluids from the ground surface into the subsurface; a bored, drilled, or driven shaft whose depth is greater than the largest surface dimension; or an improved sinkhole, which is a natural crevice that has been modified; or a subsurface fluid distribution system that includes an assemblage of perforated pipes, drain tiles, or other similar mechanisms intended to distribute fluids below the surface of the ground. Examples of UIC wells or subsurface infiltration systems include drywells, drain fields, infiltration trenches with perforated pipe, storm chamber systems with the intent to infiltrate, French drains, bioretention systems intended to distribute water to the subsurface by means of perforated pipe installed below the treatment soil, and other similar devices that discharge to the ground.
Underdrain	Plastic pipes with holes or slots drilled through the top, installed within the bottom of an infiltration BMP to collect and remove excess runoff.
Unpaved Road	A road that consists of gravel, crushed surfacing top course, or other dirt surface that has not received a surfacing coat of asphalt. A road treated with only a dust preventative or dust treatment shall be considered an unpaved road.
Unstable Slopes	Those sloping areas of land that have in the past exhibited, are currently exhibiting, or will likely in the future exhibit, mass movement of earth.

Term	Definition
Values (Wetland)	Wetland processes or attributes that are valuable or beneficial to society (also see 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	Relief from the application of a core requirement to a project.
Vegetated Flow Path	Well-established lawn or pasture, landscaping with well-established groundcover, native vegetation with natural groundcover, or an area that meets Post-Construction Soil Quality and Depth (Chapter 7, Section 7.4.1). The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.
Vegetation	Any organic plant life growing on the surface of the earth.
Vehicular Use	Regular use of an impervious or pervious surface by motor vehicles. The following are subject to regular vehicular 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 vehicular use: • sidewalks not subject to drainage from roads for motor vehicles, • 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.
Water Body	Surface waters including rivers, streams, lakes, marine waters, estuaries, and wetlands.
Water Cleanup Plan	See Total Maximum Daily Load.
Water Quality	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 State, Ecology sets water quality standards.
Water Table	The upper surface or top of the saturated portion of the soil or bedrock layer indicates the uppermost extent of groundwater.
Watercourse	A river, stream, creek, or other course of flowing water that flows intermittently or perennially and discharges into another watercourse or body of water.
Waters of the State	Those waters as defined in 40 CFR Subpart 122.2 and Chapter 90.48 RCW.

Term	Definition
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.
Weir	Device for measuring or regulating the flow of water, by having the water flow over a specifically-designed spillway.
Wet Ponds and Wet Vaults	Runoff treatment BMPs 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. See Chapter 8 for design criteria.
Wet Pool	A pond or constructed wetland that stores runoff temporarily and whose normal discharge location is elevated so as to maintain a permanent pool (i.e., a wet pool) of water between storm events.
Wetlands	Those areas that are inundated or saturated by surface or groundwater 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 constructed wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention BMPs, 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 constructed wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands. (Water bodies not included in the definition of wetlands as well as those mentioned in the definition are still waters of the state.)

Abbreviations

Abbreviation	Definition
AADT	average annual daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
AKART	all known, available, and reasonable methods of treatment, prevention, and control
API	American Petroleum Institute
APWA	American Public Works Association (Washington State Chapter)
ASTM	American Society for Testing and Materials
BMP	best management practice
CARA	critical aquifer recharge area
CAVFS	compost-amended vegetated filter strip
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (commonly known as Superfund)
CESCL	Certified Erosion and Sediment Control Lead
cfs	cubic feet per second
CPEP	corrugated polyethylene pipe
CPESC	Certified Professional in Erosion and Sediment Control
CSWGP	Construction General Stormwater Permit
C-TAPE	Chemical Technology Assessment Protocol – Ecology
CULD	Conditional Use Level Designation
DBH	diameter at breast height
DG&PWS	Development Guidelines and Public Works Standards
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FS	factor of safety
ft/sec	feet per second
GULD	General Use Level Designation
HDPE	high-density polyethylene
HPA	hydraulic project approval
HRM	Highway Runoff Manual
HSPF	Hydrological Simulation Program—Fortran

Abbreviation	Definition
HSG	hydrologic soil group
IBC	International Building Codes
in/hr	inches per hour
ISGP	Industrial Stormwater General Permit
JARPA	Joint Aquatic Resources Permit Application
LF (or lf)	linear feet
LID	low impact development
LMC	Lacey Municipal Code
MFD	media filter drain
mg/L	milligrams per liter
MS4	municipal separate storm sewer system
MSDS	material safety data sheets
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NWTPH	Northwest Total Petroleum Hydrocarbons
O.C.	on center
O&M	operation and maintenance
OSHA	Occupational Safety and Health Administration
PAM	polyacrylamide
PDF	Portable Document Format
PE	professional engineer
PGHS	pollution-generating hard surface
PGIS	pollution-generating impervious surface
PGPS	pollution-generating pervious surface
PIT	pilot infiltration test
PUD	planned unit development
PVC	polyvinyl chloride
RCW	Revised Code of Washington
SA	surface area
SBUH	Santa Barbara Urban Hydrograph
SCS	Soil Conservation Service (now Natural Resources Conservation Service)

Abbreviation	Definition
SDM	Stormwater Design Manual (City of Lacey)
SEPA	State Environmental Policy Act
SF (or sf)	square feet
SWPPP	Stormwater Pollution Prevention Plan
TAPE	Technology Assessment Protocol – Ecology
TMDL	total maximum daily load
TPH	total petroleum hydrocarbons
TR-55	Technical Release No. 55 of the USDA Natural Resources Conservation Service
TSS	total suspended solids
UGA	urban growth area
UIC	underground injection control
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WQ	water quality
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WWHM	Western Washington Hydrology Model, 2012 or newest version

Chapter 2 – Applicability and Core Requirements

Table of Contents

Tables

Figures

Chapter 2 – Applicability and Core Requirements

2.1 Introduction

2.1.1 Purpose, Content, and Organization

Purpose

Chapter 2 of this manual summarizes the nine core requirements for stormwater management applicable to new development and redevelopment. The remaining chapters of this manual cover submittal requirements and best management practices (BMPs) for specific aspects of stormwater management.

Core requirements cover a range of issues, such as submittal requirements, 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 core requirements applicable to a project vary depending on the type and size of the proposed project.

Content

This chapter identifies the nine core requirements for stormwater management applicable to new development and redevelopment sites. The core requirements are:

1. Core Requirement #1: Stormwater Site Plans
2. Core Requirement #2: Construction Stormwater Pollution Prevention
3. Core Requirement #3: Source Control of Pollution
4. Core Requirement #4: Preservation of Drainage Systems and Outfalls
5. Core Requirement #5: On-Site Stormwater Management
6. Core Requirement #6: Runoff Treatment
7. Core Requirement #7: Flow Control
8. Core Requirement #8: Wetlands Protection
9. Core Requirement #9: Operation and Maintenance

Depending on the type and size of the proposed project, different combinations of these core requirements apply. In general, small sites are required to control erosion and sediment from construction activities and to apply simpler approaches for runoff 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. For residential plats, erosion and sedimentation control during construction applies to individual lots after the developer transfers the project to the builder(s).

Larger sites must provide erosion and sediment 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 impacts of the project. Sites being redeveloped must generally meet the same core requirements as new development for the new hard surfaces and pervious surfaces converted to lawn or landscaped areas. 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 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.

Sections 2.2 and 2.3 provide additional information on applicability of the core requirements to different types of sites. Development sites are to demonstrate compliance with these requirements through the preparation of Stormwater Site Plans. These plans are described in detail in Chapter 3.

Finally, it is important to note that other City requirements beyond those outlined in this chapter, but still related to stormwater management, may apply to a given project. Project proponents are responsible for identifying and addressing all requirements applicable to their proposed project.

Organization

Following this introduction, Chapter 2 contains four additional sections:

- **Section 2.2 – Core Requirements** identifies the core requirements for stormwater management at all new development and redevelopment projects.
- **Section 2.3 – Additional Requirements** describes additional requirements, including financial guarantees and other applicable regulations.
- **Section 2.4 – Adjustments** describes allowable adjustments to the core requirements.
- **Section 2.5 – Exceptions and Variances** describes allowable exceptions and variances to the core requirements.

2.1.2 Applicability of the Core Requirements

Not all of the core 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 core requirements to different projects.

Use the flow charts in Figures 2.1 (new development) and 2.2 (redevelopment) to determine which core requirements apply. The core requirements themselves are presented in Section 2.2. Development sites are to demonstrate compliance with the core requirements through the preparation and submittal of drainage plans and reports. Submittal requirements are described in Chapter 3.

Projects that propose the use of deep underground injection control (UIC) wells must meet Core Requirements #1 through #9. For more information on deep UICs and the UIC Program, refer to Chapter 7, Appendix 7C.

Note: For definitions related to the core requirements (e.g., redevelopment, converted pervious surface, pollutant generating surface, etc.), refer to the Glossary.

New Development

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

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

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

The following new development shall comply with Core Requirements #1 through #9 for the new and replaced hard surfaces and the converted vegetation areas:

- Results in 5,000 square feet, or more, of new plus replaced hard surface area, or
- Converts 0.75 acre, or greater, of vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or greater, 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) the hard surface coverage, as well as the converted vegetation areas, must be specified for each lot and recorded with the City on the face of the final plat (or an alternative acceptable to the City). Where City regulations restrict maximum hard (or impervious) surfaces to smaller amounts, those maxima may be used.

Basin planning is encouraged and may be used to tailor Core Requirements #5: On-Site Stormwater Management, #6: Runoff Treatment, #7: Flow Control, and/or #8: Wetlands Protection. Basin planning may be used to support alternative treatment, flow control, and/or wetland protection through construction of regional stormwater facilities. Such facilities must be operational prior to and must have capacity for new development.

Additional examples of how basin planning can alter the core requirements are given in Appendix I-BB of the 2019 Ecology Manual. Regional stormwater facility guidance is provided in Appendix I-D of the 2019 Ecology Manual.

Basin planning provides a mechanism by which the core requirements and implementing BMPs can be evaluated and refined based on an analysis of a basin or watershed. Basin plans may be used 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 groundwater resources. Basin planning will require the use of continuous simulation computer models and field work to verify and support the models.

In order for a basin plan to serve as a means of modifying the core 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; and
- The basin plan must be reviewed and approved by Ecology.

Compensatory Flow Control or Treatment

Where new development projects require improvements (e.g., frontage improvements) that are not within the same threshold discharge area, the City may allow the core requirements to be met for an equivalent (flow and pollution characteristics) area that drains to the same receiving water. Guidance on stormwater control transfer programs is included in Appendix I-E of the Ecology Manual. Discussion with the City would be needed prior to implementation of a stormwater control transfer.

Redevelopment

All redevelopment shall be required to comply with Core Requirement #2.

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

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

The following redevelopment shall comply with Core Requirements #1 through #9 for the new hard surfaces and converted pervious areas:

- Adds 5,000 square feet or greater of new hard surfaces, or

- Converts 0.75 acre, or greater, of vegetation to lawn or landscaped areas, or
- Converts 2.5 acres, or greater, of native vegetation to pasture.

In addition, projects that exceed the above thresholds and: **1) are within the 1-year time of travel zone for a wellhead protection area, and 2) contain existing hard surfaces that do not drain to an approved stormwater BMP** are required to apply the applicable core requirements to the entire project site (i.e., not just to the new and replaced hard surfaces). See area maps in Chapter 8, Appendix 8B as well as on the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/>.

The City may allow the core requirements to be met for an equivalent (flow and pollution characteristics) area. The equivalent area may be within the same threshold discharge area (TDA). If the equivalent area is outside the TDA, or off-site, the equivalent area must drain to the same receiving water and the guidance for equivalent facilities using in-basin transfers must be followed (see Appendix I-E of the 2019 Ecology Manual). The City is responsible for maintaining tracking records for all area transfers approved by the City.

Additional Requirements

For road-related projects, runoff from the replaced and new hard surfaces (including pavement, shoulders, curbs, and sidewalks) and the converted vegetated areas shall meet all the core requirements if the new hard surfaces total 5,000 square feet or greater and total 50 percent or more of the existing hard 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 Core Requirements #1 through #9 for the new and replaced hard surfaces and the converted vegetated areas if:

- The total of new plus replaced hard surfaces is 5,000 square feet or greater, and
- For commercial and industrial projects: the valuation of proposed improvements—including interior improvements—exceeds 50 percent of the assessed value of the existing Project Site improvements as determined by the City Building Official.
- For all other projects: the valuation of the proposed improvements, including interior improvements, exceeds 50 percent of the assessed value of the existing Site improvements as determined by the City Building Official.

Finally, if the City determines that the project site contributes to an existing water quality, flooding, or erosion problem, the City may require that the project site comply with additional stormwater management requirements.

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 are not 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.

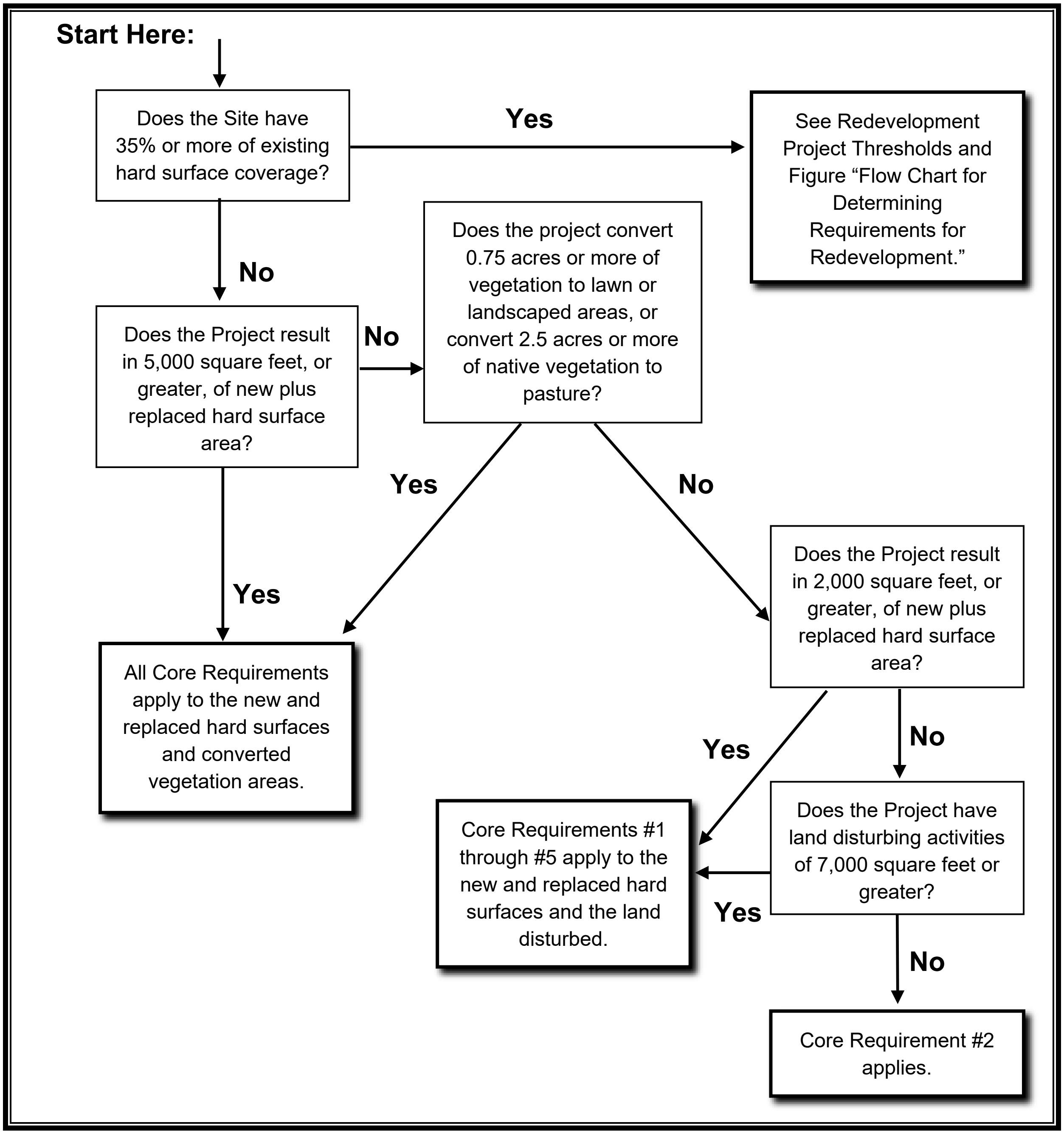


Figure 2.1. Flow Chart for Determining Requirements for New Development.

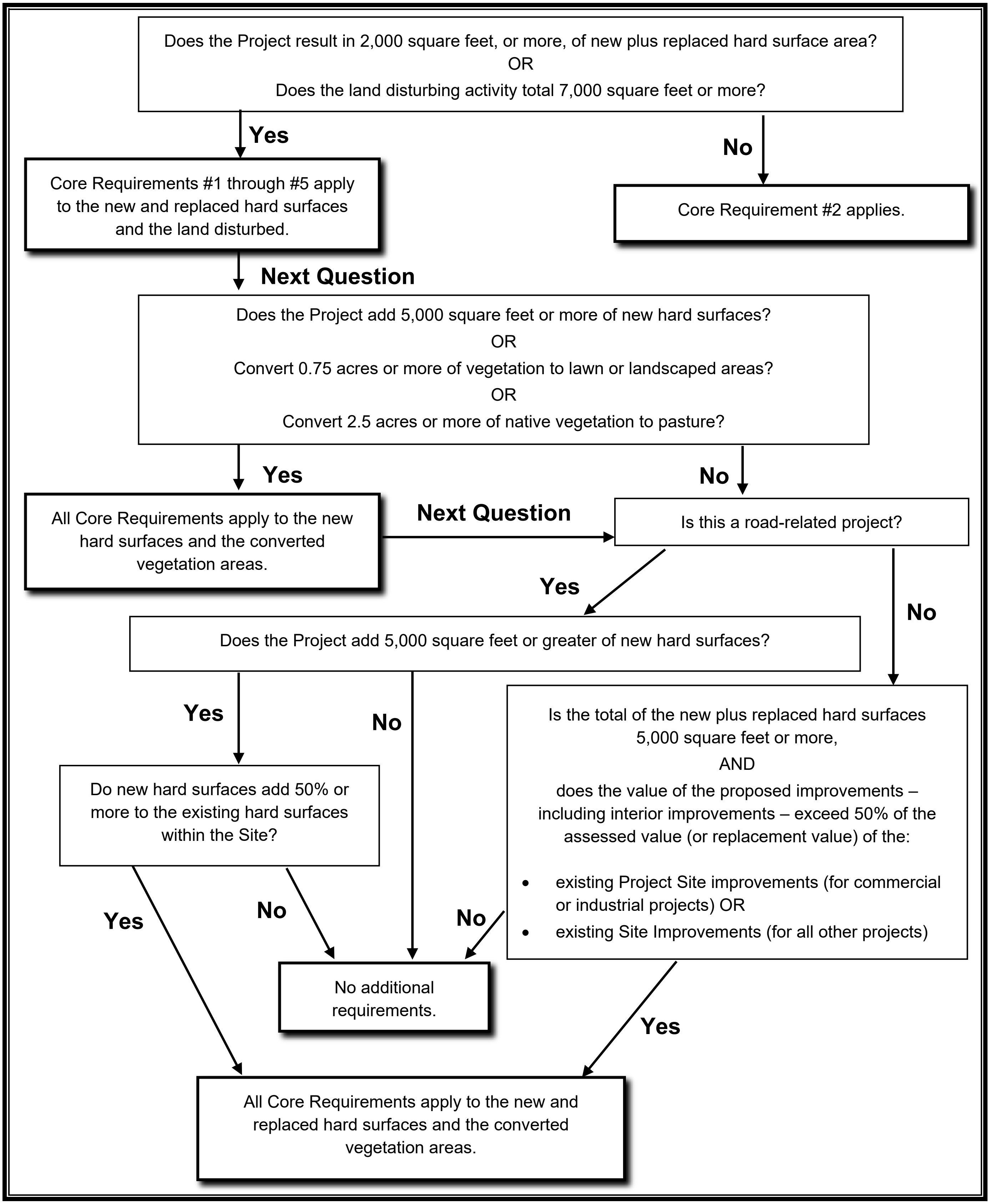


Figure 2.2. Flow Chart for Determining Requirements for Redevelopment.

2.1.3 Exemptions

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

Forest Practices

Forest practices regulated under Title 222 WAC, except for Class IV General forest practices that are conversions from timberland to other uses, are exempt.

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.

Pavement Maintenance

The following pavement maintenance practices are exempt from the core requirements, but should use appropriate BMPs to minimize erosion and sediment transport:

- 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
- Vegetation maintenance.

The following pavement maintenance practices are not categorically exempt. 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 pavement base: If impervious surfaces are not expanded, Core Requirements #1 through #5 apply.
- Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders: These are considered new hard surfaces and are

subject to the core requirements that are triggered when the thresholds identified for new or redevelopment projects are met.

- Resurfacing by upgrading from dirt to gravel, bituminous surface treatment ("chip seal"), asphalt, or concrete; upgrading from gravel to chip seal, asphalt, or concrete; or upgrading from chip seal to asphalt or concrete: These are considered new impervious surfaces and are subject to the core 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 Core Requirement #2: Construction Stormwater Pollution Prevention.

2.2 Core Requirements

This section describes the core requirements for stormwater management at development and redevelopment sites. Section 2.1 must be consulted to determine which requirements apply to any given project. Figures 2.1 and 2.2 should be consulted to determine whether the core requirements apply to new surfaces, replaced surfaces, or new and replaced surfaces. Chapters 4, 5, 7, and 8 of this manual present BMPs for use in meeting the core requirements.

2.2.1 Core Requirement #1: Stormwater Site Plans

All projects meeting the thresholds in Section 2.1 shall prepare a Stormwater Site Plan for City review. Stormwater Site Plans shall be prepared in accordance with Chapter 3 of this manual.

A Stormwater Site Plan is a comprehensive report containing all of the technical information, analysis, calculations, maps, and graphics necessary for the City to evaluate a proposed project for compliance with stormwater requirements. The information required in the Stormwater Site Plan depends on the nature of the project and its location. Stormwater Site Plans shall use site-appropriate development principles to retain native vegetation and minimize impervious surfaces to the extent feasible.

Each of the plan submittal types listed below are described in detail in Chapter 3. See Chapter 3 and Table 3.1 for the specific information on required plans and plan content.

- SWPPP Short Form: for small projects subject to Core Requirement #2 only
- Abbreviated Drainage Plan: for intermediate-size projects subject to Core Requirements #1-5 only
- Drainage Control Plan: for larger projects subject to all Core Requirements #1-9

Completing the applicable plan type in accordance with the requirements in Chapter 3 will meet Core Requirement #1.

Objective

The 2,000-square-foot threshold for hard surfaces and 7,000-square-foot threshold for land disturbance are specified by the Department of Ecology to capture most single-family home construction and their equivalent. The City-specific thresholds and requirements identified in Chapter 3, Table 3.1, were developed to meet more specific City needs and interests, without negating Ecology's requirements.

Supplemental Guidelines

Projects proposed by City departments and agencies must comply with this requirement. The City shall determine the process for ensuring proper project review, inspection, and compliance by its own departments and agencies. See also Chapter 3, Section 3.2.1.

2.2.2 Core Requirement #2: Construction Stormwater Pollution Prevention

All projects shall address erosion and sediment control during site construction activities.

Thresholds

All new development and redevelopment projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters, and shall comply with Construction SWPPP Elements #1 through #13 as detailed in Chapter 5. The 13 elements are summarized below, but project applicants must refer to Chapter 5 for the full description of applicable requirements.

Projects which result in 2,000 square feet or more of new plus replaced hard surface area, or which disturb 7,000 square feet or more of land must prepare a Construction SWPPP as part of the Stormwater Site Plan submittal (see Chapter 3, Section 3.3). 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 Construction SWPPP. The SWPPP shall be implemented beginning with initial soil disturbance and shall be maintained until final stabilization of the entire project site.

Projects that result in less than 2,000 square feet of 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 13 elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site. In addition, these projects shall submit a complete SWPPP Short Form (see Chapter 3, Appendix 3A) to record basic project information, and to document that the 13 elements are being considered and addressed as applicable. See also Chapter 3.

These elements cover the general water quality protection strategies of limiting site impacts, preventing erosion and sedimentation, and managing activities and sources during the construction phase of a project. The 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 dewatering
11. Maintain BMPs
12. Manage the project
13. Protect Low Impact Development BMPs

A complete description of each element and the associated BMPs are given in Chapter 5.

Additional Requirements

If a Construction SWPPP is found to be inadequate (with respect to erosion and sediment control requirements), the City may require that other BMPs be implemented as needed. The City may also require a wet season amendment to the SWPPP if work will be performed between October 1 and April 30. See Chapter 5, Section 5.2.3 for details.

Note that clearing and grading activities for developments may 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. 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 shall be delineated on the site plans and at the development site. See Chapter 3 for additional details on project submittal requirements.

In addition, a Construction Stormwater General Permit may be required by Ecology. See Chapter 1, Section 1.7.7, and Chapter 5 of this manual for additional information regarding Ecology's Construction Stormwater General Permit.

2.2.3 Core Requirement #3: Source Control of Pollution

All known, available, and reasonable source control BMPs shall be applied to all projects to prevent stormwater from coming in contact with pollutants on the developed site.

"Source control" is *postdevelopment* pollution prevention which applies after development occurs. Core Requirement #2 addresses source control during construction, while Core Requirement #3 focuses on postdevelopment measures to prevent pollution. Source control BMPs shall be selected, designed, and maintained according to Volume IV of the 20192019 Ecology Manual, as described and referenced in Chapter 9. Source control BMPs shall be identified in the Stormwater Site Plans submitted for City review and must be shown on all applicable plans submitted for City review and approval.

Objective

The 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 or a TMDL (also known as a water cleanup plan or water quality improvement program) 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 Chapter 9 for design details of these BMPs. For construction sites, see Chapter 5.

2.2.4 Core Requirement #4: Preservation of Drainage Systems and Outfalls

Both natural drainage patterns and existing stormwater drainage systems shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable.

Objective

To preserve and utilize 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.

Guidelines

The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters or down gradient properties. The discharge must have an identified overflow route that is safe and certain, and leads to the ultimate outfall location (such as a receiving water or municipal drainage system). All outfalls require energy dissipation. To demonstrate compliance with this core requirement, all projects shall submit a *qualitative analysis* downstream from the site to the receiving water. A *quantitative analysis* may be required for any project deemed to need additional downstream information or where the project proponent or the SDM Administrator determines that a quantitative analysis is necessary to evaluate the off-site impacts or the capacity of the conveyance system. See Chapter 3 for additional details.

Off-site drainage is drainage from adjacent property that enters the proposed project site in other than a defined natural channel. Existing off-site flows must be accommodated without causing erosion or flooding impacts. Off-site flows shall not be routed through the project's conveyance, treatment, or retention/detention systems, unless those systems are sized to control those flows. Off-site contribution areas shall be mapped.

Off-site flows that are collected and routed through or around the site in a separate conveyance shall be dispersed at the downgradient property line, if feasible, or discharged at a project outfall (or outfalls) in a manner that does not violate the criteria below or cause the capacity of a conveyance system to be exceeded.

Where no conveyance system exists at the adjacent downgradient property line and the discharge was previously unconcentrated flow or significantly lower concentrated flow, 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.

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, including off-site drainage, must be discharged as follows:

1. If the 100-year peak discharge, as estimated using an approved continuous simulation model using 15-minute time steps, is less than or equal to 0.3 cfs under existing conditions and will remain less than or equal to 0.3 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.

2. If the 100-year peak discharge, as estimated using an approved continuous simulation model using 15-minute time steps, is between 0.3 and 0.75 cfs under existing conditions and will remain in that range 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.

3. If the 100-year peak discharge, as estimated using an approved continuous simulation model using 15-minute time steps, is greater than 0.75 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 shall 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 retention, detention, or runoff treatment BMPs, as required by this manual, shall 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 Chapter 6.

2.2.5 Core Requirement #5: On-Site Stormwater Management

Projects shall employ on-site stormwater management BMPs in accordance with the following project thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff on site to the extent feasible without causing flooding or erosion impacts. Table 2.1 summarizes the list approach compliance method for Core Requirement #5. A flow chart (Figure 2.3) is provided at the end of this section to help summarize the key components of this core requirement.

Objective

To use practices as feasible, distributed across a development, which reduce the amount of disruption of the natural hydrologic characteristics of the site, and keep runoff on the parcel/lot on which it originates by keeping it dispersed rather than concentrated.

Project Thresholds

Core Requirements #1 Through #5

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

1. Use LID BMPs from List #1 for all surfaces within each type of surface in List #1 for each Site or Project Site; or

2. Demonstrate compliance with the LID Performance Standard. Projects selecting this option cannot use rain gardens. They may choose to use bioretention areas as described in Chapter 7, Section 7.4.4, to achieve the LID Performance Standard. Projects selecting this option must implement the post-construction soil quality and depth BMP described in Chapter 7, Section 7.4.1.

Core Requirements #1 Through #9

Projects triggering Core Requirements #1 through #9 shall either:

1. Use LID BMPs from List #2 for all surfaces within each type of surface in List #2 for each Site or Project Site; or

2. Use the LID Performance Standard and post-construction soil quality and depth BMP (see Chapter 7, Section 7.4.1). Projects selecting this option cannot use rain gardens.

Projects triggering Core Requirements #1 through #9 which qualify as Flow Control exempt in accordance with the TDA Exemption in Core Requirement #7 (Section 2.2.7) shall either:

1. Use the LID BMPs from List #3 for all surfaces within each type of surface in List #3 for each tract, parcel, or lot within the Site or Project Site; or

2. Use any flow control BMP(s) desired to achieve the LID Performance Standard and apply the post-construction soil quality and depth BMP. Projects selecting this option cannot use rain gardens.

If the project has multiple TDAs, all TDAs must be flow control exempt per the TDA Exemption in Core Requirement #7 (Section 2.2.7) for the project to use the options listed here.

Low Impact Development Performance Standard

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

In order to meet the LID Performance Standard, designers may use any flow control BMP. There are no specific flow control BMPs that must be used to meet the LID Performance Standard. In order to meet the LID Performance Standard, the selected flow control BMPs will most likely need to include infiltration.

Note that rain gardens cannot be used to meet the requirements of the LID Performance Standard. This is because the LID Performance Standard requires the submittal of an engineered design and analysis and rain gardens by definition are non-engineered. For projects proposing to meet the LID Performance Standard, a bioretention BMP must be used in lieu of a rain garden, even though they may look and perform similarly in practice.

List Approach

The list approach compliance method for Core Requirement #5 required evaluating the BMPs in List #1, #2, or #3 (see Table 2.1).

For each surface, evaluate the feasibility of the BMPs in the order listed, and use the first BMP that is considered feasible. The designer must document the site conditions and infeasibility criteria used to deem BMPs infeasible. Once a BMP is deemed feasible and used for a surface, 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 Chapter 7 and Appendix 7B of this manual; and

2. Competing Needs Criteria listed below.

If all BMPs in the list are infeasible, then the designer must document the site conditions and infeasibility criteria used to deem each BMP infeasible. This documentation will demonstrate compliance with Core Requirement #5.

Table 2.1. The List Approach for Core Requirement #5 Compliance.

List #1 (for projects triggering Core Requirements #1–5)	List #2 (for projects triggering Core Requirements #1–9)	List #3 (for flow control exempt projects)
Surface Type: Lawn and Landscaped Areas		
Post-Construction Soil Quality and Depth (Chapter 7, Section 7.4.1)	Post-Construction Soil Quality and Depth (Chapter 7, Section 7.4.1)	Post-Construction Soil Quality and Depth (Chapter 7, Section 7.4.1)
Surface Type: Roofs		
1. Full Dispersion (Chapter 7, Section 7.4.2) or Downspout Full Infiltration (Chapter 7, Section 7.4.10) 2. Rain Gardens (Chapter 7, Section 7.4.5)[1] or Bioretention (Chapter 7, Section 7.4.4)[1] 3. Downspout Dispersion Systems (Chapter 7, Section 7.4.10) 4. Perforated Stub-out Connections (Chapter 7, Section 7.4.10)	1. Full Dispersion (Chapter 7, Section 7.4.2) or Downspout Full Infiltration (Chapter 7, Section 7.4.10) 2. Bioretention (Chapter 7, Section 7.4.4)[1] 3. Downspout Dispersion Systems (Chapter 7, Section 7.4.10) 4. Perforated Stub-out Connections (Chapter 7, Section 7.4.10)	1. Downspout Full Infiltration (Chapter 7, Section 7.4.10) 2. Downspout Dispersion Systems (Chapter 7, Section 7.4.10) 3. Perforated Stub-out Connections (Chapter 7, Section 7.4.10)
Surface Type: Other Hard Surfaces		
1. Full Dispersion (Chapter 7, Section 7.4.2) 2. Permeable Pavements (Chapter 7, Section 7.4.6)[2] or Rain Gardens (Chapter 7, Section 7.4.5)[1] or Bioretention (Chapter 7, Section 7.4.4)[1] 3. Sheet Flow Dispersion (Chapter 7, Section 7.4.2) or Concentrated Flow Dispersion (Chapter 7, Section 7.4.2)	1. Full Dispersion (Chapter 7, Section 7.4.2) 2. Permeable Pavements (Chapter 7, Section 7.4.6)[2] 3. Bioretention (Chapter 7, Section 7.4.4)[1] 4. Sheet Flow Dispersion (Chapter 7, Section 7.4.2) or Concentrated Flow Dispersion (Chapter 7, Section 7.4.2)	Sheet Flow Dispersion (Chapter 7, Section 7.4.2) or Concentrated Flow Dispersion (Chapter 7, Section 7.4.2)

Notes for using the List Approach:

[1] Rain Gardens and Bioretention used in the List Approach to have a minimum horizontal projected surface area below the overflow which is at least 5% of the area draining to it.

[2] When the designer encounters Permeable Pavements in the List Approach, it 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.

Competing Needs

LID BMPs can be superseded or restricted where they are in conflict with:

- Requirements of the following federal or state laws, rules, and standards:
  - Historic preservation laws and archaeology laws listed at <https://dahp.wa.gov/project-review/preservation-laws>
  - Federal Superfund or Washington State Model Toxics Control Act (MTCA)
  - Federal Aviation Administration requirements for airports
  - Americans with Disabilities Act (ADA)
- Special zoning district design criteria adopted and being implemented pursuant to a community planning process found in Title 16 Lacey Municipal Code (LMC); the existing local codes may supersede or alter the LID requirement.
- Public health and safety standards.
- Transportation regulations to maintain the option for future expansion or multi-modal use of public rights-of-way.
- Critical Area Ordinance (Chapter 16.54 LMC), as well as Chapter 14.32 LMC that provides specific protection of tree species.
- A local code or rule adopted as part of a wellhead protection program established under the Safe Drinking Water Act; or adopted to protect a critical aquifer recharge area established under the state Growth Management Act.

Supplemental Guidelines

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

An adopted and implemented basin plan, or a TMDL may be used to develop on-site stormwater management requirements that are tailored to a specific basin and may also be used to ensure that stormwater design provides a sampling location for sampling the water quality of any stormwater leaving the site. However, on-site stormwater management requirements shall not be less than that required by List #1, List #2, List #3, or the LID Performance Standard.

Recent research indicates that 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 simulation 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 minimize their disruption of the natural hydrologic cycle in order to avoid significant natural resource degradation in lowland streams.

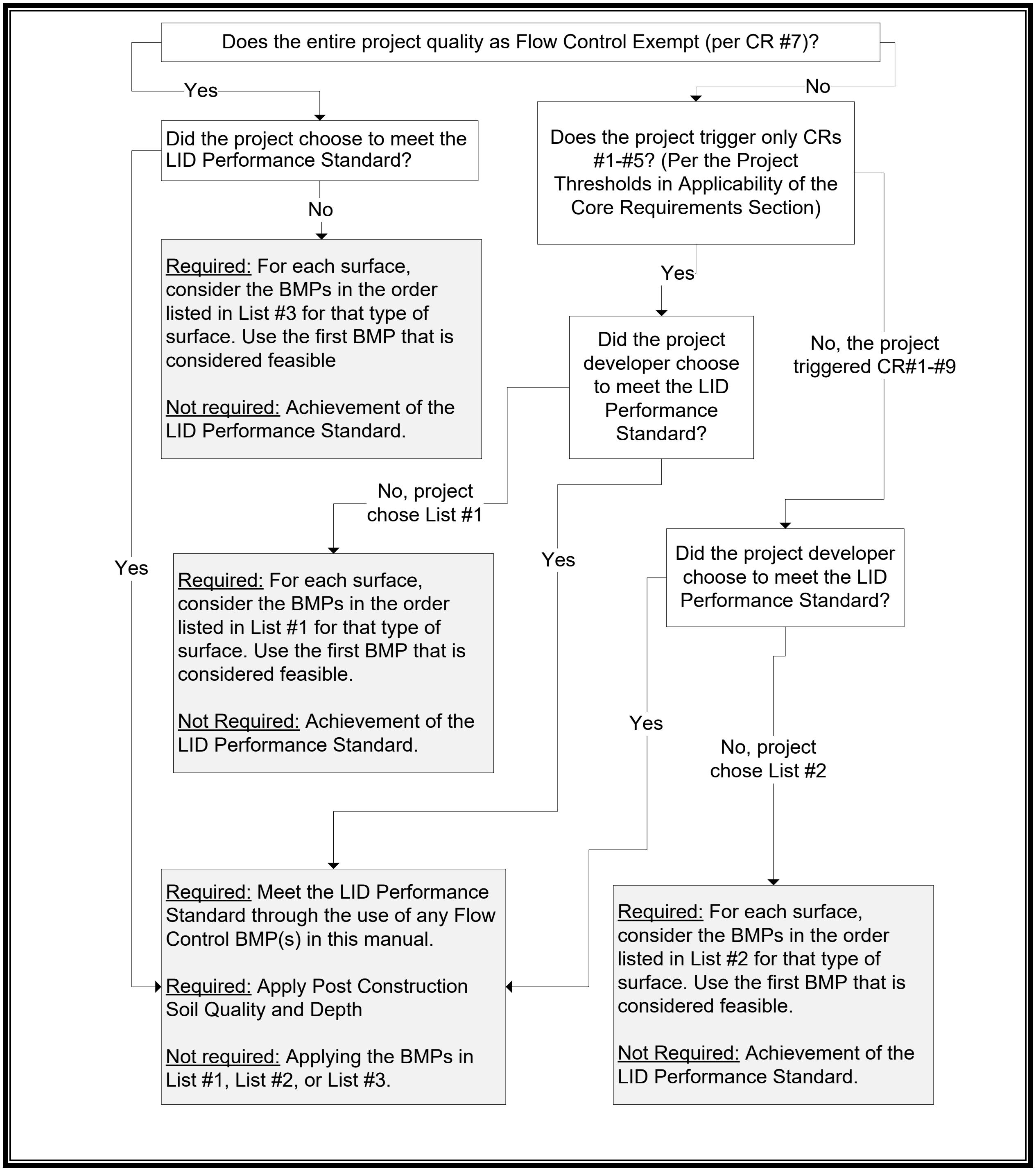


Figure 2.3. Flow Chart for Determining Core Requirement #5 Requirements.

2.2.6 Core Requirement #6: Runoff Treatment

Runoff treatment shall be provided at development project sites to remove pollutants from stormwater runoff, and to reduce the water quality impacts of stormwater runoff.

This shall include treatment for oil products, phosphorus control, basic treatment for suspended solids, or enhanced treatment for dissolved metals for projects that meet specified thresholds.

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.

Runoff Treatment BMP Selection, Design, and Maintenance

Runoff treatment BMPs shall be:

- Selected in accordance with the process identified in Chapter 4 and detailed in Chapter 8
- Designed in accordance with the design criteria in Chapter 8
- Maintained in accordance with the maintenance checklists in Chapter 10.

TDA Thresholds

Each TDA within a project that requires Core Requirement #6 (as detailed in Section 2.1.2 Applicability of the Core Requirements) must be reviewed to determine if Runoff Treatment BMPs are required for the TDA to be in compliance with Core Requirement #6.

Any TDA that includes a deep UIC well is required to construct stormwater treatment facilities. Additional treatment volume/flow rate requirements apply to projects with deep UICs. For more information related to deep UICs and the UIC Program, refer to Chapter 7, Appendix 7C.

Note that it is possible for a project that requires Core Requirement #6 with multiple TDAs to not need runoff treatment BMP(s) in one or more individual TDAs. If a TDA does not trigger the TDA threshold for runoff treatment BMPs, then the designer must document the areas within the TDA used to determine that the TDA threshold was not met. This documentation will demonstrate compliance with Core Requirement #6 for the TDA.

When assessing a TDA against the following thresholds, only consider those hard and pervious surfaces that are subject to this core requirement as determined in Section 2.1.2 of this chapter.

The following TDAs require construction of stormwater treatment facilities. If a TDA meets any of the following thresholds, runoff treatment BMPs are required. The project proponent must demonstrate that the TDA does not meet either of the following thresholds for runoff treatment BMPs to not be required for that TDA.

- TDAs in which the total of effective, pollution-generating hard surface (PGHS) is 5,000 square feet or more, or
- TDAs in which the total area of pollution-generating pervious surfaces (PGPS)—not including permeable pavements—is 0.75 acre or more, and from which there will be a surface discharge in a natural or constructed conveyance system from the site.

Additional Requirements

Direct discharge of untreated stormwater from pollution-generating impervious surfaces to groundwater is prohibited. Chapter 8, Section 8.3 provides additional detail on stormwater treatment requirements that may apply to projects that incorporate infiltration facilities, while Section 8.6.3 details the soil requirements to achieve runoff treatment through infiltration. Projects proposing to drain to existing BMPs must ensure and provide documentation that those BMPs have been maintained, are fully functional, and have adequate capacity.

Additional/specific requirements apply to development projects located within basins with known water quality problems. A water quality problem, for the purposes of impact mitigation in this manual, is defined as a stream reach, lake, or other waterbody of the state that is either: currently designated in the state’s Water Quality Assessment 303(d)/305(b) Integrated Report as a Category 5, 4, or 2 water due to exceedance or concern for exceedance of the state’s numeric action standard for any pollutants of concern (fecal coliform, dissolved oxygen, or temperature, as noted below), or 2) is currently designated by the City or Thurston County as a problem based on credible data indicating exceedance or concern for exceedance of the state’s numeric action standard.

Based on the current 303(d) listings in the City, there are currently three types of downstream water quality problems for which additional attention needs to be given to preventing or minimizing increases in the pollutant or pollutants of concern discharging from the site (fecal coliform bacteria, dissolved oxygen, or temperature issues). The additional requirements associated with these known problem conditions are outlined in Chapter 8, Sections 8.2.1 and 8.3.5.

Supplemental Guidelines

See Chapter 8 for more detailed guidance on selection, design, and maintenance of treatment facilities. Chapter 8 includes performance goals for basic, enhanced, phosphorus, and oil control treatment, and a menu of BMP options for each treatment type. Runoff treatment BMPs 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, or a TMDL 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 applicable treatment menu for the site (see Chapter 8, Section 8.3).

Runoff treatment BMPs 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). 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; state groundwater quality standards, Chapter 173-200 WAC; state sediment management standards, Chapter 173-204 WAC; and the underground injection control program, 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 BMPs that utilize the natural soil profile can also be very effective at treating stormwater runoff. However, note that pretreatment is required for most infiltration facilities, and soil conditions must also be appropriate to achieve effective treatment while not impacting groundwater resources. See Chapter 8, Sections 8.2.2 and 8.6.3 for further details.

2.2.7 Core Requirement #7: Flow Control

Projects that discharge stormwater directly or indirectly into surface water must provide flow control of stormwater discharges and infiltration, to reduce the impacts of stormwater runoff from impervious surfaces and land-cover conversions. Discharges to closed depressions also must provide flow control to minimize potential flooding in the closed depression area.

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 historical rainfall and natural land cover conditions. That threshold is assumed to be 50 percent of the 2-year recurrence interval peak flow. Maintaining the naturally occurring erosion rates within streams is vital, though by itself insufficient, to protect fish habitat and production.

TDA Exemption

Flow control is not required for TDAs that discharge to Puget Sound or the Nisqually River.

Discharges to flow control-exempt waters are only allowed in accordance with 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.
- If flow splitters or conveyance elements are applied to route natural runoff volumes from the TDA to any downstream Type 5 stream or Category IV wetland, then:
  - Design of flow splitters or conveyance elements must be based on approved continuous simulation modeling analysis. The design must assure that flows delivered to Type 5 stream reaches will approximate, but in no case exceed, durations ranging from 50 percent of the 2-year to the 50-year recurrence interval peak flow.
  - Flow splitters or conveyance elements that deliver flow to Category IV wetlands must also be designed using approved continuous simulation modeling to preserve pre-project wetland hydrologic conditions unless specifically waived or exempted by regulatory agencies with permitting jurisdiction.
- The TDA must be drained by a conveyance system that is composed entirely of constructed conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water mark of the exempt receiving water.
- The conveyance system between the TDA 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 off-site areas from which runoff is or will be collected.
- Any erodible elements of the constructed conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.
- Surface water from the area must not be diverted from or increased to an existing wetland, stream, or near-shore habitat sufficient to cause a significant adverse impact.

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 Core Requirement #8 apply.

Refer to Appendix I-E (Flow Control Exempt Surface Waters) of the 2019 Ecology Manual for a complete list of Flow Control Exempt Surface Waters. An exemption from flow control requirements for a waterbody that is not listed in Ecology's Appendix I-E (Flow Control Exempt Surface Waters) is subject to Ecology approval on the basis of a hydrologic study demonstrating the absence of significant downstream impacts.

TDA Thresholds

Each TDA within a project that requires Core Requirement #7 (as detailed in Section 2.1.2) must be reviewed to determine if Flow Control BMPs are required for the TDA to be in compliance with Core Requirement #7.

Note that it is possible for a project that requires Core Requirement #7 with multiple TDAs to not need flow control BMP(s) in one or more individual TDAs. If a TDA does not trigger the TDA thresholds for flow control BMPs, then the designer must document the areas within the TDA used to determine that the TDA thresholds were not met. This documentation will demonstrate compliance with Core Requirement #7 for the TDA

When assessing a TDA against the following thresholds, consider only those impervious, hard, and pervious surfaces that are subject to this core requirement as determined in Section 2.1.2. If a TDA meets any of the following thresholds, flow control BMPs are required. The project proponent must demonstrate that the TDA does not meet any of the following thresholds for flow control BMPs to not be required for that TDA.

The following circumstances require achievement of the standard flow control requirement for western Washington:

- TDAs in which the total of effective impervious surfaces is 10,000 square feet or more, or

- TDAs that convert 0.75 acre or more of vegetation to lawn or landscape, or convert 2.5 acres or more of native vegetation to pasture, and from which there is a surface discharge in a natural or constructed conveyance system from the TDA, or

- TDAs that through a combination of effective hard surfaces and converted vegetation areas cause a 0.15 cubic feet per second (cfs) increase in the 100-year recurrence interval flow frequency as estimated using the WWHM or other approved model and 15-minute time steps. See the supplemental guidelines below for example scenarios that could trigger this requirement.

Development projects that discharge stormwater off site shall submit an 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.

Discharge Requirements

The allowable release rates from a project are dependent upon the ultimate destination for the stormwater. All projects not directly attributable to Category B below, and not exempted per the flow-control exempt receiving waters outlined above, shall use Category A for determining the allowable discharge rates.

Category A: Discharge to a fresh waterbody.

Any waterbody not defined as a flow control-exempt receiving waters (described above), or closed depression.

Requirements

Stormwater discharges shall match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50 percent of the 2-year recurrence interval peak flow up to the full 50-year peak flow. The predeveloped condition to be matched shall be a forested land cover unless reasonable, historical information is provided that indicates the site was prairie prior to settlement (modeled as “pasture” in the WWHM).

In addition, flow control BMPs shall be selected, designed, and maintained according to this manual.

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 percent of the 2-year recurrence interval 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
- A duration control standard is not necessary for protection, maintenance, or restoration of designated and existing beneficial uses or Clean Water Act compliance.

Category B: Discharge to a closed depression.

Discharges to any low-lying area which has no outlet, or such a limited surface outlet that in most storm events the area acts as a retention basin holding water for infiltration or evaporation, shall be considered discharges to a closed depression. Appropriate runoff treatment BMPs shall be applied to all discharges.

Requirements

Due to the significant adverse impacts that can result from increasing the rate, volume, and duration of stormwater runoff to closed depressions, the contributing area to the closed depression must be analyzed using a continuous simulation model for the 100-year recurrence interval flow. When a proposed development contributes to a closed depression area, flow from the entire drainage basin tributary to the closed depression shall be routed into the closed depression, using only infiltration as outflow. (Infiltration rates shall be determined as specified in Chapter 7, Section 7.2.3, and Appendix 7A.) Discharge to the area may be allowed when modeling of the postdevelopment (i.e., postproject) high water level indicates no more than a 0.1-foot increase relative to the predevelopment (i.e., existing) high water level for the 100-year recurrence interval, unless the development has acquired ownership or discharge rights to the closed depression. Absent ownership or discharge rights, projects must excavate additional storage volume in the closed depression (subject to all applicable requirements, for example, providing a defined overflow system) needed to achieve the 0.1-foot maximum water level increase.

Note that where there is a flooding potential, concern about rising ground water levels, property rights/ownership/use issues, or sensitive area ordinances and rules, this analysis may not be sufficient. In such cases, the City may require additional analysis and impose more stringent requirements.

Appropriate runoff treatment BMPs must also be applied to all discharges. When selecting appropriate treatment BMPs, the engineer shall assume the soil is fully saturated all year within the closed depression unless the engineer provides supporting documentation for an alternative condition.

Additional Requirements

Projects proposing to drain to existing BMPs must ensure and provide documentation that those BMPs have been maintained, are fully functional, and have adequate capacity.

Supplemental Guidelines

Calculations to determine whether a project exceeds 0.15 cfs using a 15-minute time step in the 100-year recurrence interval flow must be done individually for each project using an approved continuous simulation runoff model. The calculation will compare runoff in the postdevelopment site to the predevelopment land cover. Predevelopment, for this activity, is the lower runoff of the pre project condition or the site in 1997[1]. The unique site, soil, precipitation, and other project-specific factors will ultimately determine whether this threshold is exceeded. Nonetheless, the following general guidelines (based on hypothetical site designs) may be used to help identify the likelihood of this threshold being exceeded. The following land uses changes are likely to exceed this threshold under certain conditions:

[3] November 3, 1997, effective date of first ordinance to meet Clean Water Act and NPDES permit requirements for flow control.

- Converting approximately 5,000 square feet of forest to impervious surface
- Converting approximately 5,000 square feet of pasture to impervious surface
- Converting approximately 0.25 acre of forest to landscape surface
- Converting approximately 1.25 acres of forest to pasture surfaces (in till soil conditions).

Reduction of flows through infiltration decreases surface water runoff and helps to maintain base flow throughout the summer months. However, infiltration shall follow the requirements in this manual (particularly Chapters 7 and 8) to reduce the chance that groundwater quality is threatened by such discharges.

Chapter 7 includes a description of the WWHM and other approved continuous simulation runoff models. Some of these models provide tools and/or credits for use of certain on-site stormwater management BMPs and LID techniques described in Chapter 7. Using those BMPs and LID techniques reduces the predicted runoff rates and volumes and thus also reduces the size of the required flow control facilities.

Application of sufficient types of on-site stormwater management BMPs can result in reducing the effective impervious area and the converted vegetation areas, thereby reducing or eliminating the need for a flow control BMP. Impervious surfaces that are fully dispersed in accordance with full dispersion in Chapter 7, Section 7.4.2, are not considered effective impervious surfaces. Impervious surfaces that are dispersed in accordance with downspout dispersion in Chapter 7, Section 7.4.10; concentrated flow dispersion in Chapter 7, Section 7.4.2; and sheet flow dispersion in Chapter 7, Section 7.4.2, are still considered effective surfaces though they may be modeled as pervious surfaces if flow path lengths meet the specified minimums. Permeable pavers and modular grid pavements are assigned lower surface runoff calibrations and may also reduce flow control BMP sizes. See Chapter 7 for more complete descriptions of hydrologic credits for LID and on-site stormwater management BMPs.

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 drainage features. Bypassing shall not be considered as an alternative to applicable flow control or runoff treatment if the flooding, stream stability, water quality, or habitat problem to be solved would be caused by the project. In addition, the proposal shall 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 shall be documented by an engineer or scientist after review of any available drainage reports, basin plans, or other relevant literature. The restrictions in this core 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.

2.2.8 Core Requirement #8: Wetlands Protection

Wetlands protection is intended to prevent diminishment of the functions and values of wetlands by avoiding alterations to the structural, hydrologic, and water quality characteristics of existing wetlands to the extent feasible during new development, redevelopment, and stormwater management projects.

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 groundwater 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 the natural hydrologic pattern of the wetland

Applicability

The requirements below apply only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system.

Thresholds

Refer to Figure 2.4 to determine what level(s) of wetland protection must be applied to comply with Core Requirement #8.

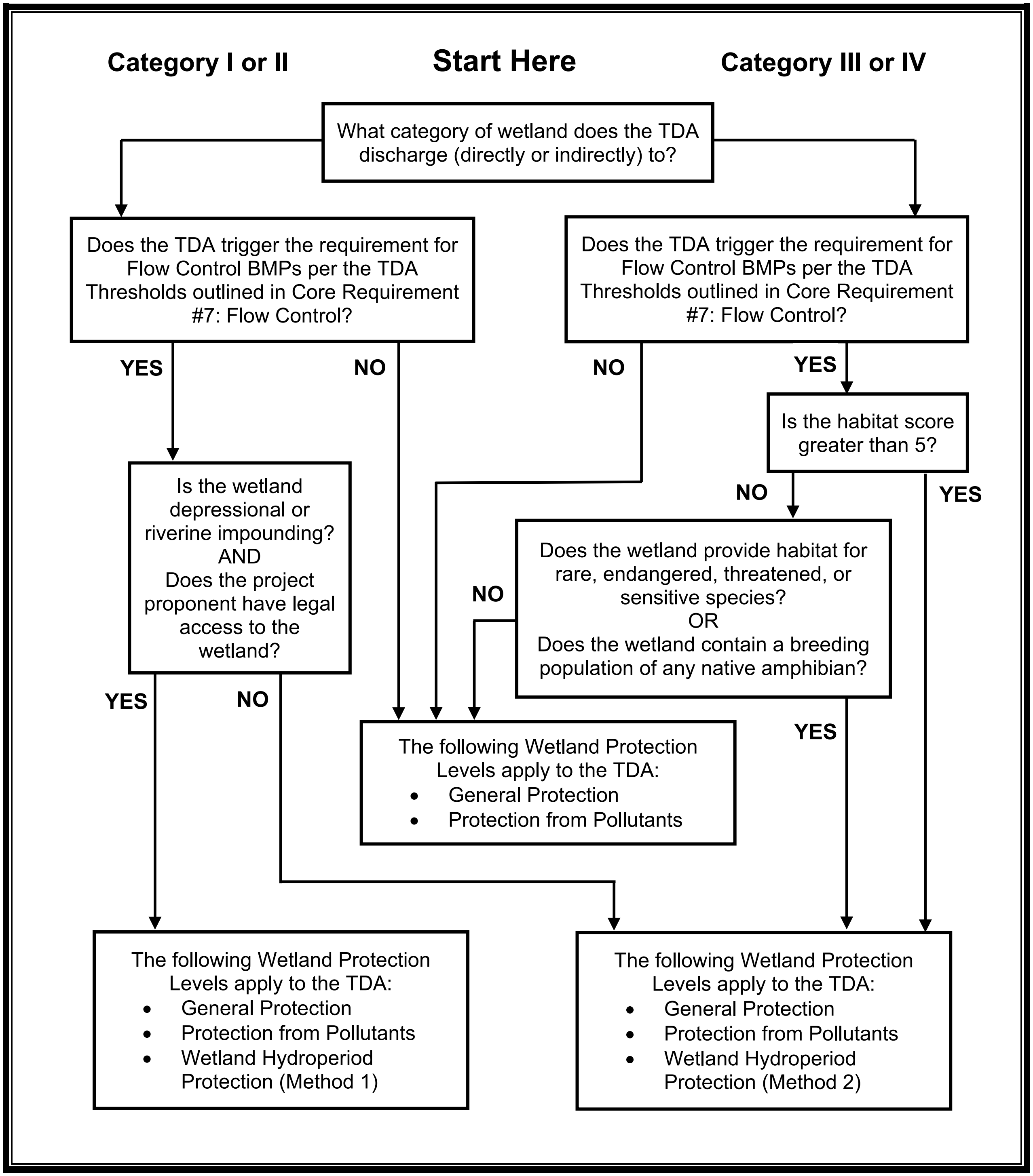


Figure 2.4. Flow Chart for Determining Wetland Protection Level Requirements.

Standard Requirement

Projects shall comply with Title 14 LMC, Chapter 14.28 LMC, and Appendix I-C of the 2019 Ecology Manual. For general protection, see Section I-C.2 and for wetland hydroperiod protection, see Section I-C.3 of the 2019 Ecology Manual. A wetland can be considered for hydrologic modification and/or stormwater treatment in accordance with City codes and Appendix I-C of the 2019 Ecology Manual.

Additional Requirements

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

- Necessary conveyance systems as approved by the City
- As allowed in Appendix I-C.6 of the 2019 Ecology Manual.

An adopted and implemented basin plan or TMDL may be used to develop requirements for wetlands that are tailored to a specific basin.

Supplemental Guidelines

Appendix I-C of the 2019 Ecology Manual, "Wetlands Protection Guidelines," shall be used for discharges to natural wetlands and wetlands constructed as mitigation. While it is always necessary to pretreat 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 must comply with the LMC as well as the requirements and Appendix I-C.

In most cases, if wetland hydroperiod protection is required per Core Requirement #8, then meeting the discharge requirements listed in Core Requirement #7 is also required. In these cases, the designer must attempt to meet the requirements for both Core Requirements. This may prove to be feasible in many situations because Core Requirement #7 will seek to adjust the flow in small time intervals and Core Requirement #8 looks to maintain daily flow volumes.

If the designer is unable to meet both requirements, then the requirement to maintain the hydroperiod of the wetland becomes the overriding concern and the designer must show compliance with Core Requirement #8. If this is the case, the designer must also provide documentation detailing why they are unable to meet both requirements.

2.2.9 Core Requirement #9: Operation and Maintenance

Maintenance access, a project-specific operation and maintenance agreement, and Maintenance and Source Control Manual shall be provided for all proposed stormwater facilities and BMPs.

The Maintenance and Source Control Manual shall be consistent with the provisions in Chapters 3, 9, and 10 of this manual. A Maintenance and Source Control Manual shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified. For most facilities, the owner shall sign the maintenance agreement and record it at the Thurston County Auditor's Office. At private facilities, a copy of the manual shall be retained on site or within reasonable access to the site, and shall be transferred with the property to the new owner. Copies of the agreement and manual shall be retained on site or within reasonable access to the site. For City-owned facilities, maintenance agreements are not required, but a copy of the maintenance manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken and when (as part of the required ongoing maintenance inspections) shall be kept and be available for inspection by the City at any time. See also the stormwater maintenance requirements in Chapter 14.25 LMC.

Objective

To ensure that stormwater control BMPs are adequately maintained and operated properly long-term.

Supplemental Guidelines

Inadequate maintenance is a common cause of failure for stormwater control facilities. The Maintenance and Source Control Manual should be viewed as the owner's manual, written for the person who was not the designer, builder, or inspector but who, in the future, is charged with the responsibility to maintain the facilities built for them. While the Maintenance and Source Control Manual may be submitted during permitting at the same time as the complete set of construction plans, the two are often separated after final construction. The manual should be written with sufficient information to describe the number, location, and type of BMPs as well as specific details and inspection intervals to ensure proper maintenance long into the future. The description of each BMP in Chapters 4, 5, 7, and 8 includes a section on maintenance to assist in writing the Maintenance and Source Control Manual. Chapter 10 includes maintenance checklists for many drainage BMPs.

2.3 Additional Requirements

2.3.1 Financial Guarantees

Maintenance and/or operational bonding or other appropriate financial guarantees are required for all projects to ensure construction and functionality of drainage facilities in compliance with applicable standards. These guarantees are to be consistent with the most recent edition of the City of Lacey *Development Guidelines and Public Works Standards*.

2.3.2 Other Additional Requirements

Requirements of this manual may be superseded or augmented by the adoption of ordinances and rules to implement the recommendations of watershed plans or basin plans, or through the adoption of actions and requirements identified in a TMDL (or water quality improvement program) that is approved by Ecology and the U.S. EPA. These additional requirements are reflected in (Core Requirement #6 and Chapter 8).

Additional requirements apply to projects that propose the use of deep UICs:

- Project proponents must develop a replacement plan or include additional property set asides to account for potential well failure.
- Project proponents must identify a party who has long-term responsibility and liability for the monitoring, maintenance, and potential replacement of the well.
- Project proponents must create a funding security mechanism.

For more information related to deep UICs and the UIC program, refer to Chapter 7, Appendix 7C.

The City may request additional information or impose controls that differ from (and may exceed the core requirements of) those specified in this manual, at the discretion of the City. In doing so, the City shall act reasonably, exercising best professional judgment based on available information. Typical reasons for requiring additional information or controls may include, but are not limited to, the following:

- Water quality degradation potential
- Stream bank erosion potential caused by increased flows, leading to habitat damage
- Flooding potential that may present risk to life, safety, vital services, or property
- TMDLs or other regulatory mandates imposed by state or federal agencies

2.4 Adjustments

Adjustments to the core requirements may be granted prior to permit approval and construction. The SDM Administrator may grant an adjustment, subject to a written finding of fact that documents the following:

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

2.5 Exceptions and Variances

Exceptions/variances to the core requirements may only be granted prior to permit approval and construction, subject to the requirements specified below and pursuant to provisions of the LMC. Chapter 2.30 LMC and Chapter 16.90 LMC, and other sections of the LMC may be applicable.

Exceptions and variances to the core requirements may be granted following legal public notice of an application for an exception or variance, legal public notice of the City's decision on the application, and written findings of fact that document the City's determination to grant an exception. The City shall keep records, including the written findings of fact, of all local exceptions to the core requirements.

The City may grant an exception to the core requirements if such application imposes a severe and unexpected economic hardship. To determine whether the application imposes a severe and unexpected economic hardship on the project applicant, the applicant must consider and document with written findings of fact the following:

- The current (pre-project) use of the site
- How the application of the core requirements restricts the proposed use of the site compared to the restrictions that existed prior to the adoption of the core requirements
- The possible remaining uses of the site if the exception were not granted
- The uses of the site that would have been allowed prior to the adoption of the core requirements
- A comparison of the estimated amount and percentage of value loss as a result of the core requirements versus the estimated amount and percentage of value loss as a result of requirements that existed prior to adoption of the core requirements
- The feasibility for the applicant to alter the project to apply the core requirements.

In addition, any exception must meet the following criteria:

- The exception will not 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 core requirements.

Chapter 3 – Stormwater Submittals

Table of Contents

Tables

Chapter 3 – Stormwater Submittals

3.1 Purpose, Content, and Organization

This chapter outlines the various requirements for submittals of stormwater plans, reports, and other documents for review by the City of Lacey (City). The submittals described in this chapter are required for compliance with Core Requirement #1: Preparation of Stormwater Site Plans and Reports, as well as for preparation of a Construction Stormwater Pollution Prevention Plan (SWPPP), in accordance with Core Requirement #2.

The amount of document preparation and review required for stormwater plan submittals are tiered to match the impact potential of a particular project to the appropriate amount of regulatory oversight and control. All projects are subject to the core requirements outlined in Chapter 2, and the plans described in this chapter meet the requirements of the Stormwater Site Plan required by Core Requirement #1. Based on the project size and proposed conditions, a project applicant will have to prepare one of three submittal types: a SWPPP Short Form, an Abbreviated Drainage Plan, or a Drainage Control Plan (outlined further below).

The remainder of this chapter is divided into three major sections:

- Section 3.2 describes which submittals are required, depending on project thresholds.
- Section 3.3 describes each type of drainage review submittal, including SWPPP Short Forms, Abbreviated Drainage Plans, and Drainage Control Plans.
- Section 3.4 describes submittal requirements for changes that may occur after Stormwater Site Plan approval.

3.2 Drainage Review Types and Submittals

Project thresholds and associated submittal requirements are summarized in Table 3.1. Project applicants should identify their type of project in the Table 3.1 rows, and then identify the appropriate submittal requirements by each column, as well as any applicable table notes. Note that Table 3.1 only summarizes submittal requirements and cannot be used to identify applicable minimum requirements, exemptions, etc. Project proponents must refer to Chapter 2 for detailed information and requirements.

For projects requiring an Abbreviated Drainage Plan or Drainage Control Plan, Table 3.2 provides an overview of the submittal requirements. Additional requirements for the Abbreviated Drainage Plan and Drainage Control Plan can be found in Sections 3.3.2 and 3.3.3, respectively.

Information on other project permit requirements and materials—including applications, fees, right-of-way use requirements, and other code requirements—are outlined in the City of Lacey *Development Guidelines and Public Works Standards* (DG&PWS) or can be obtained from the City of Lacey Public Works Department or Community and Economic Development Department.

In addition, any activity that alters the approved plans for a given project (e.g., stormwater best management practice [BMP] maintenance or repair, drainage BMP resizing, other project design changes to impervious surfaces or land cover) will require re-approval by the City, regardless of whether the thresholds listed in Table 3.1 have been exceeded. This may include updates to the original SWPPP Short Form, Abbreviated Drainage Plan, or Drainage Control Plan, and associated Construction SWPPP. See Section 3.4 for additional details.

3.2.1 City Projects

Projects conceived, designed, or constructed by or through an agent of the City shall meet the requirements of this manual. This includes development of all required Stormwater Site Plan documentation, and maintenance of records adequate to reflect compliance with these requirements.

3.2.2 Project Submittal Process

Presubmission Meeting

Most projects will require a presubmission meeting, as outlined in the DG&PWS. The presubmission meeting is to help the City understand the project, to help the project applicant understand the requirements, and to make a preliminary determination of the type of submittal required based on project thresholds.

Stormwater Scoping Meeting

In addition to the presubmission meeting described above, an optional stormwater scoping meeting can be conducted at the request of the project applicant prior to any stormwater plan submittals. The purpose of the stormwater scoping meeting is to discuss what stormwater requirements apply to a given project, and what steps the project proponent must take toward developing a complete project submittal.

Draft Stormwater Site Plans

Projects requiring an Abbreviated Drainage Plan (per Section 3.3.2) or Drainage Control Plan (per Section 3.3.3) shall submit a complete draft of the plan for review and inclusion in the permit or land use application package, provided to the City in both electronic (PDF) and hard copy formats. **The draft plan shall target an approximately 90 percent (or greater) level of completion, with the majority of the content outlined in Section 3.3 being complete or nearly complete at the time of submittal.** The draft Stormwater Site Plan submittal for land-use approval shall include the following:

- Draft Abbreviated Drainage Plan or Drainage Control Plan Report
    - Documentation of feasibility for all proposed BMPs
    - Documentation that all applicable core requirements will be met
- 90 Percent Site Development Drawings
- Draft Construction SWPPP (Temporary Erosion and Sediment Control [TESC] Plan and narrative document)
- Soils Report (if required)
- Initial Land Use Application

Plan drawings shall show a well-developed concept with sufficient detail to enable review and evaluation of the feasibility and acceptability of the proposed Stormwater Site Plan. All pertinent Drainage Report documentation requirements (per Section 3.3), including the soils report and infiltration analysis, shall also be sufficient to enable review and evaluation of the proposed plan. Minor changes and revisions may be made following the draft plan submittal and review, though substantive changes are only expected if the draft plan does not meet the intent or requirements of this manual.

A Drainage Report template is available on the City's website.

Final Stormwater Submittal

After the draft Abbreviated Drainage Plan or draft Drainage Control Plan has been reviewed and accepted (e.g., Site Plan Review approval or Preliminary Plat approval), the applicant shall submit a final plan for the project, incorporating any comments and necessary revisions from the draft plan review. The final Stormwater Site Plan shall incorporate any minor revisions and modifications identified in the draft and shall be provided to the City in both electronic (PDF) and hard copy formats as specified in the DG&PWS.

The final Abbreviated Drainage Plan or Drainage Control Plan is intended to be complete and final, however it is understood that occasionally further changes may be needed after project approval. See Section 3.4 for procedures related to submitting changes to final plans after approval.

3.2.3 Design Plan Certification

All preliminary and final plans, drawings, and reports must be stamped and signed by a professional engineer licensed in Washington State. In many situations, it also will be necessary for a licensed professional to prepare components of the Abbreviated Drainage Plan. See Sections 3.3.1 through 3.3.3 for plan-specific requirements.

All land boundary surveys, and legal descriptions used for preliminary and engineering plans must be stamped and signed by a land surveyor licensed in Washington State. Topographic survey data and mapping prepared for a proposed project may be performed by the professional engineer who stamps the engineering plans.

Table 3.1. Thresholds for SWPPP Short Forms, Abbreviated Drainage Plans, and Drainage Control Plans.

Category[a,b,c]	<2,000 sq. ft. New or Replaced Impervious/Hard Surface	If Core Requirements #1 through #5 Apply	If Core Requirements #1 through #9 Apply
Subdivisions, Short Plats, Binding Site Plans	SWPPP Short Form	Abbreviated Drainage Plan	Drainage Control Plan
Creation of New or Replaced Impervious/Hard Surface[d]	SWPPP Short Form	Abbreviated Drainage Plan[e]	Drainage Control Plan[e]
Construction of Roads, Shared Accesses, and Alleyways	SWPPP Short Form	Abbreviated Drainage Plan	Drainage Control Plan
Building Permit	SWPPP Short Form	Abbreviated Drainage Plane	Drainage Control Plane
Clearing or Grading	SWPPP Short Form	Abbreviated Drainage Plan	Drainage Control Plan
Maintenance and Repair of Roads, Shared Accesses, and Alleyways		Abbreviated Drainage Plan	Drainage Control Plan
Utility Line Work (construction or maintenance—inside right-of-way)[f]		Abbreviated Drainage Plan	Drainage Control Plan
Utility Line Work (construction or maintenance—outside right-of-way)[d,g]		Abbreviated Drainage Plan	Drainage Control Plan
Driveway culvert installation in Roadside Swales/Ditches[h]	SWPPP Short Form		

SWPPP Short Form = Construction Stormwater Pollution Prevention Plan Short Form (see Appendix 3A).

sq. ft. = square feet.

Note that all Abbreviated Drainage Plans and Drainage Control Plans also require a completed Construction Stormwater Pollution Prevention Plan (SWPPP).

[a] See Chapter 2 to identify applicable minimum requirements, exemptions, etc. Chapter 2, Section 2.1.3 in particular includes information on projects that are exempt from the requirements of this manual. Table 3.1 is only intended to summarize submittal requirements, not overall project requirements.

[b] For sites that contain critical areas or critical area buffers, a submittal stamped by a professional engineer licensed in Washington State is required, unless waived by the City.

[c] All development must consider the thirteen elements of Core Requirement #2 (see Section 2.4.2). Depending on the scope of the project, components of the Construction SWPPP shall be required with the plan submittal.

[d] Routine, repetitive maintenance or repair activities that do not meet the threshold for an Abbreviated Drainage Plan or Drainage Control Plan shall be performed in accordance with standard BMPs as published by the City.

[e] As noted in Chapter 2, Section 2.1.2, projects that exceed the above thresholds and: 1) are within the 1-year time of travel zone for a wellhead protection area, and 2) contain existing hard surfaces that do not drain to an approved stormwater management BMP are required to apply the applicable core requirements to the entire project site (i.e., not just to the new and replaced hard surfaces).

[f] All work shall be performed in accordance with the DG&PWS, shall include the implementation of the applicable Abbreviated Drainage Plan or Drainage Control Plan measures, and shall be in compliance with this manual for the life of the installation.

[g] An individual site development permit is not required if utility line improvements are performed within a larger project (i.e., subdivision construction) that has a site development permit and the utility line improvements have been addressed under the larger project's site development permit.

[h] Driveway culvert size and location to be per City inspector's direction. The City may require that the project applicant retain an engineer to size and design the culvert in situations where there may be a drainage issue. Note that a driveway and/or right-of-way permit may also be required.

Table 3.2. Abbreviated Drainage Plan and Drainage Control Plan Requirements.

	Abbreviated Drainage Plan	Drainage Control Plan
Applicable Core Requirements		
Core Requirements #1-5	✓	✓
Core Requirements #6-9	Not Applicable	✓
Drainage Report		
Section 1: Project Overview	✓	✓
Section 2: Development Conditions and Requirements	✓	✓
Section 3: Site and Vicinity Description	✓	✓
Section 4: Soils and Infiltration Analysis	★	✓
Section 5: On-Site Stormwater Management and LID (Core Requirement #5)	✓	✓
Section 6: Runoff Treatment and Flow Control (Core Requirements #6 & #7)	Not Applicable	✓
Section 7: Runoff Collection and Conveyance System	If Applicable to Project	✓
Section 8: Source Control (Core Requirement #3)	✓	✓
Section 9: Covenants, Dedications, Easements, Agreements, and Guarantees	✓	✓
Appendices		
Appendix 1: Maps and Plans		
• Vicinity Map	✓	✓
• NRCS Soil Types Map	✓	✓
• Existing Site Topography	✓	✓
• Basin Map	If Applicable to Project	✓
• Soil Pits/Borings	★	✓
• Stormwater Drainage Plan (duplicated from full-size plan set)	✓	✓
• Stormwater Details (duplicated from full-size plan set)	✓	✓
Appendix 2: Supplemental Reports and Information		
• Soils and Geotechnical Report	★	✓
• Other Environmental Analyses (e.g., Wetlands Report)	If Applicable to Project	If Applicable to Project
• GULD Documents and Manufacturer's Product Information	If Applicable to Project	If Applicable to Project
Appendix 3: Design Calculations	✓	✓
Appendix 4: Soil Management Plan	★	✓
Attachments		
Attachment No. 1: Construction SWPPP	✓	✓
Attachment No. 2: Maintenance and Source Control Manual	Not Applicable	✓

✓ Include in Abbreviated Drainage Plan or Drainage Control Plan

★ Soils documentation generally required for most sites/projects, though usually less extensive than for full Drainage Control Plan.

3.3 Drainage Submittals for Permit Application

3.3.1 SWPPP Short Form

In accordance with Core Requirement #2, all projects must address construction-phase erosion and sediment control, starting prior to initial land disturbance and continuing throughout the site work. Projects that are identified in Table 3.1 as needing a SWPPP Short Form shall submit a complete SWPPP Short Form (see Appendix 3A) as well as a basic site illustration showing existing and proposed site features including SWPPP BMPs. The intent of the SWPPP Short Form is to record basic project information, and to document that the 13 construction stormwater pollution prevention elements of Core Requirement #2 are being considered and addressed as applicable.

3.3.2 Abbreviated Drainage Plan

Projects that are identified in Table 3.1 as needing an Abbreviated Drainage Plan require a Site Development Permit submittal, document preparation, City review, and City inspection. Abbreviated Drainage Plans have to address Core Requirements #1 through #5. An overview of the Abbreviated Drainage Plan requirements is included in Table 3.2 and detailed descriptions are outlined in the following subsections. Refer to the DG&PWS for requirements related to the number of copies and dimensions required by the City.

The purpose of an Abbreviated Drainage Plan is:

1. To ensure that a project complies with the applicable core requirements.

2. To incorporate requirements that achieve the intent and purpose of the Critical Area Regulations. Flood, landslide, shoreline erosion, wetland, and other critical areas sometimes require measures that must be depicted on Abbreviated Drainage Plan drawings to achieve compliance with these regulations.

3. To prevent development-related stormwater runoff from impacting neighboring properties.

Abbreviated Drainage Plan Requirements

If new, replaced, or new plus replaced hard surfaces are greater than or equal to 2,000 square feet (but less than 5,000 square feet), or if land-disturbing activity is greater than or equal to 7,000 square feet, an Abbreviated Drainage Plan must be submitted. Fundamentally, the Abbreviated Drainage Plan must demonstrate how Core Requirements #1 through #5 are being met. Note that Core Requirement #5 includes detailed requirements and decision points that can affect the project significantly, which must be reflected in the Abbreviated Drainage Plan documentation. Likewise, compliance with Core Requirement #2 will require preparation of a full Construction SWPPP.

The following sections provide detail on the requirements for Abbreviated Drainage Plans. Each section covers a required Abbreviated Drainage Plan section or attachment. In many situations, it will be necessary for a licensed professional to prepare components of the Abbreviated Drainage Plan. In some cases, the additional required information pertinent to the Abbreviated Drainage Plan may be available within the plat or other approved documents related to the project.

The following Abbreviated Drainage Plan topics are discussed:

- Abbreviated Drainage Plan Report sections
- Abbreviated Drainage Plan appendices
  - Drawing requirements for Abbreviated Drainage Plans
  - Soils Report requirements
- Abbreviated Drainage Plan attachments
  - Construction SWPPP requirements

Abbreviated Drainage Plan Report

The Abbreviated Drainage Plan Report is a major component of the Abbreviated Drainage Plan. The Abbreviated Drainage Plan Report shall include detailed information and data related to stormwater planning and design that facilitate plan review. Specific components of the Abbreviated Drainage Plan Report are described in detail below.

Cover Sheet: The Abbreviated Drainage Plan Report must have a cover sheet with the following information included:

- Title “Abbreviated Drainage Plan Report for (project name)”
- Project location
- Project applicant’s name, address, telephone number, and e-mail address
- Project engineer’s (if applicable) name, company name, address, telephone number, and e-mail address
- Date of submittal

Project Engineer’s Certification: The project engineer responsible for completion of an Abbreviated Drainage Plan submittal as described herein shall be a professional engineer licensed in Washington State. All plans and specifications, calculations, certifications, as-built drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer’s official seal and signature.

The Abbreviated Drainage Plan Report shall contain a page with the project engineer's seal and the following statement:

> *"I hereby state that this Abbreviated Drainage Plan Report for__________________ (name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the City of Lacey does not and will not assume liability for the sufficiency, suitability, or performance of stormwater BMPs prepared by me."*

Table of Contents: Show the page number for each section of the report. Show page numbers of appendices. Identify all attachments included with the report. All pages of the Abbreviated Drainage Plan Report shall be numbered.

All Abbreviated Drainage Plan Reports shall include each of the following section titles and subsections (if some sections do not apply, keep the section titles, but designate as "Not applicable" where a specific section does not apply.):

Abbreviated Drainage Plan Report Section 1: Project Overview

1.1 Site Information: Parcel number(s), address or legal description of site property, current zoning, streets/general vicinity, property owner(s), total project site area, surrounding land uses.

1.2 Project Description: Provide a brief description of the proposed development project (type, size, location, proposed improvements including structures and paving, phasing (if applicable), and for additions/remodels only, current assessed value and cost of improvements excluding land value).

1.3 Proposed Stormwater Drainage Design: Describe the overall drainage plan concept, proposed permanent stormwater BMPs, their locations and distribution across the site, and proposed ownership (e.g., private or public). Briefly describe all stormwater features proposed to be installed for runoff collection, conveyance, runoff treatment, and infiltration and/or discharge (types, sizes, and locations). If applicable, describe the detention system, control structure/outlet, and spillways. See Chapter 8 for more details regarding stormwater BMPs that could be adopted and maintained by the City.

1.4 Subarea Data Tabulation: Provide data tables for existing and proposed surface areas, including hard surface areas by type (roof, driveway, walkway, etc.); new and replaced impervious, pervious, and hard surface areas; pollution-generating impervious and pervious surfaces (PGIS and PGPS); disturbed pervious (such as landscaped areas); converted vegetation areas; and undisturbed areas. Example subarea data tabulations for existing and proposed surface areas are provided in Tables 3.3 and 3.4.

Table 3.3. Example Existing Site Land Coverage Tabulation for an Abbreviated Drainage Plan.			
Existing Surface	**Surface Type**	**Area (square feet)**	**Area (acres)**
Driveway	Hard/Impervious		
Walkway	Hard/Impervious		
Roof	Hard/Impervious		
Forested/Trees	Pervious		
Pasture/Landscaping	Pervious		
	Total Site/Parcel Area		

Table 3.4. Example Proposed Site Land Use Coverage Tabulation for an Abbreviated Drainage Plan.				
Proposed Surface	**Surface Type**	**Pollutant Generating**	**Area (square feet)**	**Area (acres)**
Roadway	Hard/Impervious	Yes - PGIS		
Driveway	Hard/Impervious	Yes - PGIS		
Walkway	Hard/Impervious	No		
Roof	Hard/Impervious	No		
Permeable Pavement	Hard/Pervious	Yes - PGPS		
Landscaping	Pervious	Yes - PGPS		
Undisturbed (e.g., tree tract)	Pervious	No		
Other: ________________				
		Total Project Area		

PGIS = Pollution Generating Impervious Surface

PGPS = Pollution Generating Pervious Surface

Abbreviated Drainage Plan Report Section 2: Development Conditions and Requirements

2.1 Project Vesting: Specify applicable versions of SDM and DG&PWS (i.e., 2022 SDM); if other than current versions were used, provide justification.

2.2 Permits Required: List applicable permits for the project that are required by the City and other agencies. Describe type of permit for which the project applicant is applying, and describe other permits required (e.g., hydraulic permits, U.S. Army Corps of Engineers [USACE] Section 404 Permit, wetlands development permit, etc.) and present status.

Construction of stormwater BMPs may require additional permits from other agencies. These additional permits may contain more restrictive drainage control requirements. This section should provide the title of any other necessary permits, the agencies requiring the other permits, and identify the permit requirements that affect the project.

Other agencies including, but not limited to, those listed in Table 3.5 may require drainage review for a proposed project's impact on surface waters, stormwater, and conveyance systems. The project applicant should take care to note that these other agency drainage requirements are separate from, and in addition to, City's drainage requirements. The project applicant will be responsible to coordinate joint agency drainage review, including resolution of any conflicting requirements between agencies.

Table 3.5. Examples of Applicable City and Agency Permits to List in an Abbreviated Drainage Plan.

Agency	Permit/Approval
Thurston County Environmental Health Department	On-site Sewage Disposal and Well Permits
Washington State Department of Transportation (WSDOT)	Developer/Local Agency Agreement
Washington State Department of Ecology	Short Term Water Quality Modification Approval
Washington State Department of Fish and Wildlife	Hydraulic Project Approval
Washington State Department of Ecology	Dam Safety Permit
United States Army Corps of Engineers	Section 10 Permit
United States Army Corps of Engineers	Section 401 Certification
United States Army Corps of Engineers	Section 404 Permit
City of Lacey	Shoreline Substantial Development Permits, Conditional Use Permits, and Variance Permits
City of Lacey	Right-of-Way Access Permit
City of Lacey	Wetland Development Permit

Note: This is not a complete list of possible permits that may be required.

2.3 <u>Project Type and Size:</u> Specify the project type as either new development or redevelopment (per definitions in the glossary); the total area of new and/or replaced hard surfaces; the total area to be disturbed; and the results from the applicable flow chart in Figure 2.1 or 2.2 of applicable Core Requirements. Include the valuation of the proposed improvements, including interior improvements, for redevelopment projects.

2.4 <u>Critical Areas:</u> Projects that involve work in or near critical areas must demonstrate compliance with Chapter 16.54 LMC. Describe the presence of any critical areas or environmentally sensitive areas, including wetlands, Endangered Species Act (ESA) species habitat, Wellhead Protection Areas (WHPAs), Critical Aquifer Recharge Areas (CARAs), geologically hazardous areas, steep slopes, etc. on the project site. Include any specific requirements of a basin plan or water quality improvement program (such as the Henderson Inlet Watershed Total Maximum Daily Load [TMDL]) for the project area. See maps in Appendix 8B for WHPAs and CARAs. The Abbreviated Drainage Plan also must indicate any site design and construction requirements that implement the applicable critical area standards and requirements.

2.5 Core Requirements: **Identify which of the core requirements apply to the project, and how they are being addressed.** Utilize applicable flow charts and provide appropriate data to determine which Core Requirements apply to the project. Include justification for those core requirements that do not apply. For Core Requirement #5, describe how low impact development (LID) principles were applied to the site planning process, and indicate whether the project used the mandatory list option, or the LID performance standard option, and provide complete documentation demonstrating compliance with either approach. Refer to Abbreviated Drainage Plan Report Section 5 for additional guidance.

Abbreviated Drainage Plan Report Section 3: Site and Vicinity Description

A description of the site and vicinity analysis shall be submitted as part of the Abbreviated Drainage Plan submittal. Information in this section should also be used to help prepare the Construction SWPPP. Where subsequent report sections call for more details on these issues (e.g., soils, wells, septic systems), a brief description and reference to the specific Abbreviated Drainage Plan Report section or appendix is sufficient.

3.1 Existing Physiography: Describe the existing physical setting of the project site, including, but not limited to, the items listed below.

- Existing topography and slopes.
- Existing land cover, including trees, shrubs, lawn, etc.
- Creeks, lakes, ponds, wetlands, ravines, gullies, springs, or other surface waters, on or downgradient of the property.
- Determine whether the project is within the potential flood hazard area as defined in Chapter 14.34 LMC, show the 100-year flood hazard area on the plans. If project is determined to be in the flood hazard area additional requirements may apply per Chapter 14.34 LMC.

3.2 Existing Improvements: Describe any existing constructed improvements and other non-natural features on the project site, including, but not limited to, wells, septic tanks, septic drainfields, storage tanks, pipes, utilities (pedestals, lines, vaults, etc.), structures, pavement, encumbrances, or other features that will be removed or affected by the site development.

- Drinking water wells, both active and abandoned, shall be shown on the plans or as-builts (if found during construction).
  - If no wells are found, indicate so.
  - The project engineer shall inquire with the Thurston County Environmental Health Department and neighboring property owners as necessary to obtain location of wells that are not of record.

- Septic systems, both active and abandoned, shall be shown on the plans or as-builts (if found during construction).
  - If no septic systems are found, indicate so.
  - The project engineer shall inquire with the Thurston County Environmental Health Department and neighboring property owners as necessary to obtain location of septic systems that are not of record.
- Identify the existence of fuel tanks, in-use or abandoned. Fuel tanks shall be shown on the plans or as-builts (if found during construction). If fuel tanks will be abandoned, contact the Thurston County Environmental Health Department for specific instructions. If no fuel tanks are found, indicate so.

3.3 Drainage Patterns: Describe existing drainage patterns at the project site and adjacent lands, and proposed accommodations and/or alterations to existing drainage flows, including:

- Off-site drainage to the property, including slopes and drainage patterns.
- Drains, channels, and swales, within the project site and immediately adjacent.
- Points of exit for existing drainage from the property.
- Any known historical drainage problems such as flooding, erosion, etc. including drainage complaints history from City and road drainage problems (per City and Thurston County).
- Summary of existing soil type, groundwater levels, and soil hydraulic conductivity (details to be covered in Appendix 2).
- Include references to relevant reports such as basin plans, flood studies, groundwater studies, wetland designations, sensitive area designations, environmental impact statements, environmental checklists, lake restoration plans, water quality reports, soils reports, etc. Where such reports impose additional conditions on the project applicant, state these conditions and describe any proposed mitigation measures.

3.4 Qualitative Analysis: In accordance with Core Requirement #4, all projects shall submit a qualitative analysis downstream from the site to the receiving water and upstream of the site to characterize any potential offsite flow to the site or backwatering effects.

The **qualitative analysis** must be sufficient for the City to evaluate whether the project has adequately identified potential impacts and whether proposed mitigation measures are supported by the analysis. Some “rough” quantitative analysis, which can be based on non-surveyed field data, may be necessary at this stage. A downstream analysis of the project for a minimum of one-half of a mile is required. The analysis must also extend upstream to a point beyond any backwater effects caused by the project and should characterize any run-on to the project site. The existing or potential impacts to be evaluated and mitigated should include:

- Conveyance system capacity problems
- Localized flooding
- Erosion, including landslide hazards and erosion along streambanks and at the outfall location
- Violations of surface water quality standards as identified in a basin plan or a TMDL; or violations of groundwater quality standards in a WHPA

The analysis must include field inspections of all existing stormwater drainage systems downstream from the project and determination of whether the capacity of the drainage system(s) is adequate to handle the existing flows, flows generated by the proposed project, and any overflow. Adequacy will be evaluated based on conveyance capacity, flooding problems, erosion damage or potential, amount of freeboard in channel and pipes, and storage potential within the system. 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 groundwater.

3.5 <u>Quantitative Analysis:</u> A quantitative analysis may be required for any project deemed to need additional downstream information or where the project engineer or the SDM Administrator determines that a quantitative analysis is necessary to evaluate the off-site impacts or the capacity of the conveyance system.

The **quantitative analysis** shall include the qualitative analysis described above, as well as:

- Quantitative calculations and/or modeling analyses of on-site and off-site water quality, erosion, slope stability, and other drainage-related impacts that may be caused or aggravated by a proposed project.
- Measures for preventing impacts and for not aggravating existing impacts. (“Aggravating existing impacts” means increasing the frequency of occurrence and/or severity of an impact.)

Both the qualitative analysis and the quantitative analysis (when required) shall include descriptions and/or analyses of the following items. The descriptions shall identify existing or potential problem areas, and whether adequate mitigation can be identified (or whether more detailed quantitative analysis is necessary). References to other Abbreviated Drainage Plan Report sections (e.g., BMP sizing, conveyance, attachments, and appendices, etc.) are encouraged to eliminate report redundancy, as long as all of the required Drainage Report issues are clearly presented:

- Map of the study area showing all areas pertinent to the analyses including:
  - Site boundaries
  - Study area boundaries
  - Study area topography
  - Boundaries of proposed land disturbance
  - Streets and prominent features
  - Downstream flow path(s)
  - Tributary drainage areas to downstream flow path(s)
  - Potential and/or existing problems
- Describe drainage system between the site and the receiving surface waters (or pothole, regional detention BMP, etc.). Provide information on pipe sizes, channel characteristics, and drainage structures. Describe emergency services located along the flow path (e.g., fire/police stations, hospitals). Describe environmentally sensitive areas, such as wetlands, etc.
- Describe off-site drainage tributary to the project. Describe any bypass drainage from the project which will not be controlled.
- Identify CARAs, WHPAs, drinking water wells, and septic systems both of record and others on the site and on adjacent property within the setback distance for stormwater BMPs identified in Chapter 7. See area maps in Appendix 8B as well as on the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/>.
- The bulk of the analysis shall focus on highlights of important considerations from the existing conditions section related to the drainage system and potential problems or concerns. 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
  - 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.

Abbreviated Drainage Plan Report Section 4: Soils and Infiltration Analysis

4.1 Summary of Soils and Geotechnical Data: Provide a summary of existing site soil conditions and pertinent information from the site geotechnical report. Emphasis is on data used to assess infiltration at the site. This section should include the following components as applicable:

- Number of test pits and/or soil borings conducted on the project site, and when the soil explorations were conducted.
- Soil test pit/boring locations in relation to proposed stormwater BMPs.
- Soil types on-site, both geologic/glacial (e.g., Vashon till or recessional outwash) and Natural Resources Conservation Service [NRCS] Soil Units (e.g., Indianola series, Hydrologic Soil Group A).
- Presence of any fill material, mounds, piles, etc.

4.2 Subsurface Factors: Describe subsurface soil, rock, and groundwater conditions in relation to proposed stormwater BMPs.

- Infiltration feasibility assessment, including presence of any restrictive layers within 10 feet depth below the base of any proposed infiltration BMPs.
- Determination of seasonal high groundwater levels at the site and methodology.

4.3 Infiltration Rates: Describe the methodology and results used to determine initial and design infiltration rates.

- Measured (initial) saturated hydraulic conductivity, K_{sat}, for each proposed BMP location where infiltration is feasible.
- Design (long-term) infiltration rate calculations for each proposed BMP location where infiltration is feasible. For calculations, show your work.
- If infiltration is not feasible, provide justification.

Abbreviated Drainage Plan Report Section 5: On-Site Stormwater Management and Low Impact Development (Core Requirement #5)

This section shall describe how Core Requirement #5 will be implemented for the project. Where feasible, projects shall maximize the use of LID site design strategies to minimize effective impervious areas, vegetation loss, and stormwater runoff. See Chapter 1, Section 1.4, and Chapter 4, Section 4.3 for additional details and recommended BMPs.

LID site design in particular is intended to complement the existing conditions on the site. However, not all sites are appropriate for all LID and on-site stormwater management BMPs, as site conditions often determine the feasibility of using these techniques. The site and vicinity analysis, consistent with the requirements of Section 3, shall determine the feasibility of using these BMPs. This section should include the following components:

5.1 LID Site Design: Provide the following:

- Summary of LID site design considerations and how they are being implemented.
- Description of how LID principles and practices will be applied to the project.

5.2 Methodology: For LID BMPs and Core Requirement #5, describe the following:

- Project narrative showing how the project will fulfill the requirement for on-site management of stormwater to the extent feasible.
- How site planning and layout (per Chapter 1, Section 1.4) were implemented in the project design.
- Total area of vegetation retained.
- Specify choice of List #1 or LID Performance Standard, and describe how the project complies with the selected option.
- For projects using the list option for Core 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. Information obtained and documented in the Site and Vicinity Description (Section 3, see above) shall be used to substantiate any BMP infeasibility determinations. (See also Chapter 7, Appendix 7B, for a summary of infeasibility criteria for all BMPs.)
- For projects using the LID Performance Standard option for Core Requirement #5, provide modeling results that demonstrate compliance.

5.3 LID Practices: Describe the LID BMPs that are proposed to be implemented on-site. Specify the BMP names and BMP numbers per the SDM.

5.4 Post-Construction Soil Quality and Depth:

- Specify the implementation option(s) for post-construction soil quality and depth selected for the project site (see Chapter 7, Section 7.4.1).

- Quantify the areas of disturbed soils to be amended. (Note: All lawn and landscaped areas are to meet requirements of postconstruction soil quality and depth [see Chapter 7, Section 7.4.1]. Use of compost is one way to meet the requirement). Calculations shall be provided in the Soil Management Plan (Abbreviated Drainage Plan Report Appendix 4).

5.5 Retained Trees and Aesthetics:

- Identify retained trees and newly planted trees for which impervious reduction credits are claimed (see Chapter 7, Section 7.4.3 for information on impervious surface credits associated with trees).

- Describe how the stormwater design blends-in with the site layout and landscaping.

- Aesthetic Considerations for BMPs. Describe the effort made to make the BMPs aesthetically pleasing, how BMPs will provide useable open space, and how the BMPs will fit into the landscaping plan for the property and be in keeping with any approved community plan. Stormwater BMPs should be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping BMPs. Note that BMPs shall also meet the landscaping requirements of Chapter 16.80 LMC.

Abbreviated Drainage Plan Report Section 6: Runoff Treatment and Flow Control (Core Requirements #6 and #7)

This section is not applicable for the Abbreviated Drainage Plan. If runoff treatment and/or flow control is required, the project applicant must prepare a Drainage Control Plan. Refer to Section 3.3.3.

Abbreviated Drainage Plan Report Section 7: Runoff Collection and Conveyance System

Not all projects requiring an Abbreviated Drainage Plan will need Section 7. If applicable, this section must document the methods and results of analyses used to evaluate and design the conveyance system per the hydraulic computation guidance in Chapter 6. All calculations, equations, graphs, nomographs, and references used shall be provided in Appendix 3 of the Abbreviated Drainage Plan Report (Design Calculations) and summarized in this section.

7.1 System Design and Layout: Provide a narrative description of the runoff collection and conveyance system. Describe the general layout, and identify all components of the system including pipes, inlets, manholes, open channels, natural channels, and culverts.

7.2 Conveyance System Calculations Summary: Provide summaries of all calculations for capacity of channels, culverts, drains, gutters, etc. Describe design flow rates for each component, as well as pipe/culvert/ditch dimensions, inverts, slopes, and flow capacities. Summarize the applicable performance standard (e.g., 25-year return period peak runoff) used for the conveyance system. Describe required materials or specifications for the design (e.g., rock lining for channels when velocity is exceeded, high density polyethylene pipe needed for steep slope). If a backwater analysis is required, calculations should also include grate interception calculations (spread and bypass), hydraulic grade line at structures, and tabulated results.

If used, include nomographs and tables indicating how they were used. Show headwater and tailwater analysis for culverts when necessary. Provide details on references and sources of information used.

Abbreviated Drainage Plan Report Section 8: Source Control

8.1 Potential Sources of Pollutants: Describe potential pollutant sources that may occur on the developed project site, based on the expected site use.

8.2 Source Control BMPs: List and provide a description of applicable permanent post-construction Source Control practices.

8.3 Source Control Checklist and Worksheet: Check and list all activities that will occur at proposed project. Use one worksheet for each activity from the checklist. Refer to Chapter 9, Appendix 9A.

Abbreviated Drainage Plan Report Section 9: Covenants, Dedications, Easements, Agreements, and Guarantees

9.1 Covenants, Dedications, and Easements: Information relevant to covenants, dedications, and easements need only be summarized in this section. Details shall be provided in the Establishment of Maintenance Covenant (see Section 3.4.3).

Describe legal instruments needed to guarantee preservation of drainage systems and access for maintenance purposes (attach copies if not included as part of other Abbreviated Drainage Plan submittals). Describe the organization or person who will be responsible for operation and maintenance of stormwater BMPs. For projects subject to Core Requirement #5, a declaration of covenant must be recorded for each parcel that contains on-site stormwater management BMPs, to ensure future maintenance of those BMPs. Also attach a copy of any property owners' articles of incorporation, if applicable and available.

Last, describe how utilities will be installed, any easements that affect stormwater BMPs, and how the project will ensure no conflicts exist between proposed utility locations and proposed stormwater quantity and quality control measures.

9.2 Agreements and Guarantees: Maintenance and/or operational bonding or other appropriate financial guarantees are required for all projects to ensure construction and functionality of stormwater BMPs in compliance with applicable standards. These guarantees shall be consistent with the most recent edition of the DG&PWS.

Abbreviated Drainage Plan Appendices

The previous sections outline the required documentation for Abbreviated Drainage Plan submittals. Where the project warrants additional technical documentation, or where the SDM Administrator determines that additional information is necessary, that information shall be included as appendices to the Abbreviated Drainage Plan, bound within the Abbreviated Drainage Plan Report document. The following highlights typical Abbreviated Drainage Plan appendices.

Abbreviated Drainage Plan Report Appendix 1: Maps and Plans

In addition to full-size plan sets submitted for land-use and civil review/approval, various maps and plan drawings shall be included in Abbreviated Drainage Plan Report Appendix 1. Maps and plans in the printed version of the Abbreviated Drainage Plan Report should be 8.5”x11” or 11”x17” fold-outs, sized as needed to show details (see preferred sizes in list below).

Appendix 1 of the Abbreviated Drainage Plan Report shall include the following maps, sized so that all pertinent details are clearly visible:

1a. Vicinity Map (8.5”x11”): Show city boundary, major streets, and project location.

1b. NRCS Soil Types Map (8.5”x11”): e.g., from Web Soil Survey.

1c. Existing Site Topography Map (11”x17” fold-out): Show all features described in Drainage Report Section 3, including existing ground contours at 1-foot intervals, slopes, trees, surface waters, utilities, any existing constructed improvements (prior to project development), and drainage patterns.

1d. Basin Map (11”x17” fold-out): Delineation of post-development site areas draining to each runoff collection point, including surface flow arrows. Identify threshold discharge areas (TDAs) where applicable. Use an appropriate scale for the project site. Show the following on the Basin Map (or on a schedule):

- Total project area (including project boundaries)
- Subbasin boundaries
- Off-site area tributary

- Total hard surfaces
- PGIS/pollution-generating hard surface (PGHS), PGPS, and total disturbed area
- Major drainage features (such as channels and detention BMPs and floodways)
- Conveyance data, conveyance system capacities, identifier (for reference to model output), length, slope, inverts up and down
- Overland flow paths and distances to receiving waters
- Average slope
- Projects with one basin do not require a Basin Map. A Basin Map is only required for projects with two or more basins.

1e. Soil Data Locations Map(s) (11"x17" fold-out): Locations of soil test pits and/or borings relative to both the existing ground contours and the proposed site layout and stormwater BMP locations.

1f. Site Plan and Stormwater BMP Plans (11"x17" fold-out): Reduced-size duplicate(s) of the site plan and drainage plan sheet(s) from the full-size plan set submittal, showing all proposed stormwater BMPs, site improvements, finished grades, etc. The site plan shall include a table or "schedule" for the storm drainage structures used on the project, including the following information:

- Catch basin/manhole number
- Stationing, as applicable
- City of Lacey Ground Scale Coordinate System (conversion from Washington State Plane Coordinate System) (i.e., Northings and Eastings) if used
- Street name and side located on, if applicable
- Catch basin/manhole diameter or size
- Invert elevation in/out
- Pipe diameter in/out
- Type of each structure and pipe, i.e., Type II, concrete

1g. Stormwater Details (11"x17" fold-out): Reduced-size duplicate(s) of the Drainage Details sheet(s) from the full-size plan set submittal, showing stormwater system section views, BMP details, etc.

General Site Development Drawing Requirements

It is the responsibility of the project engineer to ensure that engineering drawings submitted for review are sufficiently clear to construct the project in proper sequence, using specified methods and materials, and with sufficient dimensions to fulfill the intent of drainage laws and ordinances and these design guidelines.

Refer to the DG&PWS for requirements related to site drawing size, content, notes, organization, etc. The following notes identify and emphasize important stormwater-related components that must be reflected in the site drawings. Complete drawing requirements are provided in the DG&PWS.

- The project's existing and proposed storm drainage along with easements, tracts, stormwater BMPs, all buffer and screening areas, off-site and on-site existing drainage courses, delineated wetlands, and associated buffers. Indicate direction of flow, size, and kind of each drainage channel, pipe, and structure. The status of existing drainage structures must be clarified as either "existing-abandon" or "existing-remove." For on-site stormwater management BMPs, provide a scale drawing of the lot or lots, and any public-right-of-way that displays the location of the BMPs and the areas served by them.

- Include details of all on-site stormwater management BMPs that are used to help achieve compliance with Core Requirement #5. See the DG&PWS for standard drawings and details.

- 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 shall also be shown.

- Existing paved surfaces, including roads.

- Areas of possible significant environmental concern (gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, creeks, lakes, etc.). For natural drainage features show direction of flow.

- 100-year floodplain boundary (if applicable).

- Soil logs, soil log locations, and soils within the project site as verified by field testing (and documented in Abbreviated Drainage Plan Section 4).

- Wells and WHPAs—existing and proposed, on site and on adjacent properties (both of record and not of record) within specified setbacks.

- Topographic features that may act as natural stormwater storage, infiltration, or conveyance.

- Abbreviated Drainage Plans must include a complete Construction SWPPP. See Chapter 5, Section 5.2.2 for information on the items that shall be included as part of the Construction SWPPP narrative report and drawings. See the DG&PWS for standard notes related to SWPPPs. Construction SWPPP drawings should be included as part of the Site Development Drawings package.

- Proposed grades.

- Topographic information including contour lines of the property in its existing condition. City or U.S. Geological Survey (USGS) topographic mapping must be field verified and supplemented with additional field topographic information when necessary to provide an accurate depiction of the property.

- Other typical features as listed in the DG&PWS including but not limited to utilities, lot dimensions and areas, grading/clearing setbacks from property lines, earthwork/geotechnical requirements, etc.

Detail Drawings

The most recently adopted editions of standard specifications and standard plans shall be the standards for all design and construction of stormwater BMPs not explicitly described herein. In the event of a conflict between the standard specifications, standard plans, and the manual, this manual shall prevail. When required by the City, standard specifications and general provisions for construction must be submitted with any road construction plans. The detail drawings must include the following:

- All applicable standard notes from the DG&PWS.

- A minimum of two cross-sections of each retention/detention pond and bioretention area showing original property lines, slope catch points, and all other pertinent information to adequately construct the pond or bioretention area.

- Details of all on-site stormwater management BMPs that are used to help achieve compliance with Core Requirement #5.

- Identify locations and approximate size of all permeable pavement surfaces and bioretention areas to be installed, including those that will be installed on individual lots.

- Standard open conveyance system cross-sections if applicable.

- Right-of-way cross-sections as required by the City.

- Construction recommendations from a Soils Report, if applicable.

Abbreviated Drainage Plan Report Appendix 2: Supplemental Reports and Information

Depending on site and vicinity characteristics, various special reports and studies may be required to provide supplemental information.

The various types of supplemental reports and information may include:

- Soils/geotechnical report (see required contents below)
- Wetland delineation and description
- Groundwater quality and/or hydrogeology
- Critical areas analysis and delineation
- Slope protection/stability
- Floodplain delineation/flood protection BMP conformance
- Ecology's applicable GULD documentation and the manufacturer's product data

Soils Report: Criteria and Contents

For virtually all project sites, particularly those sites utilizing infiltration for stormwater management, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, an engineering geologist, or a hydrogeologist, and that summarizes site characteristics and demonstrates that sufficient permeable soil for infiltration exists at the proposed BMP locations.

Soil explorations shall be performed during the winter "wet season" (October 1 through April 30) to accurately assess soil saturation and seasonally-high/perched groundwater conditions. Soil explorations conducted during other times of the year may require supplemental winter groundwater monitoring prior to approval of the draft stormwater site plan.

The reporting requirements depend on the types of BMPs proposed and analyses being performed. Note that additional BMP-specific soils and infiltration testing, analysis, and documentation requirements are outlined in Chapter 7, Section 7.2 (for infiltration basins and trenches), Section 7.4.4 (for bioretention), and Section 7.4.6 (for permeable pavements). Of particular note is that if the site is located near a groundwater protection area or water supply well, the Soils Report must demonstrate and document that the criteria for infiltrating near a water supply well (refer to Chapter 7 and Chapter 8) are met. Additional soils information related to runoff treatment may be required as outlined in Chapter 8 (e.g., Section 8.6).

At a minimum, the Soils Report for all project sites must contain the following:

- Map figure showing the following:
    - Existing site topography.`
    - Locations of test pits and/or test borings relative to both existing topographic contours and proposed site plan layout, including infiltration BMP locations.
    - Locations of all water supply wells and monitoring wells on or near the site.
    - Locations of any groundwater protection areas, critical aquifer recharge areas, and 1-, 5-, and 10-year time-of-travel zones for WHPAs (see CARA and WHPA maps in Appendix 8B).
- Soil test pits and/or soil borings distributed across the site sufficiently to identify and characterize variability of the soils underlying the site. Depth should extend to at least 5 feet below estimated bottom elevation of proposed infiltration BMPs and road subgrades.
- Results of on-site soils tests including but not limited to:
    - Detailed soil logs, including the elevation of the ground surface at the test pit and/or test boring location, depths to soil strata, total depth of pit or boring, soil descriptions (see below), degree of compaction, depth to groundwater (if present), and presence of any restrictive layers/stratification affecting infiltration. Soil descriptions shall include the following:
        - Deposit Type (e.g., recessional outwash, compacted till, etc.)
        - Soil Classification (e.g., SM for silty sand, or GP for poorly-graded gravel)
        - Material Description (e.g., brown silty fine sand with minor gravel)
        - Relative Density (e.g., medium dense)
        - Moisture Content, relative/measured (e.g., dry, moist, or wet; MC = 12 percent)
    - Whether glacially-compacted till is present, and if so, its depth.
    - Visual grain-size analysis
    - Grain-size distribution (required if using the grain size analysis method to estimate infiltration rates)

- Percent clay content (include type of clay, if known)
- Color/mottling
- Variations and nature of stratification
  - 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.
  - Seasonal high groundwater elevation (and/or perched groundwater elevation) during the late winter "wet season" (i.e., highest expected level of groundwater). If the groundwater level varies across the site, specify the level for each proposed infiltration BMP location.

- Detailed documentation of the initial measured K_{sat} and long-term (design) infiltration rate determination for each proposed infiltration BMP location, as specified in Chapter 7, Appendix 7A.
- State whether location is suitable for infiltration and recommend a design infiltration rate.
  - Note that surface infiltration must be determined to be infeasible before deep UIC wells can be considered. Refer to Chapter 7, Appendix 7C for additional guidance and requirements related to UIC wells.
- The results of testing for a hydraulic restriction layer (groundwater, soil layer with less than 0.3 in/hr K_{sat}, glacial till, bedrock, etc.) under possible sites for infiltration BMPs. This analysis shall be performed during the winter "wet season" (October 1 through April 30). Site historical information and evidence of high groundwater in the soils can also be used.
- Any additional BMP-specific soils and infiltration testing information that is required for the project's flow control or runoff treatment BMPs (e.g., for infiltration basins and trenches, bioretention, and permeable pavements).
- If on-site infiltration may result in shallow lateral flow (interflow), the conveyance and possible locations where that interflow may re-emerge shall be assessed by a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.
- If a retention and/or detention BMP is near the top of a slope that is regulated through local ordinance, then a geotechnical assessment addressing effects of seepage and the potential for slope failure during any precipitation event though the design event is required as part of this section of the Drainage Report.

Abbreviated Drainage Plan Report Appendix 3: Design Calculations

Design calculations must include complete calculations for the conveyance, flow control, and water quality BMPs. Calculations must be presented in a clear and orderly manner and labeled and annotated as needed to facilitate an efficient review and approval process. Required calculation components include:

- Printouts of the continuous modeling computation files (e.g., continuous modeling inputs, screenshots, and results) annotated to highlight and clarify key inputs, results, and conclusions.
- Other computer printouts or manual calculations used in the stormwater design.
- Digital copies of the model files sufficient to re-run the model including input parameters and model output files.

Abbreviated Drainage Plan Report Appendix 4: Soil Management Plan

If Post-construction Soil Quality and Depth BMP is used on site (refer to Chapter 7, Section 7.4.1), a Soil Management Plan must be included in the project submittal. The Soil Management Plan must include the following:

- A site map showing areas to be fenced and left undisturbed during construction, and areas that will be amended at the turf or planting bed rates
- Determination of soil conditions
- Identified soil quality implementation option
- Calculations of the amounts of compost, compost amended topsoil, and mulch to be used on the site.

General guidance on these procedures can be found in the Building Soil manual (Stenn, et al. 2018), available at <https://www.soilsforsalmon.org/>.

Abbreviated Drainage Plan Attachments

Abbreviated Drainage Plan Attachment 1: Construction SWPPP Report

Chapter 5, Section 5.2.2, of this manual describes the items that shall be included in the Construction SWPPP report. At a minimum, all 13 Construction Stormwater Pollution Prevention elements in accordance with Core Requirement #2 (Chapter 2, Section 2.4.2) must be addressed. The Construction SWPPP shall be implemented starting prior to any land disturbance and continue until final stabilization. The City may require the completion, submission, and approval of a wet-season amendment to the Construction SWPPP, which may include additional construction BMPs (e.g., stabilized parking, dewatering provisions, etc.), stopping work during the wettest months, and/or a bond for maintenance of the downstream system. See Chapter 5, Section 5.2.3 for more details.

Note: The Construction SWPPP consists of two parts: a narrative report and drawings. **A complete Construction SWPPP (both report and drawings) is required as part of the Drainage Control Plan submittal.** Note that the Construction SWPPP drawings should be included in the drawing packet required as Abbreviated Drainage Plan Appendix 1.

Abbreviated Drainage Plan Attachment 2: Maintenance and Source Control Manual

A full Maintenance and Source Control Manual is not required for the Abbreviated Drainage Plan. If applicable, provide the manufacturer's maintenance recommendations for proprietary manufactured BMPs.

3.3.3 Drainage Control Plan

The Drainage Control Plan is the full submittal package meeting all core requirements per Chapter 2, Figures 2.1 and 2.2. The Drainage Control Plan submittal package includes the following components: Drainage Control Plan Report, Site Development Drawings, Construction SWPPP, Maintenance and Source Control Manual, and any plan appendices. An overview of the components of a typical Drainage Control Plan is presented in Table 3.2. The Construction SWPPP consists of two parts: a narrative report, and temporary erosion & sediment control (TESC) drawings, which should be included in the plan set with the other Site Development Drawings. Additional details on each component of the Drainage Control Plan are provided in the following sections. Refer to the DG&PWS for requirements related to the number of copies and dimensions required by the City.

Phased Project Submittals

Phased projects shall be completed in accordance with approved Drainage Control Plans and in accordance with phased development requirements placed upon the development by the City. Phasing of projects shall not result in a reduction of drainage control requirements. Drawings showing the overall project, clearly delineating phase boundaries, and estimating dates of construction (if known), shall be part of any initial submittal.

Drainage Control Plan Report

The Drainage Control Plan Report is a major component of the Drainage Control Plan. The Drainage Control Plan Report shall include detailed information and data related to stormwater planning and design that facilitate plan review. Specific components of the Drainage Control Plan Report are described in detail below.

A Drainage Control Plan Report template is available on the City's website.

Cover Sheet: The Drainage Control Plan Report must have a cover sheet with the following information included:

- Title "Drainage Control Plan Report for (project name)"

- Project location
- Project applicant's name, address, telephone number, and email address
- Project engineer's name, company name, address, telephone number, and email address
- Date of submittal

The initial submittal shall be titled "DRAFT Drainage Control Plan Report for (project name)."

Project Engineer's Certification: The project engineer responsible for completion of a Drainage Control Plan submittal as described herein shall be a professional engineer licensed in Washington State. All plans and specifications, calculations, certifications, as-built drawings, and all other submittals which will become part of the permanent record of the project must be dated and bear the project engineer's official seal and signature.

The Drainage Control Plan Report shall contain a page with the project engineer's seal and the following statement:

> *"I hereby state that this Drainage Control Plan Report for _______ (name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the City of Lacey does not and will not assume liability for the sufficiency, suitability, or performance of drainage BMPs prepared by me."*

Table of Contents: Show the page number for each section of the report. Show page numbers of appendices. Identify all attachments included with the report. All pages of the Drainage Control Plan Report shall be numbered.

All Drainage Control Plan Reports shall have each of the following section titles and subsections (if some sections do not apply, list and mark N.A.):

Drainage Control Plan Report Section 1: Project Overview

1.1 Site Information: Parcel number(s), address or legal description of site property, current zoning, streets/general vicinity, property owner(s), total project site area, surrounding land uses.

1.2 Project Description: Provide a brief description of the proposed development project (type, size, location, proposed improvements including structures and paving, phasing (if applicable), and for additions/remodels only, current assessed value and cost of improvements excluding land value).

1.3 Proposed Stormwater Drainage Design: Describe the overall drainage plan concept, proposed permanent stormwater BMPs, their locations and distribution across the site, and proposed ownership (e.g., private or public). Briefly describe all stormwater features proposed to be installed for runoff collection, conveyance, runoff treatment, and infiltration and/or discharge (types, sizes, and locations). If applicable, describe the detention system, control structure/outlet, and spillways. See Chapter 8 for more details regarding stormwater BMPs that could be adopted and maintained by the City.

1.4 Subarea Data Tabulation: Provide data tables for existing and proposed surface areas, including hard surface areas by type (roof, driveway, walkway, etc.); new and replaced impervious, pervious, and hard surface areas; PGIS and PGPS; disturbed pervious (such as landscaped areas); converted vegetation areas; and undisturbed areas. Example subarea data tabulations for existing and proposed surface areas are provided in Tables 3.6 and 3.7.

Table 3.6. Example Existing Site Land Coverage Tabulation for a Drainage Control Plan.

Existing Surface	Surface Type	Area (square feet)	Area (acres)
Driveway	Hard/Impervious		
Walkway	Hard/Impervious		
Roof	Hard/Impervious		
Forested/Trees	Pervious		
Pasture/Landscaping	Pervious		
	Total Site/Parcel Area		

Table 3.7. Example Proposed Site Land Use Coverage Tabulation for a Drainage Control Plan.

Proposed Surface	Surface Type	Pollutant Generating	Area (square feet)	Area (acres)
Roadway	Hard/Impervious	Yes - PGIS		
Driveway	Hard/Impervious	Yes - PGIS		
Walkway	Hard/Impervious	No		
Roof	Hard/Impervious	No		
Permeable Pavement	Hard/Pervious	Yes - PGPS		
Landscaping	Pervious	Yes - PGPS		
Undisturbed (e.g., tree tract)	Pervious	No		
Other: ________________				
		Total Project Area		

PGIS = Pollution Generating Impervious Surface

PGPS = Pollution Generating Pervious Surface

Drainage Control Plan Report Section 2: Development Conditions and Requirements

2.1 Project Vesting: Specify applicable versions of SDM and DG&PWS (i.e., 2022 SDM); if other than current versions were used, provide justification.

2.2 Permits Required: List applicable permits for the project that are required by the City and other agencies. Describe type of permit for which the project applicant is applying, and describe other permits required (e.g., hydraulic permits, USACE Section 404 Permit, wetlands development permit, etc.) and present status.

Construction of stormwater BMPs may require additional permits from other agencies. These additional permits may contain more restrictive drainage control requirements. This section should provide the title of any other necessary permits, the agencies requiring the other permits, and identify the permit requirements that affect the project.

Other agencies including, but not limited to, those listed in Table 3.8 may require drainage review for a proposed project's impact on surface waters, stormwater, and conveyance systems. The project applicant should take care to note that these other agency drainage requirements are separate from, and in addition to, City's drainage requirements. The project applicant will be responsible to coordinate joint agency drainage review, including resolution of any conflicting requirements between agencies.

Table 3.8. Examples of Applicable City and Agency Permits to List in a Drainage Control Plan.

Agency	Permit/Approval
Thurston County Environmental Health Department	On-site Sewage Disposal and Well Permits
Washington State Department of Transportation (WSDOT)	Developer/Local Agency Agreement
Washington State Department of Ecology	Short Term Water Quality Modification Approval
Washington State Department of Fish and Wildlife	Hydraulic Project Approval
Washington State Department of Ecology	Dam Safety Permit
United States Army Corps of Engineers	Section 10 Permit
United States Army Corps of Engineers	Section 401 Certification
United States Army Corps of Engineers	Section 404 Permit
City of Lacey	Shoreline Substantial Development Permits, Conditional Use Permits, and Variance Permits
City of Lacey	Right-of-Way Access Permit
City of Lacey	Wetland Development Permit

* This is not a complete list of possible permits that may be required.

2.3 Project Type and Size: Specify the project type as either new development or redevelopment (per definitions in this manual's glossary); the total area of new and/or replaced hard surfaces; the total area to be disturbed; and the results from the applicable flow chart in Figure 2.1 or 2.2 of applicable Core Requirements. Include the valuation of the proposed improvements, including interior improvements, for redevelopment projects.

2.4 Critical Areas: Projects that involve work in or near critical areas must demonstrate compliance with Chapter 16.54 LMC. Describe the presence of any critical areas or environmentally sensitive areas, including wetlands, ESA species habitat, WHPAs, CARAs, geologically hazardous areas, steep slopes, etc. on the project site. Include any specific requirements of a basin plan or water quality improvement program (such as the Henderson Inlet Watershed TMDL) for the project area. See maps in Appendix 8B for WHPAs and CARAs. The Drainage Control Plan also must indicate any site design and construction requirements that implement the applicable critical area standards and requirements.

2.5 Core Requirements: List the core requirements that apply to the project, and describe how they are being addressed. Utilize applicable flow charts and provide appropriate data to determine which Core Requirements apply to the project. Include justification for those core requirements that do not apply. For Core Requirement #5, describe how LID principles were applied to the site planning process, and indicate whether the project **used** the mandatory list option, or the LID performance standard option, and provide complete documentation demonstrating compliance with either approach. Refer to Drainage Control Plan Report Section 5 for additional guidance.

Drainage Control Plan Report Section 3: Site and Vicinity Description

A description of the site and vicinity analysis shall be submitted as part of the Drainage Control Plan submittal. Information in this section should also be used to help prepare the Construction SWPPP. Where subsequent report sections call for more details on these issues (e.g., soils, wells, septic systems), a brief description and reference to the specific Drainage Control Plan Report section or appendix is sufficient.

3.1 Existing Physiography: Describe the existing physical setting of the project site, including, but not limited to, the items listed below.

- Existing topography and slopes.
- Existing land cover, including trees, shrubs, lawn, etc.
- Creeks, lakes, ponds, wetlands, ravines, gullies, springs, or other surface waters, on or downgradient of the property.
- Determine whether the project is within the potential flood hazard area as defined in Chapter 14.34 LMC, show the 100-year flood hazard area on the plans. If project is determined to be in the flood hazard area additional requirements may apply per Chapter 14.34 LMC.

3.2 Existing Improvements: Describe any existing constructed improvements and other non-natural features on the project site, including, but not limited to, wells, septic tanks, septic drainfields, storage tanks, pipes, utilities (pedestals, lines, vaults, etc.), structures, pavement, encumbrances, or other features that will be removed or affected by the site development.

- Drinking water wells, both active and abandoned, shall be shown on the plans or as-builts (if found during construction).

  - If no wells are found, indicate so.
  - The project engineer shall inquire with the Thurston County Environmental Health Department and neighboring property owners as necessary to obtain location of wells that are not of record.

- Septic systems, both active and abandoned, shall be shown on the plans or as-builts (if found during construction).
  - If no septic systems are found, indicate so.
  - The project engineer shall inquire with the Thurston County Environmental Health Department and neighboring property owners as necessary to obtain location of septic systems that are not of record.

- Identify the existence of fuel tanks, in-use or abandoned. Fuel tanks shall be shown on the plans or as-builts (if found during construction). If fuel tanks will be abandoned, contact the Thurston County Environmental Health Department for specific instructions. If no fuel tanks are found, indicate so.

3.3 <u>Drainage Patterns:</u> Describe existing drainage patterns at the project site and adjacent lands, and proposed accommodations and/or alterations to existing drainage flows, including:

- Off-site drainage to the property, including slopes and drainage patterns.
- Drains, channels, and swales, within the project site and immediately adjacent.
- Points of exit for existing drainage from the property.
- Any known historical drainage problems such as flooding, erosion, etc. including drainage complaints history from City and road drainage problems (per City of Lacey and Thurston County).
- Summary of existing soil type, groundwater levels, and soil hydraulic conductivity (details to be covered in Appendix 2).
- Include references to relevant reports such as basin plans, flood studies, groundwater studies, wetland designations, sensitive area designations, environmental impact statements, environmental checklists, lake restoration plans, water quality reports, soils reports, etc. Where such reports impose additional conditions on the project applicant, state these conditions and describe any proposed mitigation measures.

3.4 <u>Qualitative Analysis:</u> In accordance with Core Requirement #4, all projects shall submit a qualitative analysis downstream from the site to the receiving water and upstream of the site to characterize any potential offsite flow to the site or backwatering effects.

The **qualitative analysis** must be sufficient for the City to evaluate whether the project has adequately identified potential impacts and whether proposed mitigation measures are supported by the analysis. Some "rough" quantitative analysis, which can be based on non-surveyed field data, may be necessary at this stage. A downstream analysis of the project for a minimum of one-half of a mile is required. The analysis must also extend upstream to a point beyond any backwater effects caused by the project and should characterize any run-on to the project site. The existing or potential impacts to be evaluated and mitigated should include:

- Conveyance system capacity problems
- Localized flooding
- Erosion, including landslide hazards and erosion along streambanks and at the outfall location
- Violations of surface water quality standards as identified in a basin plan or a TMDL; or violations of groundwater quality standards in a WHPA

The analysis must include field inspections of all existing stormwater drainage systems downstream from the project and determination of whether the capacity of the drainage system(s) is adequate to handle the existing flows, flows generated by the proposed project, and any overflow. Adequacy will be evaluated based on conveyance capacity, flooding problems, erosion damage or potential, amount of freeboard in channel and pipes, and storage potential within the system. 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 groundwater.

3.5 <u>Quantitative Analysis:</u> A quantitative analysis may be required for any project deemed to need additional downstream information or where the project engineer or the SDM Administrator determines that a quantitative analysis is necessary to evaluate the off-site impacts or the capacity of the conveyance system.

The **quantitative analysis** shall include the qualitative analysis described above, as well as:

- Quantitative calculations and/or modeling analyses of on-site and off-site water quality, erosion, slope stability, and other drainage-related impacts that may be caused or aggravated by a proposed project.
- Measures for preventing impacts and for not aggravating existing impacts. ("Aggravating existing impacts" means increasing the frequency of occurrence and/or severity of an impact.)

- Documentation of how flow control and runoff treatment BMPs identified in the Drainage Control Plan will mitigate the potential to create new problems or aggravate existing conditions. In many cases, design of flow control and runoff treatment BMPs according to the procedures contained in this manual will be adequate demonstration of mitigation. However, upon review of this analysis and the severity of an existing problem, the City may require more detailed analysis and/or additional mitigation measures.

Both the qualitative analysis and the quantitative analysis (when required) shall include descriptions and/or analyses of the following items. The descriptions shall identify existing or potential problem areas, and whether adequate mitigation can be identified (or whether more detailed quantitative analysis is necessary). References to other Drainage Control Plan Report sections (e.g., BMP sizing, conveyance, attachments, and appendices, etc.) are encouraged to eliminate report redundancy, as long as all of the required Drainage Control Plan Report issues are clearly presented:

- Map of the study area showing all areas pertinent to the analyses including:
    - Site boundaries
    - Study area boundaries
    - Study area topography
    - Boundaries of proposed land disturbance
    - Streets and prominent features
    - Downstream flow path(s)
    - Tributary drainage areas to downstream flow path(s)
    - Potential and/or existing problems.
- Describe drainage system between the site and the receiving surface waters (or pothole, regional detention BMP, etc.). Provide information on pipe sizes, channel characteristics, and drainage structures. Describe emergency services located along the flow path (e.g., fire/police stations, hospitals). Describe environmentally sensitive areas, such as wetlands, etc.
- Describe off-site drainage tributary to the project. Describe any bypass drainage from the project which will not be controlled.
- Identify CARAs, WHPAs, drinking water wells, and septic systems both of record and others on the site and on adjacent property within the setback distance for stormwater BMPs identified in Chapter 7. See area maps in Appendix 8B as well

as on the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/>.

- The bulk of the analysis shall focus on highlights of important considerations from the existing conditions section related to the drainage system and potential problems or concerns. 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
    - 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.

Drainage Control Plan Report Section 4: Soils and Infiltration Analysis

4.1 Summary of Soils and Geotechnical Data: Provide a summary of existing site soil conditions and pertinent information from the site geotechnical report. Emphasis is on data used to assess infiltration at the site. This section should include the following components:

- Number of test pits and/or soil borings conducted on the project site, and when the soil explorations were conducted.
- Soil test pit/boring locations in relation to proposed stormwater BMPs.
- Soil types on-site, both geologic/glacial (e.g., Vashon till or recessional outwash) and NRCS Soil Units (e.g., Indianola series, Hydrologic Soil Group A).
- Presence of any fill material, mounds, piles, etc.

4.2 Subsurface Factors: Describe subsurface soil, rock, and groundwater conditions in relation to proposed stormwater BMPs.

- Infiltration feasibility assessment, including presence of any restrictive layers within 10 feet depth below the base of any proposed infiltration BMPs.
- Determination of seasonal high groundwater levels at the site and methodology.

4.3 Infiltration Rates: Describe the methodology and results used to determine initial and design infiltration rates.

- Measured (initial) saturated hydraulic conductivity, K_{sat}, for each proposed BMP location where infiltration is feasible.
- Design (long-term) infiltration rate calculations for each proposed BMP location where infiltration is feasible. For calculations, show your work.
- If infiltration is not feasible, provide justification.

Drainage Control Plan Report Section 5: On-Site Stormwater Management and Low Impact Development (Core Requirement #5)

This section shall describe how Core Requirement #5 will be implemented for the project. Where feasible, projects shall maximize the use of LID site design strategies to minimize effective impervious areas, vegetation loss, and stormwater runoff (before selecting permanent flow control and runoff treatment BMPs). See Chapter 1, Section 1.4, and Chapter 4, Section 4.3 for additional details and recommended BMPs.

LID site design in particular is intended to complement the existing conditions on the site. However, not all sites are appropriate for all LID and on-site stormwater management BMPs, as site conditions often determine the feasibility of using these techniques. The site and vicinity analysis, consistent with the requirements of Section 3, shall determine the feasibility of using these BMPs. This section should include the following components:

5.1 LID Site Design: Provide the following:

- Summary of LID site design considerations and how they are being implemented.
- Description of how LID principles and practices will be applied to the project.

5.2 Methodology: For LID BMPs and Core Requirement #5, describe the following:

- Project narrative showing how the project will fulfill the requirement for on-site management of stormwater to the extent feasible.
- How site planning and layout (per Chapter 1, Section 1.4) were implemented in the project design.
- Total area of vegetation retained.
- Specify choice of List #2 or LID Performance Standard, and describe how the project complies with the selected option.

- For projects using the list option for Core 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. Information obtained and documented in the Site and Vicinity Description (Section 3, see above) shall be used to substantiate any BMP infeasibility determinations. (See also Chapter 7, Appendix 7B, for a summary of infeasibility criteria for all BMPs.)

- For projects using the LID Performance Standard option for Core Requirement #5, provide modeling results that demonstrate compliance.

5.3 <u>LID Practices:</u> Describe the LID BMPs that are proposed to be implemented on-site. Specify the BMP names and BMP numbers per the SDM.

5.4 <u>Post-Construction Soil Quality and Depth:</u>

- Specify the implementation option(s) for post-construction soil quality and depth selected for the project site (see Chapter 7, Section 7.4.1).

- Quantify the areas of disturbed soils to be amended. (Note: All lawn and landscaped areas are to meet requirements of postconstruction soil quality and depth [see Chapter 7, Section 7.4.1]. Use of compost is one way to meet the requirement). Calculations shall be provided in the Soil Management Plan (Drainage Control Plan Report Appendix 4).

5.5 <u>Retained Trees and Aesthetics:</u>

- Identify retained trees and newly planted trees for which impervious reduction credits are claimed (see Chapter 7, Section 7.4.3 for information on impervious surface credits associated with trees).

- Describe how the stormwater design blends-in with the site layout and landscaping.

- Aesthetic Considerations for BMPs. Describe the effort made to make the BMPs aesthetically pleasing, how BMPs will provide useable open space, and how the BMPs will fit into the landscaping plan for the property and be in keeping with any approved community plan. Stormwater BMPs should be made attractive features of the urban environment. Engineers are encouraged to be creative in shaping and landscaping BMPs. Note that BMPs shall also meet the landscaping requirements of Chapter 16.80 LMC.

Drainage Control Plan Report Section 6: Runoff Treatment and Flow Control (Core Requirements #6 and #7)

6.1 <u>Runoff Treatment Selection:</u> Summarize the selection process for runoff treatment BMPs. Specify the runoff treatment performance goals that are required for the project site (e.g., oil control and enhanced treatment), and the basis for the selected BMPs (e.g., site location in a CARA Category 1).

6.2 BMP Types & Descriptions: Specify and describe the runoff treatment BMPs that are proposed to be implemented on-site to meet the required performance standards. If separate flow control BMPs are proposed, describe those BMPs and how they are proposed to be implemented. Use the BMP names and BMP numbers per the SDM.

6.3 Facility Selection and Design Data: Describe facility selection and sizing, both minimum required size/capacity and proposed size/capacity. If proprietary manufactured BMPs (or "emerging technologies") are proposed to be implemented, provide Ecology's applicable GULD (General Use Level Designation) documentation and the manufacturer's product data in Appendix 2 of the Drainage Control Plan Report. Provide the manufacturer's maintenance recommendations in Drainage Control Plan Report Attachment 2, the project's Maintenance and Source Control Manual.

6.4 Design Calculations: Provide design calculations for all proposed BMPs. Complete engineering calculations, including hydrologic modeling analyses and documentation, must be included with the report. Generally, calculations should be summarized in this subsection of the Drainage Control Plan Report, with computer printouts placed in Appendix 3 and referenced where appropriate.

The project engineer shall provide complete calculations for the project's flow control and runoff treatment system components. All WWHM inputs and results shall be provided in Appendix 3 and summarized in this section. All relevant work/calculations shall be submitted for City review, either in this section of the report or in included appendices if needed.

- Describe the sizing required and provided by each BMP.
- For infiltration BMPs, specify the design infiltration rate, describe how rate was determined, and provide calculations ("show your work").
- All calculations shall be keyed to features shown on the Site Development Drawings.
- Include a table that identifies the design BMP stage expected for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval flows.

If hydrologic modeling (see Chapters 2, 6, 7, and 8) is required, the project engineer and project applicant shall:

- Use an approved continuous simulation runoff model.
    - Continuous simulation runoff models must receive prior concurrence from the City before being used for BMP design. Ecology's approval status for other

continuous simulation runoff models is provided in the "Additional Resources" section of the online 2019 Ecology Manual: <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm>

- Document modeling methods, assumptions, parameters, data sources, and all other relevant information to the analysis.
- If model parameters are used that are outside the standards of practice, or if parameters are different than those standards, justify the parameters.
- Provide hard copies of the model inputs and outputs, with annotations (clear, hand-written notes are acceptable) in Appendix 3 of the Drainage Control Plan Report (Design Calculations) specifically highlighting key model inputs and results. This will provide clarity and facilitate a more efficient review and approval process.
- Provide digital copies of the model files sufficient to re-run the model and include input parameters, as well as model output files to the City.
- Projects taking an impervious surface reduction credit for newly planted or retained trees (see tree planting and tree retention in Chapter 7, Section 7.4.3) 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.

For design of runoff treatment BMPs specifically, if bioretention and/or infiltration below PGHS through adequate soils (see Chapter 8, Section 8.6.3) will be used to help meet runoff 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 percent of the total stormwater runoff file. This sum of volumes must include:

- Stormwater that has infiltrated through a bioretention area, and stormwater that has infiltrated below PGHS (e.g., permeable pavement) through adequate soils.
- Stormwater that passes through a properly-sized runoff treatment BMP. Note that stormwater that is re-collected below a bioretention area and routed to a centralized runoff treatment BMP must not be counted twice.
- Subtraction of any stormwater that does not receive treatment due to bypass of, or overflow from a runoff treatment BMP or a bioretention area (if the overflow is not subsequently routed to a runoff treatment BMP).

For a subdivision project, document assumptions related to roof, driveway, and other hard surface lot coverages (as well as contributing pervious areas) that have been used in the design and sizing of BMPs.

Drainage Control Plan Report Section 7: Runoff Collection & Conveyance System

This section must document the methods and results of analyses used to evaluate and design the conveyance system per the hydraulic computation guidance in Chapter 6. All calculations, equations, graphs, nomographs, and references used shall be provided in Appendix 3 of the Drainage Control Plan (Design Calculations) and summarized in this section.

7.1 System Design & Layout: Provide a narrative description of the runoff collection and conveyance system. Describe the general layout, and identify all components of the system including pipes, inlets, manholes, open channels, natural channels, and culverts.

7.2 Conveyance System Calculations Summary: Provide summaries of all calculations for capacity of channels, culverts, drains, gutters, etc. Describe design flow rates for each component, as well as pipe/culvert/ditch dimensions, inverts, slopes, and flow capacities. Summarize the applicable performance standard (e.g., 25-year return period peak runoff) used for the conveyance system. Describe required materials or specifications for the design (e.g., rock lining for channels when velocity is exceeded, high density polyethylene pipe needed for steep slope). If a backwater analysis is required, calculations should also include grate interception calculations (spread and bypass), hydraulic grade line at structures, and tabulated results.

If used, include nomographs and tables indicating how they were used. Show headwater and tailwater analysis for culverts when necessary. Provide details on references and sources of information used.

Drainage Control Plan Report Section 8: Source Control

8.1 Potential Sources of Pollutants: Describe potential pollutant sources that may occur on the developed project site, based on the expected site use.

8.2 Source Control BMPs: List and provide a description of applicable permanent post-construction Source Control practices that will be described in greater detail in the Maintenance and Source Control Manual (Drainage Control Plan Attachment 2). Refer to Chapter 9, Section 9.2 for Source Control BMP Selection.

8.3 Source Control Checklist and Worksheet: Check and list all activities that will occur at proposed project. Use one worksheet for each activity from the checklist. Refer to Chapter 9, Appendix 9A.

Drainage Control Plan Report Section 9: Covenants, Dedications, Easements, Agreements, and Guarantees

9.1 Covenants, Dedications, and Easements: Information relevant to covenants, dedications, and easements need only be summarized in this section. Details shall be provided in the Maintenance and Source Control Manual and the Establishment of Maintenance Covenant (see Section 3.4.3).

Describe legal instruments needed to guarantee preservation of drainage systems and access for maintenance purposes (attach copies if not included as part of other Drainage Control Plan submittals). Describe the organization or person who will be responsible for operation and maintenance of storm drainage BMPs. For projects subject to Core Requirement #5, a declaration of covenant must be recorded for each parcel that contains on-site stormwater management BMPs, to ensure future maintenance of those BMPs. Also attach a copy of any property owners' articles of incorporation, if applicable and available.

Last, describe how utilities will be installed, any easements that affect stormwater BMPs, and how the project will ensure no conflicts exist between proposed utility locations and proposed stormwater quantity and quality control measures.

9.2 Agreements and Guarantees: Maintenance and/or operational bonding or other appropriate financial guarantees are required for all projects to ensure construction and functionality of drainage BMPs in compliance with applicable standards. These guarantees shall be consistent with the most recent edition of the DG&PWS.

Drainage Control Plan Appendices

The previous sections outline the required documentation for Drainage Control Plan submittals. Where the project warrants additional technical documentation, or where the SDM Administrator determines that additional information is necessary, that information shall be included as appendices to the Drainage Control Plan, bound within the Drainage Control Plan Report document. The following highlights typical Drainage Control Plan appendices.

Drainage Control Plan Report Appendix 1: Maps and Plans

In addition to full-size plan sets submitted for land-use and civil review/approval, various maps and plan drawings shall be included in Drainage Control Plan Report Appendix 1. Maps and plans in the printed version of the Drainage Control Plan Report should be 8.5"x11" or 11"x17" fold-outs, sized as needed to show details (see preferred sizes in list below).

Appendix 1 of the Drainage Control Plan Report shall include the following maps, sized so that all pertinent details are clearly visible:

1a. Vicinity Map (8.5"x11"): Show city boundary, major streets, and project location.

1b. NRCS Soil Types Map (8.5"x11"): e.g., from Web Soil Survey.

1c. Existing Site Topography Map (11"x17" fold-out): Show all features described in Drainage Control Plan Report Section 3, including existing ground contours at 1-foot intervals, slopes, trees, surface waters, utilities, any existing constructed improvements (prior to project development), and drainage patterns.

1d. Basin Map (11"x17" fold-out): Delineation of post-development site areas draining to each runoff collection point, including surface flow arrows. Identify TDAs where applicable. Use an appropriate scale for the project site. Show the following on the Basin Map (or on a schedule):

- Total project area (including project boundaries)
- Subbasin boundaries
- Off-site area tributary
- Total hard surfaces
- PGHS, PGIS, PGPS, and total disturbed area
- Major drainage features (such as channels and detention BMPs and floodways)
- Conveyance data, conveyance system capacities, identifier (for reference to model output), length, slope, inverts up and down
- Overland flow paths and distances to receiving waters
- Average slope

1e. Soil Data Locations Map(s) (11"x17" fold-out): Locations of soil test pits and/or borings relative to both the existing ground contours and the proposed site layout and stormwater BMP locations.

1f. Site Plan & Stormwater BMP Plans (11"x17" fold-out): Reduced-size duplicate(s) of the site plan & drainage plan sheet(s) from the full-size plan set submittal, showing all proposed stormwater BMPs, site improvements, finished grades, etc. The drainage plan shall include a table or "schedule" for the storm drainage structures used on the project, including the following information:

- Catch basin/manhole number
- Stationing, as applicable
- City of Lacey Ground Scale Coordinate System (conversion from Washington State Plane Coordinate System) (i.e., Northings and Eastings) if used
- Street name and side located on, if applicable

- Catch basin/manhole diameter or size
- Invert elevation in/out
- Pipe diameter in/out
- Type of each structure and pipe, i.e., Type II, concrete

1g. Stormwater Details (11”x17” fold-out): Reduced-size duplicate(s) of the Drainage Details sheet(s) from the full-size plan set submittal, showing stormwater system section views, BMP details, etc.

General Site Development Drawing Requirements

It is the responsibility of the project engineer to ensure that engineering drawings submitted for review are sufficiently clear to construct the project in proper sequence, using specified methods and materials, and with sufficient dimensions to fulfill the intent of drainage laws and ordinances and these design guidelines.

Refer to the DG&PWS for requirements related to site drawing size, content, notes, organization, etc. The following notes identify and emphasize important stormwater-related components that must be reflected in the site drawings. Complete drawing requirements are provided in the DG&PWS.

- The project’s existing and proposed storm drainage along with easements, tracts, drainage BMPs, all buffer and screening areas, off-site and on-site existing drainage courses, delineated wetlands, and associated buffers. Indicate direction of flow, size, and kind of each drainage channel, pipe, and structure. The status of existing drainage structures must be clarified as either “existing-abandon” or “existing-remove.” For on-site stormwater management BMPs, provide a scale drawing of the lot or lots, and any public-right-of-way that displays the location of the BMPs and the areas served by them.

- Include details of all on-site stormwater management BMPs that are used to help achieve compliance with Core Requirement #5. If distributed bioretention areas and/or storage below permeable pavement are used to also meet Core Requirements #6 and/or 7, provide drawing details to confirm accurate BMP representation in the runoff models (submitted as part of Drainage Report Control Plan Report Section 6). See the DG&PWS for standard drawings and details.

- 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 shall also be shown.

- If distributed bioretention areas and/or infiltration below pollution-generating hard surfaces are used to help meet treatment requirements, provide details to confirm accurate representation in the runoff model (submitted as part of Drainage Control Plan Report Section 6).

- Existing paved surfaces, including roads.
- Areas of possible significant environmental concern (gullies, ravines, swales, wetlands, steep slopes, estuaries, springs, creeks, lakes, etc.). For natural drainage features show direction of flow.
- 100-year floodplain boundary (if applicable).
- Soil logs, soil log locations, and soils within the project site as verified by field testing (and documented in Drainage Control Plan Report Section 4).
- Wells and WHPAs—existing and proposed, on site and on adjacent properties (both of record and not of record) within specified setbacks.
- Topographic features that may act as natural stormwater storage, infiltration, or conveyance.
- Drainage Control Plan Reports must include a complete Construction SWPPP. See Chapter 5, Section 5.2.2, of this manual for information on the items that shall be included as part of the Construction SWPPP narrative report and drawings. See the DG&PWS for standard notes related to SWPPPs. Construction SWPPP drawings should be included as part of the Site Development Drawings package.
- Proposed grades.
- Topographic information including contour lines of the property in its existing condition. City or USGS topographic mapping must be field verified and supplemented with additional field topographic information when necessary to provide an accurate depiction of the property.
- Other typical features as listed in the DG&PWS including but not limited to utilities, lot dimensions and areas, grading/clearing setbacks from property lines, earthwork/geotechnical requirements, etc.

Detail Drawings

The most recently adopted editions of standard specifications and standard plans shall be the standards for all design and construction of stormwater BMPs not explicitly described herein. In the event of a conflict between the standard specifications, standard plans, and the manual, this manual shall prevail. When required by the City, standard specifications and general provisions for construction must be submitted with any road construction plans. The detail drawings must include the following:

- All applicable standard notes from the DG&PWS.

- A minimum of two cross-sections of each retention/detention pond and bioretention area showing original property lines, slope catch points, and all other pertinent information to adequately construct the pond or bioretention area.

- Details of all on-site stormwater management BMPs that are used to help achieve compliance with Core Requirement #5. If distributed bioretention areas and/or storage below permeable pavement are used, provide details to confirm accurate BMP representation in the runoff models (submitted as part of Drainage Control Plan Report Section 6).

- Identify locations and approximate size of all permeable pavement surfaces and bioretention areas to be installed, including those that will be installed on individual lots.

- If distributed bioretention areas and/or infiltration below pollution-generating hard surfaces are used to help meet treatment requirements, provide details to confirm accurate representation in the runoff model (submitted as part of Drainage Control Plan Report Section 6).

- Standard open conveyance system cross-sections if applicable.

- Right-of-way cross-sections as required by the City.

- Construction recommendations from a Soils Report, if applicable.

Drainage Control Plan Report Appendix 2: Supplemental Reports and Information

Depending on site and vicinity characteristics, various special reports and studies may be required to provide supplemental information.

The various types of supplemental reports and information may include:

- Soils/geotechnical report (see required contents below)

- Wetland delineation and description

- Groundwater quality and/or hydrogeology

- Critical areas analysis and delineation

- Slope protection/stability

- Floodplain delineation/flood protection BMP conformance

- Ecology’s applicable GULD documentation and the manufacturer’s product data.

Soils Report: Criteria and Contents

For virtually all project sites, particularly those sites utilizing infiltration for stormwater management, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, an engineering geologist, or a hydrogeologist, and that summarizes site characteristics and demonstrates that sufficient permeable soil for infiltration exists at the proposed BMP locations.

Soil explorations shall be performed during the winter "wet season" (October 1 through April 30) to accurately assess soil saturation and seasonally-high/perched groundwater conditions. Soil explorations conducted during other times of the year may require supplemental winter groundwater monitoring prior to approval of the draft stormwater site plan.

The reporting requirements depend on the types of BMPs proposed and analyses being performed. Note that additional BMP-specific soils and infiltration testing, analysis, and documentation requirements are outlined in Chapter 7, Section 7.2 (for infiltration basins and trenches), Section 7.4.4 (for bioretention), and Section 7.4.6 (for permeable pavements). Of particular note is that if the site is located near a groundwater protection area or water supply well, the Soils Report must demonstrate and document that the criteria for infiltrating near a water supply well (refer to Chapter 7 and Chapter 8) are met. Additional soils information related to runoff treatment may be required as outlined in Chapter 8 (e.g., Section 8.6).

At a minimum, the Soils Report for all project sites must contain the following:

- Map showing the following:
  - Existing site topography.
  - Locations of test pits and/or test borings relative to both existing topographic contours and proposed site plan layout, including infiltration BMP locations.
  - Locations of all water supply wells and monitoring wells on or near the site.
  - Locations of any groundwater protection areas, critical aquifer recharge areas, and 1-, 5-, and 10-year time-of-travel zones for WHPAs (see CARA and WHPA maps in Appendix 8B).
- Soil test pits and/or soil borings distributed across the site sufficiently to identify and characterize variability of the soils underlying the site. Depth should extend to at least 5 feet below estimated bottom elevation of proposed infiltration BMPs and road subgrades.
- Results of on-site soils tests including but not limited to:
  - Detailed soil logs, including the elevation of the ground surface at the test pit and/or test boring location, depths to soil strata, total depth of pit or boring,

soil descriptions (see below), degree of compaction, depth to groundwater (if present), and presence of any restrictive layers/stratification affecting infiltration. Soil descriptions shall include the following:

    - Deposit Type (e.g., recessional outwash, compacted till, etc.)
    - Soil Classification (e.g., SM for silty sand, or GP for poorly-graded gravel)
    - Material Description (e.g., brown silty fine sand with minor gravel)
    - Relative Density (e.g., medium dense)
    - Moisture Content (MC), relative/measured (e.g., dry, moist, or wet; MC = 12 percent)

  - Whether glacially-compacted till is present, and if so, its depth.
  - Visual grain-size analysis
  - Grain-size distribution (required if using the grain size analysis method to estimate infiltration rates)
  - Percent clay content (include type of clay, if known)
  - Color/mottling
  - Variations and nature of stratification
    - 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.
    - Seasonal high groundwater elevation (and/or perched groundwater elevation) during the late winter "wet season" (i.e., highest expected level of groundwater). If the groundwater level varies across the site, specify the level for each proposed infiltration BMP location.

- Detailed documentation of the initial measured K_{sat} and long-term (design) infiltration rate determination for each proposed infiltration BMP location, as specified in Chapter 7 and Appendix 7A.
- State whether location is suitable for infiltration and recommend a design infiltration rate.
  - Note that surface infiltration must be determined to be infeasible before deep UIC wells can be considered. Refer to Chapter 7, Appendix 7C for additional guidance and requirements related to UIC wells.

- The results of testing for a hydraulic restriction layer (groundwater, soil layer with less than 0.3 in/hr K_{sat}, glacial till, bedrock, etc.) under possible sites for infiltration BMPs. This analysis shall be performed during the winter "wet season" (October 1 through April 30). Site historical information and evidence of high groundwater in the soils can also be used.

- Any additional BMP-specific soils and infiltration testing information that is required for the project's flow control or runoff treatment BMPs (e.g., for infiltration basins and trenches, bioretention, and permeable pavements).

- If on-site infiltration may result in shallow lateral flow (interflow), the conveyance and possible locations where that interflow may re-emerge shall be assessed by a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington.

- If a retention and/or detention BMP is near the top of a slope that is regulated through local ordinance, then a geotechnical assessment addressing effects of seepage and the potential for slope failure during any precipitation event though the design event is required as part of this section of the Drainage Control Plan Report.

Drainage Control Plan Report Appendix 3: Design Calculations

Design calculations must include complete calculations for the conveyance, flow control, and water quality BMPs. Calculations must be presented in a clear and orderly manner and labeled and annotated as needed to facilitate an efficient review and approval process. Required calculation components include:

- Printouts of the continuous modeling computation files (e.g., continuous modeling inputs, screenshots, and results) annotated to highlight and clarify key inputs, results, and conclusions.

- Other computer printouts or manual calculations used in the stormwater design.

- Digital copies of the model files sufficient to re-run the model including input parameters and model output files.

Drainage Control Plan Report Appendix 4: Soil Management Plan

If Post-construction Soil Quality and Depth BMP is used on site (refer to Chapter 7, Section 7.4.1), a Soil Management Plan must be included in the project submittal. The Soil Management Plan must include the following:

- A site map showing areas to be fenced and left undisturbed during construction, and areas that will be amended at the turf or planting bed rates

- Determination of soil conditions

- Identified soil quality implementation option
- Calculations of the amounts of compost, compost amended topsoil, and mulch to be used on the site.

General guidance on these procedures can be found in the Building Soil manual (Stenn, et al. 2018), available at <https://www.soilsforsalmon.org/>.

Drainage Control Plan Attachments

The following two attachments shall be included in the project submittals, but as stand-alone documents bound separately from the Drainage Control Plan Report. The final version of the Construction SWPPP will be used by the contractor, CESCL, and City inspectors on the project site during construction; the Maintenance and Source Control Manual will be used by the post-development owners, BMP maintenance personnel, and City inspectors.

Drainage Control Plan Attachment 1: Construction SWPPP Report

Chapter 5, Section 5.2.2, of this manual describes the items that shall be included in the Construction SWPPP report. At a minimum, all 13 Construction Stormwater Pollution Prevention elements in accordance with Core Requirement #2 (Chapter 2, Section 2.4.2) must be addressed. The Construction SWPPP shall be implemented starting prior to any land disturbance and continue until final stabilization. The City may require the completion, submission, and approval of a wet-season amendment to the Construction SWPPP, which may include additional construction BMPs (e.g., stabilized parking, dewatering provisions, etc.), stopping work during the wettest months, and/or a bond for maintenance of the downstream system. See Chapter 5, Section 5.2.3 for more details. See Chapter 5, Section 5.2.3 for more details.

Note: The Construction SWPPP consists of two parts: a narrative report and drawings. **A complete Construction SWPPP (both report and drawings) is required as part of the Drainage Control Plan submittal.** Note that the Construction SWPPP drawings should be included in the drawing packet required as Drainage Control Plan Report Appendix 1.

Drainage Control Plan Attachment 2: Maintenance and Source Control Manual

In accordance with Core Requirement #9 and Table 3.1, a Maintenance and Source Control Manual must be developed for projects that require a Drainage Control Plan. For privately-owned BMPs, a copy of the manual shall be retained on site or within reasonable access to the site, and shall be transferred with the property to the new owner. A log of maintenance activity that indicates what actions were taken shall also be kept and be available for inspection by the City. For public BMPs, a copy of the manual shall be retained in the appropriate department.

The manual must comply with the recording standards of the Thurston County Auditor's Office. The manual must be prepared by a professional engineer, but must be understandable to the typical property owner and/or person responsible for maintenance.

(Note that the Maintenance and Source Control Manual may be presented in outline form for the draft Drainage Control Plan Report submittal, but completed for Public Works civil plan approval. It is a document that will live with the project site after completion, so it needs to reflect final [built] conditions.)

For both private and public BMPs, it is important to work with maintenance personnel early and throughout the design process. During discussions with maintenance personnel, describe the maintenance procedures that will be performed on the site BMPs. This will help ensure that future maintenance work and potential access needs are clearly understood.

The Maintenance and Source Control Manual must include site-specific details including applicable BMPs, frequency of maintenance activities, a landscape plan, and specific contaminants that are restricted and controlled. The Maintenance and Source Control Manual must include the following components:

Cover Page: The Maintenance and Source Control Manual must have a cover page that includes the project name; engineer's name, address, telephone number, and email address; date of preparation of the manual (and any updates); project parcel numbers; and applicable City permit numbers.

Map: A map of the project site area must be included in the manual. The extent of the map shall be inclusive of all the drainage BMPs that are a part of the Drainage Control Plan for the project. The intent of the map is to show the drainage BMPs, boundaries (drainage easements) of the maintenance responsibilities, and access easements that the Maintenance and Source Control Manual addresses. Include a key referencing the applicable maintenance checklists required to be used in performing routine inspection and maintenance for the BMP. The map is not intended to provide a high level of detail nor is it intended to call out every drainage structure (e.g., catch basins). The map shall provide road names of the existing roads that the project connects to as well as any proposed roads. The map can be one or multiple pages.

Drawings and Specifications: The Maintenance and Source Control Manual must reference the approved plans, specifications, and Drainage Control Plan Report on file at the City.

Maintenance and Source Control Manual Sections

Section 1: Project Description

Provide a brief description of the development project, including project type (plat, short plat, commercial center, industrial, etc.) and size (acres, number of lots, linear feet of road, square feet of building, etc.). Describe the stormwater BMPs and conveyance systems, and how these systems are designed to manage the volume, rate, and quality of stormwater runoff from the project. Describe where stormwater flows come from, how water moves through the site and BMPs, and how and where the stormwater leaves the site.

Section 2: Maintenance Importance and Intent

Include the following statement in this section:

"The importance of maintenance for the proper functioning of stormwater control BMPs cannot be over-emphasized. A substantial portion of failures (clogging of filters, resuspension of sediments, loss of storage capacity, etc.) are due to inadequate maintenance. Stormwater BMP maintenance is essential to ensure that BMPs function as intended throughout their full life cycle.

The fundamental goals of maintenance activities are to ensure the entire flow regime and treatment train designed for this site continue to fully function. For this site these include (Note to engineer: include in your text all of the following bullets that apply to your site. Non-applicable content can be omitted):

- Maintain designed stormwater infiltration capacity
- Maintain designed stormwater detention/retention volume
- Maintain ability of stormwater BMP to attenuate flow rates
- Maintain ability to safely convey design stormwater flows
- Maintain ability to treat stormwater runoff
- Preserve soil and plant health, as well as stormwater flow contact with plant and soil systems
- Clearly identify systems so they can be protected
- Keep maintenance costs low
- Prevent large-scale or expensive stormwater system failures
- Prevent water quality violations or damage to downstream properties.

The intent of this section and manual is to pass on to the responsible party(s) all the information critical to understand the design of the system, risks and considerations for proper use, suggestions for maintenance frequencies, and cost so that realistic budgets can be established."

Section 3: Responsible Parties

Stormwater BMPs range in size and complexity. Entities responsible for maintenance should be appropriately matched to the tasks required to ensure long-term performance. For example, an individual homeowner may be able to reasonably maintain a rain garden, permeable driveway, infiltration trench, or other small BMP. However, larger BMPs are often maintained through private parties, shared maintenance covenants with the City, or by City ownership.

This section of the Maintenance and Source Control Manual must identify the party (or parties) responsible for maintenance and operation of all stormwater structures and BMPs requiring maintenance. Also include a statement of who will keep the Maintenance and Source Control Manual, the address where it will be kept, and language noting that it must be made available for inspection by the City upon request. For a subdivision, the Maintenance and Source Control Manual shall be held by the Home Owners Association president, and shall be included by reference in the articles of incorporation of the Home Owners Association.

Refer to the Maintenance Covenant (Section 3.4.3) for guidance.

Section 4: BMPs Requiring Maintenance

Provide a detailed inventory of all stormwater structures and BMPs requiring maintenance. For situations where there are split maintenance responsibilities (e.g., private/public), provide a breakdown of the entity responsible for each structure and BMP. Describe (or include reference to other plan sections) how each collection, conveyance, treatment, and flow control component works. Explain the principles of BMP operation, overview of maintenance requirements, and any other information that might be helpful for future maintenance of the BMPs. This could include pipe and swale data, the design capacities of the conveyance systems, sizing, and dimensions of BMPs, rip rap specifications, and calculated flow rates.

Section 5: Maintenance Instructions

This section shall begin with the following statement, unless otherwise approved by the City:

> *"The parties responsible for maintenance must review and apply the maintenance requirements contained herein. These maintenance instructions outline conditions for determining if maintenance actions are required, as identified through inspection. However, they are not intended to be measures of the BMP's required condition at all times between inspections. Exceedance of these conditions at any time between inspections or maintenance activity does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance presented in the checklists shall be adjusted to minimize the length of time that a BMP is in a condition that requires a maintenance action. For BMPs not owned and maintained by the City, a log of maintenance activity that indicates what actions were taken must be kept on site and be available for inspection by the City."*

In addition, include a narrative description of the purpose, function, and maintenance requirements for all stormwater structures and BMPs requiring maintenance. Following the narrative description(s), include detailed maintenance checklists for all stormwater structures and BMPs requiring maintenance. Chapter 10 includes maintenance checklists for all stormwater BMPs and BMPs included in this Stormwater Design Manual. The Maintenance and Source Control Manual shall include only those checklist items that are pertinent to the structures and BMPs proposed for your project. Do not include all of the checklists provided in Chapter 10. Note that the maintenance checklists (and narrative descriptions) can be included as an attachment to the Maintenance and Source Control Manual, so long as they are clearly referenced in this section. The checklists (or City-approved equivalent) shall be used as the required log sheet for recording inspection observations and maintenance activities in accordance with the stormwater maintenance requirements within the Chapter 14.25 LMC. Note also the ongoing stormwater BMP inspection and reporting requirements, also outlined in the Stormwater Code.

Section 6: Vegetation Maintenance

The effectiveness of many stormwater BMPs will depend on the plants included in the BMP design, and their proper maintenance. A listing and location of plant species from the approved landscape plans and their requirements for maintenance shall be included in this section. This includes newly planted and retained trees claimed as flow reduction credits, as well as vegetation retention and restoration areas. Maintenance requirements must address issues including but not limited to pest and disease management practices, pruning requirements, irrigation requirements, fertilization requirements, etc.

Section 7: Pollution Source Control Measures

Pollution source control is the application of pollution prevention practices on a developed site to reduce contamination of stormwater runoff at its source. BMPs and resource management systems are designed to reduce the amount of contaminants used and potentially discharged to the environment. This section of the Maintenance and Source Control Manual shall contain language regarding pollution source controls that are specifically applicable to the site. Include pertinent text from the 15 pollution prevention principles outlined in Chapter 9, Section 9.3, plus any additional site-specific pollution source control issues. Additional information on required and suggested source control measures is provided in Chapter 9.

The completed Stormwater Pollution Source Control Checklist and Worksheet provided in Chapter 9, Appendix 9A shall be attached to the Maintenance and Source Control Manual. Any required BMPs shall be listed on the Stormwater Pollution Source Control Worksheet and identified on Stormwater Site Plans.

Section 8: Annual Cost of Maintenance

Provide an estimate of the expected annual cost of maintenance projected for 20 years. The estimate shall include the annualized cost of both routine tasks (e.g., vegetation maintenance and debris removal, refurbishing media filter cartridges, etc.) and non-routine major tasks (e.g., wet pond sediment removal, infiltration enhancement, etc.). Refer to Section 4 and summarize the number of catch basins, control structures, linear feet of pipe, etc. that require maintenance and the cost implications. See Appendix 3B for specific requirements and examples, or contact the City for additional guidance if needed.

3.4 Plans and Documentation Required After Stormwater Site Plan Approval

3.4.1 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 City for approval prior to construction. The submittals shall 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. Changes shall be "clouded" and noted in the revision block on the drawing.

4. Any other supporting information that explains and supports the reason for the change.

3.4.2 Final Corrected Plan Submittal

If the project included construction of conveyance systems, treatment BMPs, flow control BMPs, or structural source control BMPs (even if only used to meet the requirements of Core Requirement #5), the project applicant shall submit a final corrected plan ("as-builts") to the City when the project is completed. These should be engineering drawings that accurately represent the project as constructed. These corrected drawings must be professionally drafted revisions that are stamped, signed, and dated by a licensed professional engineer registered in the state of Washington. The licensed professional shall certify that the construction of conveyance systems, runoff treatment BMPs, flow control BMPs, and/or structural source control BMPs conform to the intent of the design. Performance verification may be required prior to final approval per Chapter 7, Section 7.2.2.

3.4.3 Maintenance Covenant

A maintenance covenant is required for each site/lot that contains stormwater management BMPs that will be maintained by a private entity such as an individual, corporation, or homeowner's association. The recorded maintenance covenant must be created using the provided City of Lacey *Stormwater Maintenance Covenant Form* (obtainable from the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/>), and any attachments shall meet the recording requirements of the Thurston County Auditor's Office. The covenant shall be recorded at the Thurston County Auditor's Office at the expense of the project applicant, and shall be tied to the parcel numbers that the project is built on. All covenants must be recorded prior to final construction approval for the proposed project.

The covenant shall include the following:

1. A legal description of the property.
2. Assessor parcel numbers.
3. Project name.
4. Project application/permit number.
5. Parties responsible (including contact information) for maintenance and implementation of pollution source control measures.
6. Language stating that the covenant shall run with the land and be binding on all successors and assigns.
7. A requirement that the responsible parties maintain the stormwater BMPs in accordance with the attached project Maintenance and Source Control Manual.
8. A requirement that the responsible parties implement pollution source control measures in the attached Maintenance and Source Control Manual.
9. A requirement that the responsible parties keep and maintain a log of maintenance activity that indicates what actions were taken, and that the log be made available for inspection by the City.
10. Language that prohibits unauthorized modifications, unless approved by the City.
11. Language that provides for a City approval process and allows modification to the covenant, or to the Maintenance and Source Control Manual.
12. Language that provides for a City process (remedies) for situations where the responsible party fails to perform the required maintenance or fails to implement the pollution source control measures.
13. Language that provides access authority to the City for purposes of inspection, maintenance, and repair.
14. Language that provides for reimbursement to the City by the responsible party in the event that the City incurs costs related to maintenance or repair.
15. The location of the approved Drainage Control Plan.
16. The Maintenance and Source Control Manual as an attachment.

Chapter 3 References

Stenn, et al. 2018. Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington. 2018 Edition. <https://www.soilsforsalmon.org/>.

Appendix 3A – Construction Stormwater Pollution Prevention Plan (SWPPP) "Short Form"

All projects are subject to Core Requirement #2 of the City of Lacey *Stormwater Design Manual* to address erosion and sediment control, starting prior to initial land disturbance and continuing until final stabilization of the entire project site. This "Short Form" is for small projects that are not required to complete a full Construction Stormwater Pollution Prevention Plan (SWPPP)*.

Please submit a completed Short Form to the City of Lacey along with a basic site illustration showing existing site features and proposed improvements. Refer to the City of Lacey 2022 *Stormwater Design Manual* for further information on construction erosion and sediment control. Please print clearly.

Project Information

Project Name: ______________________________

Project Address or Location: ______________________________

Parcel Number: ______________________________

Parcel Owner: ______________________________ Phone: ______________

Address (if different from above): ______________________________

Contractor/Construction Company: ______________________________

Project Foreman: ______________________________ Phone: ______________

Form Completed By:

____

(printed name) (signature) (date)

Project Description: ______________________________

____

Total Area of Land Disturbance: ____________________ sq. ft. (must be <7,000 sq. ft.)*

Hard Surface Areas (e.g., driveways, sidewalks, pavement, etc.):

Existing Hard Surface = ____________________ sq. ft. (total, before project)

Proposed Hard Surface = ____________________ sq. ft. (total, after project)

Hard Surface Area to be Replaced = ____________________ sq. ft. (total, after project)

Roof Area of Structures:

Existing Roof Area = ____________________ sq. ft. (total, before project)

Proposed New Roof Area = ____________________ sq. ft. (total, after project)

Roof Area to be Replaced = ____________________ sq. ft. (total, after project)

Total of New + Replaced Hard Surfaces = ______________ sq. ft. (must be <2,000 sq. ft.)*

** Note:*

If project exceeds the size thresholds, you cannot use this Short Form and must complete a full SWPPP.

▶Conditions or features present within or adjacent to the project site:

Trees/Forest Buffer	☐ Yes	☐ No	Slopes >20%	☐ Yes	☐ No
Wetlands, Lakes, Ponds	☐ Yes	☐ No	Creek or Stream	☐ Yes	☐ No
Ditches or Swales (along street frontage)	☐ Yes	☐ No	Storm Drain Inlets (in street gutter within 300 ft. of site)	☐ Yes	☐ No

▶Estimated schedule of site construction activities:

Site Construction Activities	Estimated Start Date	Estimated End Date
Begin Project: Install Temporary Erosion & Sediment Controls (stabilized construction access, silt fence, etc.)	________	
Demolition, Vegetation Removal, and Earthwork (including Clearing, Grading, and Excavation)	________	________
Asphalt, Concrete, and/or Gravel Paving	________	________
House/Building/Structure Construction	________	________
Landscaping/Lawn and Final Site Stabilization	________	________
Completion of Project (Removal of Temporary Erosion & Sediment Controls)		________

▶**Erosion & Sediment Control "Best Management Practices" (BMPs)**

All land-disturbing projects are required to consider all 13 elements identified on the following pages. However, small sites using this Short Form should pay particular attention to these five **basic Erosion & Sediment Control objectives and** Best Management Practices (BMPs):

1. <u>Protection of Adjacent Properties, Drainage Systems, Surface Waters (Elements #1 – #9)</u>

   Protect adjacent off-site areas from surface water flows and sediment deposition by appropriate use of BMPs such as silt fencing, straw wattles, mulching, inlet protection, etc. Apply BMPs prior to initial land-disturbance, and maintain until site work is finished and site is stabilized.

2. <u>Prevent Soil Track-out onto Streets (Element #2)</u>

   Stabilize access route with quarry spalls or crushed rock (or pavement) to minimize the tracking of soils and debris onto public roads. Limit vehicle access to one route to/from work site.

3. <u>Stabilization of Cleared Areas (Elements #5, #6, and #8)</u>

   Stabilize all exposed soils through application of BMPs to prevent erosion and movement of sediments. At all times, contractor should have sufficient labor, materials, and equipment on-site to apply BMPs and stabilize all exposed soils within 12 hours as site and weather conditions dictate. Seasonal restrictions under Element #5 apply to all sites. Permanently stabilize site at project completion.

4. <u>Apply and Maintain BMPs (Elements #11 and #12)</u>

   Control any adverse effects due to site work with appropriate erosion and sediment control BMPs, and regularly inspect and maintain all erosion and sediment control BMPs to ensure continued performance of their intended functions. Remove temporary BMPs at project completion.

5. <u>Protect Low Impact Development BMPs (Element #13)</u>

   Protect stormwater infiltration areas from soil compaction and sedimentation, by using careful site planning, equipment operation, erosion & sediment control, and site restoration.

Checklist: 13 Elements of Construction Site Erosion and Sediment Control

Note: Each of the 13 Elements must be considered for applicability to your project. Review each element and identify all BMPs that are likely to be implemented on your site. Refer to the City of Lacey 2022 Stormwater Design Manual (SDM) Chapter 5 for more information on these and other construction-phase BMPs, and for supplemental information for each element that should also be considered for your site.

The 2022 SDM is available online at <https://cityoflacey.org/resource_library/stormwater-utility/>.

Required Elements	General Requirements	Best Management Practices (BMPs) (check all that are likely to be implemented)
Element #1: Clearing Limits	Prior to beginning land-disturbing activities, mark clearing limits and delineate sensitive areas and their buffers with high-visibility fencing.	☐ BMP C101: Preserve Natural Vegetation ☐ BMP C102: Buffer Zones ☐ BMP C103: High-Visibility Fence ☐ BMP C233: Silt Fence
Element #2: Construction Access	Establish stabilized access to project site (quarry spalls, etc.). Clean the public road if sediment is tracked off site.	☐ BMP C105: Stabilized Construction Access ☐ BMP C106: Wheel Wash ☐ BMP C107: Construction Road/ Parking Area Stabilization
Element #3: Control Flow Rates	Prevent erosion and protect off-site and downstream areas by controlling the volume, velocity and peak flow rate of site runoff.	☐ BMP C207: Check Dams ☐ BMP C209: Outlet Protection ☐ BMP C235: Wattles ☐ BMP C240: Sediment Trap ☐ BMP C241: Sediment Pond (Temporary)
Element #4: Sediment Controls	Install sediment controls to prevent sediment movement and to keep sediment from leaving site.	☐ BMP C231: Brush Barrier ☐ BMP C233: Silt Fence ☐ BMP C234: Vegetated Strip ☐ BMP C235: Wattles ☐ BMP C240: Sediment Trap ☐ BMP C241: Sediment Pond (Temporary)
Element #5: Stabilize Soils	All unworked and exposed soils shall be stabilized to prevent erosion. During the "wet season" (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.	☐ BMP C120: Temporary & Permanent Seeding ☐ BMP C121: Mulching ☐ BMP C122: Nets and Blankets ☐ BMP C123: Plastic Covering ☐ BMP C124: Sodding ☐ BMP C125: Topsoiling/Composting ☐ BMP C130: Surface Roughening ☐ BMP C131: Gradient Terraces ☐ BMP C140: Dust Control
Element #6: Protect Slopes	Design and construct cut and fill slopes to minimize erosion.	☐ BMP C120: Temporary & 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 C204: Pipe Slope Drains ☐ BMP C206: Level Spreader ☐ BMP C207: Check Dams

Required Elements	General Requirements	Best Management Practices (BMPs) (check all that are likely to be implemented)
Element #7: Protect Drain Inlets	Protect conveyance system from sediment by filtering or treating stormwater prior to flow entering inlets.	☐ BMP C220: Inlet Protection Note: Never put anything other than stormwater into a storm drain. “Only rain down the drain.”
Element #8: Stabilize Channels and Outlets	All conveyance channels and outlets shall be constructed and stabilized to prevent erosion.	☐ BMP C202: Riprap Channel Lining ☐ BMP C122: Nets and Blankets ☐ BMP C207: Check Dams ☐ BMP C209: Outlet Protection
Element #9: Control Pollutants	Handle, store and dispose of concrete washout and const. debris in closed container or by removal from site so it does not contaminate stormwater. Apply spill prevention and cleanup to vehicle & equipment activities.	☐ BMP C151: Concrete Handling ☐ BMP C152: Sawcutting and Surfacing Pollution Prevention ☐ BMP C153: Material Delivery, Storage and Containment ☐ BMP C154: Concrete Washout Area ☐ BMP C251: Construction Stormwater Filtration
Element #10: Control Dewatering	Manage dewatering water to prevent sediment discharge from site. Manage turbid water separately from stormwater.	☐ BMP C203: Water Bars ☐ BMP C206: Level Spreaders ☐ BMP C236: Vegetative Filtration
Element #11: Maintain BMPs	Inspect, maintain and repair BMPs as needed to keep them in fully functional condition.	☐ BMP C150: Materials On Hand
Element #12: Manage the Project	Phase project to prevent soil erosion and transport. Avoid soil disturbance from October 1 through April 30. Certified Erosion and Sediment Control Lead (CESCL) to inspect and monitor BMPs on sites >1 acre.	☐ BMP C150: Materials On Hand ☐ BMP C162: Scheduling
Element #13: Protect Low Impact Development (LID) BMPs	Protect all LID BMPs from sedimentation and compaction through preventative measures, as well as installation and maintenance of construction SWPPP BMPs on portions of the site that drain to the LID BMPs.	☐ BMP C102: Buffer Zones ☐ 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) ☐ BMP C231: Brush Barrier ☐ BMP C233: Silt Fence ☐ BMP C234: Vegetated Strip

► Submit completed form to the City along with a basic site illustration showing existing and proposed site features, including property boundaries, north arrow, adjacent streets, and planned locations of erosion & sediment control BMPs.

Appendix 3B – O&M Cost Estimate Calculations

This appendix includes supplemental requirements and examples to aid in developing Section 8 of the Maintenance and Source Control Manual (Attachment 4 of the Drainage Control Plan), Annual Cost of Maintenance. The Cost Estimate for Operation and Maintenance shall be prepared by the design engineer, with the intention of assisting the postdevelopment owners of stormwater BMPs in understanding and budgeting for long-term BMP operation and maintenance costs.

The Cost Estimate for Operation and Maintenance should follow this general format:

- Introduction
- Part I: Inventory of On-Site Stormwater BMPs
- Part II: Routine Operation and Maintenance Assumptions
- Part III: Routine Operation and Maintenance Estimated Annual Costs
- Part IV: Estimated Annual Partial Replacement Cost
- Part V: Estimated Monthly Contribution to Stormwater BMPs Operation and Maintenance Account

Each section of the Cost Estimate for Operation and Maintenance is described in more detail below. The Cost Estimate for Operation and Maintenance may be in tabular format, so long as adequate annotations are provided.

Introduction

The Introduction should briefly describe what drainage BMP the cost estimate is for, where it is located, what information the estimate provides, and how to understand and use it.

Part I: Inventory of On-Site Stormwater BMPs

Part I is an Inventory of all stormwater management BMPs and drainage system components that are included in the analysis, and are the responsibility of the owners to operate and maintain. The Inventory should be accompanied by a plan map of BMP locations and detail drawings.

Part II: Routine Operation and Maintenance Assumptions

Part II lists the assumptions that are made in estimating the cost for routine operation and maintenance, including the frequency of routine maintenance tasks, which tasks will be performed by whom, and assumed cost of each maintenance activity.

Part III: Routine Operation and Maintenance Estimated Annual Cost

Part III provides detailed cost breakdowns for the routine operation and maintenance of the BMP. The sum of these cost breakdowns is the estimated annual cost of routine operation and maintenance, which is used in Part V.

Part IV: Estimated Annual Partial Replacement Cost

Part IV provides an estimate of the cost to replace a portion of the stormwater system in the future and an estimated annual contribution to the operation and maintenance account to cover the partial system replacement. These costs take inflation and interest into account. The annual payment for partial system replacement is used in Part V.

Part V: Estimated Monthly Contribution to Stormwater BMPs Operation and Maintenance Account

Part V provides an estimate of the monthly contributions from each lot owner to the operation and maintenance account. These contributions are intended to cover the routine operation and maintenance costs (Part III) and the partial replacement cost (Part IV).

* * * * *

On the following pages are three examples of a Cost Estimate for Operation and Maintenance. The examples address the five requirements above, except maps of the BMPs are not included. *The BMPs, assumptions, and values in the following examples are fictitious*. The design engineer preparing an actual estimate for actual BMPs will need to provide *actual site information* and *current, realistic values* in the calculations.

EXAMPLE 1

Residential Development with Centralized Stormwater Treatment BMP

(i.e., Wet Pond and Infiltration Basin)

Cost Estimate for Operation and Maintenance *for the Stormwater System at "Stormy Estates"*

Introduction:

The following are assumptions, estimates and recommendations for funds to set aside for routine maintenance costs and future replacement costs for the stormwater BMPs that are the responsibility of the *Stormy Estates* Homeowners' Association. The sinking fund estimate is an approximation of the annual funding needed over the next 20 years to keep the stormwater system fully functional.

The initial value of the BMPs, the annual maintenance costs (assuming all work is performed by a contractor), occasional improvements, and factors such as inflation over time are incorporated in the "sinking fund" calculation of future costs and the annual funding reserve amount needed. The calculations take into account the expected life of the materials, structures, and BMPs, and include a summary of the amount of money suggested to be set aside annually for the fund as well as the annual charge per lot owner to equal the annual set-aside. The example assumes that each of the lot owners is an equal co-owner of the common stormwater BMPs. In this example, the bottom-line estimate of total annual funding needed is divided equally among the lot owners.

Note that the sinking fund calculations are only a "best estimate" using approximated values. The homeowners' association should use these computations as a guide, and modify as needed to more accurately reflect actual costs as routine maintenance is conducted.

Part I: ON-SITE STORMWATER BMP INVENTORY			Part II: ROUTINE O&M ASSUMPTIONS		Part III: ROUTINE O&M ESTIMATED ANNUAL COST	
BMP	**Quantity**	**Unit**	**Activity**	**Maintenance Frequency**	**Unit Price[a]**	**Annual Cost[b]**
			Annual Report	Annual	$300	$300
Catch Basin	8	Each	Sediment removal with Vactor truck	Annual	$170	$1,360
Pipes	400	LF	Clean pipe ends as part of catch basin maintenance	Include with catch basins	$–	$–
Wet Pond	1,100	SF	Vegetation management	Annual	$0.18	$202
			Sediment removal including hauling, planting with shrubs and seeding mix, and site restoration	Once every 15 years	$2.25	$164
Infiltration Basin	3,100	SF	Mowing	Every 2 weeks	$0.05	$4,350
			Rehabilitation (sediment removal, repair, tilling, and reseeding)	Once every 15 years	$0.25	$51
					ANNUAL TOTAL:	**$6,400**

Notes:

CONTINUE TO PART IV

[a] Cost to maintain each unit based on estimate from maintenance contractor or literature values.

[b] Product of multiplying quantity by frequency by unit price.

O&M = operation and maintenance

LF = linear feet

SF = square feet

Part IV: ESTIMATED PARTIAL REPLACEMENT COST		
Assumptions		**Notes**
Annual Inflation Rate	4%	Annual inflation of construction cost.
Annual Interest Rate	2%	Estimate of how fast the account balance will grow.
Years in Calculation	20	Duration of calculation.
Percent of System Replaced in 20 Years	20%	Assumes 20% of the system will need replacement during the calculation period.
Present Value of Stormwater System	$170,000	Initial construction cost of the stormwater system.
Initial Reserves	$0	Initial balance in the O&M account.
Number of Owners	22	Number of lot owners.
Using Above Assumptions, Calculate Future Replacement Cost for 20% of System and Required Annual Payments		
Description	**Cost**	**Notes**
Present Value of 20% of Stormwater System (portion requiring replacement)	$34,000	Present value of the stormwater system x percent of the system that requires replacement.
Future Replacement Cost for 20% of Stormwater System	$74,498	Cost to replace the 20% of the system in the future, i.e., Present Value adjusted to account for inflation.
Annual Payment for Future Replacement	$3,066	Annual account contributions required to cover the future replacement cost. Accounts for interest.

Part V: ESTIMATED MONTHLY CONTRIBUTION TO STORMWATER BMP O&M ACCOUNT		
Description	**Cost**	**Notes**
Annual Payment for Routine O&M	$6,400	Result of Part III.
Annual Payment for Future Replacement	$3,066	Result of Part IV.
Total *Annual* Cost for O&M and Repair	$9,466	Sum of above values.
Total *Monthly* Cost for O&M and Repair	$789	Annual cost divided by 12 months.
Monthly Cost per Lot Owner	**$36**	Monthly cost divided by 22 lot owners.

O&M = operation and maintenance

Because operation and maintenance costs will vary and are also subject to inflation, they should also be adjusted over time. Owners should evaluate actual operation and maintenance needs and costs each year, and adjust set-aside funds for the following year's cost projection.

EXAMPLE 2

1-Acre Commercial Development with Bioretention

Cost Estimate for Operation and Maintenance *for the Stormwater System at "McStormy's Fast Food Restaurant"*

Introduction:

The following are assumptions, estimates and recommendations for funds to set aside for routine maintenance costs and future replacement costs for the drainage BMPs that are the responsibility of the *McStormy's Fast Food Restaurant*. The sinking fund estimate is an approximation of the annual funding needed over the next 20 years to keep the drainage system fully functional.

The initial value of the BMPs, the annual maintenance costs (assuming all work is by hired workers), occasional improvements, and factors such as inflation over time are incorporated in the "sinking fund" calculation of future costs and the annual funding reserve amount needed. The calculations take into account the expected life of the materials, structures, and BMPs, and include a summary of the amount of money to be set aside annually for the fund and the annual charge per lot owner to equal the annual set-aside.

Note that the sinking fund calculations are only a "best estimate" using approximated values. The owner should use these computations as a guide, and modify as needed to more accurately reflect actual costs as routine maintenance is conducted.

Part I: ON-SITE STORMWATER BMP INVENTORY			Part II: ROUTINE O&M ASSUMPTIONS		Part III: ROUTINE O&M ESTIMATED ANNUAL COST	
BMP	**Quantity**	**Unit**	**Activity**	**Frequency**	**Unit Price[a]**	**Annual Cost[b]**
			Annual Report	Annual	$300	$300
Catch Basin	5	Each	Sediment Removal with Vactor Truck	Annual	$170	$850
Bioretention	3,200	SF	Watering, sediment removal, vegetation management, mulching, and pest control	Annual	$2.00	$6,400
					ANNUAL TOTAL:	**$7,600**

Notes:

CONTINUE TO PART IV

[a] Cost to maintain each unit based on estimate from maintenance contractor or literature values.

[b] Product of multiplying quantity by frequency by unit price.

O&M = operation and maintenance

SF = square feet

Part IV: ESTIMATED PARTIAL REPLACEMENT COST		
Assumptions		**Notes**
Annual Inflation Rate	4%	Annual inflation of construction cost.
Annual Interest Rate	2%	Estimate of how fast the account balance will grow.
Years in Calculation	20	Duration of calculation.
Percent of System Replaced in 20 Years	20%	Assumes 20% of the system will need replacement during the calculation period.
Present Value of Stormwater System	$90,000	Initial construction cost of the stormwater system.
Initial Reserves	$0	Initial balance in the O&M account.
Number of Owners	1	Number of lot owners.
Using Above Assumptions, Calculate Future Replacement Cost for 20% of System and Required Annual Payments		
Description	**Cost**	**Notes**
Present Value of 20% of Stormwater System (portion requiring replacement)	$18,000	Present value of the stormwater system x percent of the system that requires replacement.
Future Replacement Cost for 20% of Stormwater System	$39,440	Cost to replace the system in the future, i.e., Present Value adjusted to account for inflation.
Annual Payment for Future Replacement	$1,623	Annual account contributions required to cover the future replacement cost. Accounts for interest.

Part V: ESTIMATED MONTHLY CONTRIBUTION TO STORMWATER BMP O&M ACCOUNT		
Description	**Cost**	**Notes**
Annual Payment for Routine O&M	$7,600	Result of Part III.
Annual Payment for Future Replacement	$1,623	Result of Part IV.
Total *Annual* Cost for O&M and Repair	$9,223	Sum of above values.
Total *Monthly* Cost for O&M and Repair	$769	Annual cost divided by 12 months.
Monthly Cost per Lot Owner	**$769**	Monthly cost divided by a single owner.

O&M = operation and maintenance

Because operation and maintenance costs will vary and are also subject to inflation, they should also be adjusted over time. Owners should evaluate actual operation and maintenance needs and costs each year, and adjust set-aside funds for the following year's cost projection.

EXAMPLE 3

10-Acre Commercial Development with Permeable Pavement

Cost Estimate for Operation and Maintenance *for the Stormwater System at "Storm-Co Wholesale"*

Introduction:

The following are assumptions, estimates and recommendations for funds to set aside for routine maintenance costs and future replacement costs for the drainage BMPs that are the responsibility of the *Storm-Co Wholesale*. The sinking fund estimate is an approximation of the annual funding needed over the next 20 years to keep the drainage system fully functional.

The initial value of the BMPs, the annual maintenance costs (assuming all work is by hired workers), occasional improvements, and factors such as inflation over time are incorporated in the "sinking fund" calculation of future costs and the annual funding reserve amount needed. The calculations take into account the expected life of the materials, structures, and BMPs, and include a summary of the amount of money to be set aside annually for the fund and the annual charge per lot owner to equal the annual set-aside.

Note that the sinking fund calculations are only a "best estimate" using approximated values. The owner should use these computations as a guide, and modify as needed to more accurately reflect actual costs as routine maintenance is conducted.

Part I: ON-SITE STORMWATER BMP INVENTORY			Part II: ROUTINE O&M ASSUMPTIONS		Part III: ROUTINE O&M ESTIMATED ANNUAL COST	
BMP	**Quantity**	**Unit**	**Activity**	**Frequency**	**Unit Price[a]**	**Annual Cost[b]**
			Annual Report	Annual	$300	$300
Permeable Pavement	283,000	SF	Regenerative Vacuum Sweeping	Twice per Year	$0.03	$17,000
					ANNUAL TOTAL:	**$17,300**

Notes:

CONTINUE TO PART IV

[a] Cost to maintain each unit based on estimate from maintenance contractor or literature values.

[b] Product of multiplying quantity by frequency by unit price.

O&M = operation and maintenance

SF = square feet

Part IV: ESTIMATED PARTIAL REPLACEMENT COST		
Assumptions		**Notes**
Annual Inflation Rate	4%	Annual inflation of construction cost.
Annual Interest Rate	2%	Estimate of how fast the account balance will grow.
Years in Calculation	20	Duration of calculation.
Percent of System Replaced in 20 Years	20%	Assumes 20% of the system will need replacement during the calculation period.
Present Value of Stormwater System	$1,500,000	Initial construction cost of the stormwater system.
Initial Reserves	$0	Initial balance in the O&M account.
Number of Owners	1	Number of lot owners.
Using Above Assumptions, Calculate Future Replacement Cost for 20% of System and Required Annual Payments		
Description	**Cost**	**Notes**
Present Value of 20% of Stormwater System (portion requiring replacement)	$300,000	Present value of the stormwater system x percent of the system that requires replacement
Future Replacement Cost for 20% of Stormwater System	$657,337	Cost to replace the system in the future, i.e., Present Value adjusted to account for inflation.
Annual Payment for Future Replacement	$27,054	Annual account contributions required to cover the future replacement cost. Accounts for interest.

Part V: ESTIMATED MONTHLY CONTRIBUTION TO STORMWATER BMP O&M ACCOUNT		
Description	**Cost**	**Notes**
Annual Payment for Routine O&M	$17,300	Result of Part III.
Annual Payment for Future Replacement	$27,054	Result of Part IV.
Total *Annual* Cost for O&M and Repair	$44,354	Sum of above values.
Total *Monthly* Cost for O&M and Repair	$3,696	Annual cost divided by 12 months.
Monthly Cost per Lot Owner	**$3,696**	Monthly cost divided by a single owner.

O&M = operation and maintenance

Because operation and maintenance costs will vary and are also subject to inflation, they should also be adjusted over time. Owners should evaluate actual operation and maintenance needs and costs each year, and adjust set-aside funds for the following year's cost projection.

Chapter 4 – BMP Selection and LID Site Design

Table of Contents

Figures

Chapter 4 – BMP Selection and LID Site Design

4.1 Purpose, Content, and Organization

The purpose of this chapter is to provide guidance for selecting permanent BMPs for new development and redevelopment sites (including retrofitting of redevelopment sites).

The City of Lacey's pollution control strategy is to emphasize pollution prevention first, through the application of source control BMPs. Then the application of appropriate on-site, runoff treatment, and flow control BMPs fulfills the statutory obligation to provide AKART, or "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).

This chapter presents seven steps in selecting runoff treatment and flow control BMPs, and includes low impact development (LID) site design BMPs for preserving native vegetation, restoring site vegetation, reducing effective impervious area, and improving site design.

4.2 BMP Selection Process

Step 1: Determine and Read the Applicable Core Requirements

Chapter 2 establishes project size thresholds for the application of core requirements to new development and redevelopment projects. Figures 2.1 and 2.2 provide the same thresholds in a flow chart format. Calculate total new hard surfaces, replaced hard surfaces, and converted vegetation areas to determine which core requirements apply to the project.

Step 2: Select Source Control BMPs

If the project involves construction of areas or facilities to conduct any of the activities described in Chapter 9, the required structural source control BMPs described in that chapter must be constructed as part of the project. In addition, the residential or planned business enterprise that will occupy the site needs to review the required operational source control BMPs described. Structural source control BMPs must be identified on all applicable plans submitted for City review and approval.

Refer to Chapter 9 and Volume IV of the 2019 Ecology Manual for source control BMP selection, design, and maintenance. In addition, the project may have additional source control responsibilities as a result of area-specific pollution control plans (e.g., watershed or basin plans, water cleanup plans (TMDLs), groundwater management plans, lake management plans), ordinances, and regulations.

Step 3: Determine Threshold Discharge Areas and Applicable Requirements for Runoff Treatment, Flow Control, and Wetlands Protection

Core Requirement #6 and Core Requirement #7 have specific thresholds that determine their applicability (see Chapter 2, Sections 2.2.6 and 2.2.7). Core Requirement #8 uses the same size thresholds as those used in #6 and #7. Those thresholds determine whether certain areas (called threshold discharge areas or TDAs) of a project must use runoff treatment and flow control BMPs, designed by a professional engineer, or whether just Core Requirement #5 can be applied instead (see Chapter 2, Section 2.2.5).

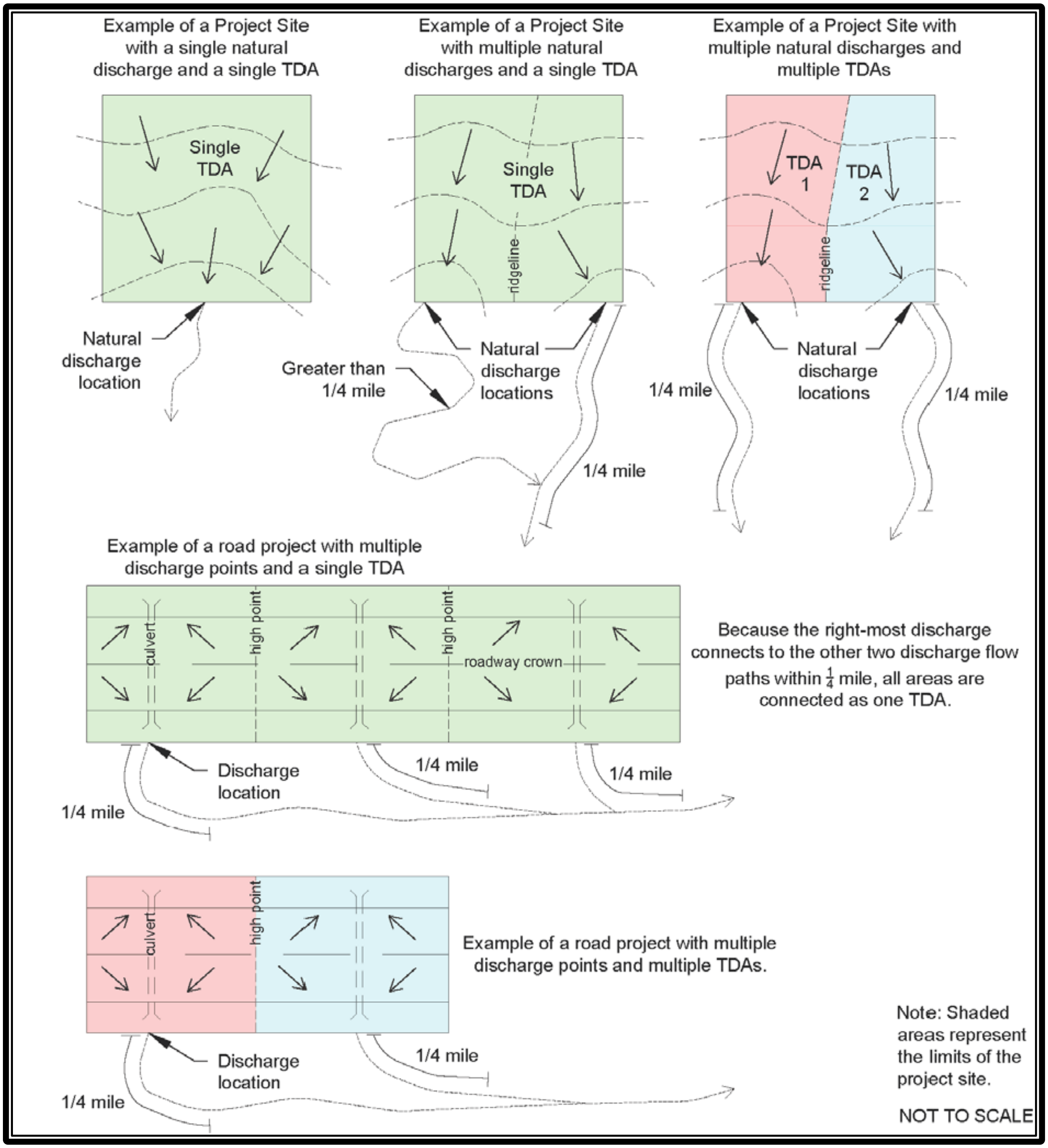
Step 3a: Review Definitions

Review the definitions in the Glossary to become acquainted with the following terms, at a minimum: effective impervious surface, impervious surface, hard surface, pollution-generating impervious surface (PGIS), pollution-generating hard surface (PGHS), pollution-generating pervious surface (PGPS), and converted vegetation areas.

Step 3b: Outline Threshold Discharge Areas

Outline the TDAs for your project site.

TDA – An area within a project site 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 4.1 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.



Source: Ecology

Figure 4.1. Threshold Discharge Areas.

Step 3c: Determine Hard Surface Areas

Determine the amount of pollution-generating hard surfaces (including pollution-generating permeable pavements) and pollution-generating pervious surfaces (not including permeable pavements) in each TDA. Compare those totals to the project thresholds in Chapter 2, Section 2.2.6, to determine where runoff treatment BMPs are necessary. Note that evaluation of on-site stormwater management BMP feasibility (Core Requirement #5) is always applicable.

Step 3d: Implement LID Site Design Strategies

Where feasible, projects shall maximize the use of LID site design strategies to minimize effective impervious areas, vegetation loss, and stormwater runoff (before selecting permanent flow control and runoff treatment BMPs). Smart site design can reduce the cost and land area required for both flow control and runoff treatment. See Chapter 1, Section 1.4, and Section 4.3, for additional details and recommended BMPs. Refer to Chapter 3, Section 3.3.3 for requirements related to documenting the feasibility and implementation of LID site design strategies.

Step 3e: Determine Effective Impervious and Converted Vegetation Areas

Compute the totals for effective impervious surface and converted vegetation areas in each TDA. Compare those totals to the project thresholds in Chapter 2, Sections 2.2.7 and 2.2.8, to determine whether flow control BMPs (Core Requirements #7 and #8) are needed. If neither threshold for flow control BMPs is exceeded, proceed to Step 3f. If one of the thresholds is exceeded, proceed to Step 4 below.

Step 3f: Model Hard Surfaces and Converted Vegetation

For each TDA, use an approved continuous simulation model (e.g., WWHM) to determine whether there is an increase of 0.15 cfs or greater in the 100-year return frequency flow using 15-minute time steps. This requires a comparison to the 100-year return frequency flow predicted for the existing (pre-project; not the historical) land cover condition of the same area. If the above threshold is exceeded, flow control—Core Requirements #7 and #8—is potentially required. See the “Applicability” sections of those core requirements. Note that evaluation of on-site stormwater management BMP feasibility (Core Requirement #5) is 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). Additional modeling guidance is found in the BMP design criteria in Chapters 7 and 8.

Step 4: Select Flow Control BMPs

A determination should have already been made whether Core Requirement #7 and/or Core Requirement #8 apply to the project site. On-site stormwater management BMPs must be applied in accordance with Core Requirement #5. In addition, flow control BMPs must be provided for discharges from those TDAs that exceed the thresholds outlined in Chapter 2, Section 2.2.7. Use an approved continuous simulation runoff model and the details in Chapter 7 to size and design the BMPs.

The following describes a selection process for those BMPs.

Step 4a: Determine Whether Infiltration Is Feasible

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 runoff treatment (see Chapter 8, Section 8.6.3). In this case, any runoff from pollutant generating surfaces must first be treated in accordance with Core Requirement #6 prior to discharge to a flow control BMP that relies on infiltration (and ultimately to the ground via infiltration). The runoff treatment BMP could be located off-line with a capacity to treat the water quality design flow rate or volume to the applicable performance goal (see Chapter 8, Section 8.4). Volumes or flow rates in excess of the water quality design volume or flow rate would bypass untreated into the infiltration BMP. The infiltration BMP must provide adequate volume such that the flow duration standard of Core Requirement #7, or the wetland protection requirements of Core Requirement #8, will be achieved.

The second option is to infiltrate through soils that meet the site characterization and site suitability criteria for runoff treatment outlined in Chapter 8, Section 8.6.3. If designed to meet both Core Requirements #6 and #7, the BMP must be designed to meet the requirements for both runoff treatment and flow control. Because such a BMP would have to be located on-line it would be quite large. Therefore, this option may, in some cases, be cost and space prohibitive.

In addition, because large portions of the City are within groundwater protection areas and critical aquifer recharge areas, projects proposing to infiltrate stormwater within a wellhead protection area or critical aquifer recharge area must be aware of the additional applicable runoff treatment and/or setback requirements that apply in these areas. Refer to Chapter 8, Sections 8.2.1 and 8.3, as well as the maps of wellhead protection areas and critical aquifer recharge areas in Appendix 8B as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>, for additional details and requirements. See Chapter 7, Section 7.2, for design criteria for infiltration BMPs intended to provide flow control without runoff treatment.

Deep UICs should only be used when surface infiltration is infeasible. Refer to Chapter 7, Appendix 7C for guidance and requirements related to UIC wells.

If infiltration is feasible, select an infiltration BMP from Chapter 7, then proceed to Step 5. If infiltration BMPs are not planned, proceed to Step 4b.

Step 4b: Use an Approved Continuous Simulation Runoff Model To Size a Detention BMP

Refer to Chapter 6, Section 6.2, for an overview of the use of continuous simulation models for flow control BMP sizing. Additional information may be available from the model developers, depending on the specific model being used.

Note that the more the site is left undisturbed, and the less impervious surfaces are created, the smaller the detention/flow control BMP. Greater use of on-site stormwater management BMPs can lead to a smaller detention BMP when supported by engineering.

Step 5: Select Runoff Treatment BMPs

Please refer to Chapter 8, Section 8.2 for step-by-step guidance to selection of runoff treatment BMPs.

- ✓ Step 1: Determine the receiving waters and pollutants of concern based on off-site analysis
- ✓ Step 2: Determine whether the BMP will be City-owned or privately owned
- ✓ Step 3: Determine whether an oil control BMP is required
- ✓ Step 4: Determine whether infiltration into the native soil for pollutant removal is practicable
- ✓ Step 5: Determine whether a phosphorous treatment BMP is required
- ✓ Step 6: Determine whether an enhanced treatment BMP is required
- ✓ Step 7: Determine if additional water quality requirements apply
- ✓ Step 8: Select a basic treatment BMP (unless previously selected treatments also meet basic treatment standards)

Step 6: Review Selection of BMPs

The list of on-site, runoff treatment, flow control, and source control BMPs should be reviewed. The site designer may want to re-evaluate site layout and design to reduce the need for stormwater BMPs or the size of the BMPs by reducing the amount of impervious surfaces created and increasing the areas to be left undisturbed. This step presents another opportunity to maximize the use of on-site stormwater management BMPs and LID site design strategies to reduce stormwater BMP needs.

Step 7: Complete Development of Permanent Stormwater Control Plans and Submittals

The design and location of the BMPs on the site must be determined using the detailed guidance in Chapter 3. Maintenance requirements for each runoff treatment and flow control BMP (see Chapter 10) are also required as part of the Maintenance and Source Control Manual submittal. Please refer to Chapter 3 for guidance on the contents of required Stormwater Site Plans and submittals.

4.3 LID Site Design BMPs

Reducing impervious areas and maximizing on-site infiltration reduces the amount of runoff generated by a project site, thereby reducing stormwater management BMP costs. The following BMPs are to be implemented to the maximum extent practicable:

- Preserving Native Vegetation (Ecology BMP T5.40) and Restoring Site Vegetation
- Reduce Effective Impervious Areas
- Better Site Design (Ecology BMP T5.41)

4.3.1 Preserving Native Vegetation (Ecology BMP T5.40) and Restoring Site Vegetation

Native soil and vegetation preservation is the single most effective strategy to reduce stormwater impacts on site, and has the added benefit of enhancing base flow in streams and recharge of aquifers. Preserving native vegetation shall be the first priority wherever feasible. Native vegetation preservation and restoration areas shall be incorporated to the maximum extent feasible and where most effective (i.e., where there is intact native vegetation and soils and/or unconcentrated flows from developed areas).

The following sections present the strategies and practices for meeting the native vegetation preservation requirements. Per Chapter 7, Section 7.4.2, it is preferable that 65 percent or more of the project site be protected for the purposes of retaining or enhancing existing forest cover and preserving wetlands and stream corridors. Additional details on flow dispersion to native vegetation areas are presented in Chapter 7, Section 7.4.2, under Full Dispersion.

Applicability

Preserving Native Vegetation

Native vegetation preservation areas may be required for any of the following conditions:

- Areas reserved for stormwater dispersion for flow control or treatment
- Wetland or other critical area buffers required by the Lacey Municipal Code (LMC)
- Riparian areas and buffers and habitat areas
- As required by the LMC

New development often takes place on tracts of forested land. 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.

With vegetation preservation, the primary goal is to retain large, connected tracts of native vegetation areas, either through a cluster design or on individual lots, to maintain the natural hydrologic function and provide infiltration areas for overland flows generated in developed portions of the site. Forest and native growth areas allow rainwater to naturally percolate into the soil, recharging groundwater for summer stream flows and reducing surface water runoff that creates erosion and flooding. Conifers can retain up to roughly 50 percent of all rain that falls during a typical storm. Of this rainfall, 20 to 30 percent may never reach the ground but evaporates or is taken up by the tree.

On lots that are 1 acre or greater, preservation of 65 percent or more of the site in native vegetation will allow the use of flow dispersion techniques presented in Chapter 7, Section 7.4.2, under Full Dispersion. Sites that can fully meet the requirements of full dispersion are not required to provide runoff treatment or flow control BMPs (as required by Chapter 2, Core Requirements #5, #6, and #7).

Restoring Site Vegetation

In situations where it is not feasible to preserve existing trees and vegetation of sufficient size and quantity to achieve the target amount of tree cover, additional tree cover shall be provided where feasible through supplemental tree and vegetation plantings. In addition, on those sites where vegetation cover does not exist due to previous removal, vegetation cover shall be reestablished to the maximum extent feasible.

Design Criteria

Preserving Native Vegetation

Vegetation Preservation Standards

The goals for native vegetation preservation/retention on a development site are as follows:

- Low-density residential (0 to 4 dwelling units/acre): 50 percent of the development site
- Low-density residential (3 to 6 dwelling units/acre): 50 percent of the development site
- Moderate density (8 to 16 dwelling units/acre): maximum practical extent
- High density (minimum 12 dwelling units/acre): maximum practical extent.

At a minimum, requirements for native vegetation preservation and/or replacement as set forth in applicable sections of the LMC, including critical areas, zoning, and grading shall be implemented.

Siting

Selection of areas for natural vegetation preservation shall be made in consultation with a landscape architect. Native vegetation and soil protection areas should be prioritized by location and type as follows:

- Large tracts of riparian areas, that connect, create, or maintain contiguous protected riparian areas
- Large tracts of critical and wildlife habitat area, that connect, create, or maintain contiguous protected areas
- Tracts that create common open space areas among or within developed sites
- Protection areas on individual lots
- Protection areas on individual lots that connect to protection areas on adjacent lots

Other minimum standards for siting include:

- The preserved area shall be situated to minimize the clearing of existing forest cover, to maximize the preservation of wetlands, and to buffer stream corridors.
- Where feasible, trees and other native vegetation shall be retained in groups of sufficient size to maintain adequate growing conditions to support natural successional patterns and develop diverse multilayer canopy structure, snags, large woody debris, understory vegetation, and forest duff. Growing conditions include slope, aspect, soil structure and moisture, sun exposure, humidity, wind, co-dependence on or competition among adjacent plants as well as other microclimatic factors.
- The preserved area shall be shown on all property maps and shall be clearly marked during clearing and construction on the site.
- Maximize the amount of preserved area that can be located downslope from the building sites, to optimize the use of full dispersion.
- For trees that are adjacent to existing or proposed structures or other impervious surfaces, it is important to also review Chapter 7, Section 7.4.3, Tree Retention and Tree Planting, to identify possible flow control credits that may be achieved through targeted tree retention.

Restoring Site Vegetation

Vegetation Restoration Standards

The following standards shall be utilized:

- Vegetation restoration and planting methods shall conform to published standards
- The applicant shall comply with the provisions for tree replacement as set forth in Section 14.32.066 LMC.
- Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system.
- Coniferous and broad leaf evergreen trees shall be no less than 4 feet in height at time of planting. Deciduous trees shall be a minimum of 8 feet in height or have a minimum caliper size of 1.5 inch at time of planting.

Construction and Operation

Conversion of a developed surface to native vegetation landscape can require the removal of impervious surface and ornamental landscaping; de-compaction of soils; and/or 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) 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. 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*.
5. The area of native vegetated landscape must be planted with native species trees, shrubs, and ground cover. Developments shall use native trees for replacement in areas separate from residential lots, or storm drainage areas adjacent to roadway or parking lots. Species must be selected based on the underlying soils, shade, and moisture conditions; as well as the historical, native indigenous plant community

type for the site. Vegetation shall be selected in accordance with the following requirements:

- 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 City requirements. No individual species of replacement tree shall exceed 50 percent of the total, nor shall any individual species be less than 10 percent of the total. Trees selected for replacement purposes must be free from injury, pests, diseases, and nutritional disorders. Trees must be fully branched and have a healthy root system. Coniferous and broad leaf evergreen trees shall be no less than 3 feet in height at time of planting. Deciduous trees shall be a minimum of 5 feet in height or have a minimum caliper size of 1 inch at time of planting.

  Note: Avoid the use of a single species of tree for replacement purposes. No individual species of replacement tree should exceed 50 percent of the total, and no individual species should be less than 10 percent of the total.

- Shrubs: a minimum of two species of shrubs shall be planted. Space plants to cover the entire landscape area, excluding points where trees are planted.

- Groundcover: a minimum of two species of ground cover shall 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.

- Refer to Chapter 16.80 LMC for additional landscaping requirements.

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. In addition:

1. The soil shall 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 4-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.

2. After soil preparation is complete, continue with steps 3 through 5 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 on center (with an average of 360 trees per acre) to allow for natural groupings and 4 to 6 feet on center for shrubs. Allowable bare-root stock types are 1-1, 2-1, P-1, and P-2. Live stakes at 4 feet on center may be substituted for willow and red-osier dogwood in wet areas.

Vegetation Protection and Maintenance

The following steps must be taken to protect preserved or restored vegetation after construction:

- Mechanisms shall be put in place to ensure long-term protection of vegetation preservation and restoration areas. Mechanisms to protect these areas include setting aside conservation areas into separate tracts, permanent easements, homeowner covenants, maintenance agreements, and education (see Chapter 3 for additional detail).
- Maintenance plans and agreements must be in compliance with Chapter 3, and must address issues including but not limited to:
  - Pest and disease management practices
  - Pruning requirements
  - Irrigation requirements
  - Fertilization requirements
  - Fire fuel management practices.
- Maintenance shall include intensive site preparation, including weed control and soil amendment. Ongoing maintenance shall include weeding and watering for a minimum of 3 years from installation so as to achieve a minimum 90 percent survival of all planted vegetation. If during the 3-year period survival of planted vegetation falls below 90 percent, additional vegetation shall be installed as necessary to achieve the required survival percentage. Additionally, the likely cause of the high rate of plant mortality shall be determined and corrective actions shall be taken as needed to ensure plant survival. If it is determined that the original plant choices are not well suited to site conditions, these plants shall be replaced with plant species that are better suited to the site.
- Permanent signs shall be installed indicating that removal of trees or vegetation is prohibited within the native vegetation preservation and restoration areas (with the exception of the removal of dangerous and diseased trees).
- Permanent fencing is required around the limits of the vegetation preservation and restoration areas. The type, size, and location of the fencing must be submitted for approval by City review staff and should be made of materials that blend in with

the natural surroundings (e.g., wood split-rail, pinned if necessary) and located in such a manner as to not impede the movement of wildlife within the vegetation preservation and restoration areas.

Additional Requirements

In addition to the general requirements outlined above, criteria specified in Chapter 7, Section 7.4.3, Tree Retention and Tree Planting, are pertinent to vegetation retention. In particular, developers should be aware of the specific measures to protect trees during construction.

4.3.2 Reduce Effective Impervious Areas

Roads, shared accesses, alleys, sidewalks, driveways, and parking areas are a substantial portion of total urban impervious area and often have highly efficient drainage systems. Reducing the effective area of these surfaces (roofs excluded) is a key concept of LID. The following sections contain strategies for reducing the impacts of impervious surfaces associated with transportation and mobility related networks.

Road Design

The objective for an LID roadway system design is to reduce the amount of impervious area associated with the road network. This may be achieved by utilizing permeable pavement, examining alternative street layouts, and determining the best option for increasing the number of homes per unit length of road, as well as aligning roads to maximize opportunities for discharging to adjacent dispersion or bioretention BMPs. Strategies to be applied (where feasible) for reducing the amount and impact of impervious area associated with the road network include:

- Design the road layout to follow the existing topographic contours to minimize cuts and fills.
- Design the road layout to avoid crossing natural resource protection areas, thereby minimizing the disruption of sheet flow within these areas.
- Natural resource protection areas or bioretention BMPs shall be located downgradient of roads, alleys, and other impervious surfaces when feasible.
- Minimize effective impervious area and concentrated surface flows on impervious surfaces by eliminating hardened conveyance structures (e.g., pipes, curbs, and gutters).
- Infiltrate or slowly convey storm flows in roadside bioretention cells and swales, and through permeable pavement and aggregate storage systems under the pavement. (Note that if using infiltration and/or conveyance under roads and parking areas in a retrofit setting the design must consider the integrity and protection of adjacent infrastructure.)

- Roads should be designed to service clusters of development located within the buildable portions of the site (i.e., cluster housing), thereby reducing the overall length of the roadway network.

- In higher density residential neighborhoods with narrow roads and where no on-street parking is allowed, pullout parking can be used. Pullouts (often designed in clusters of two to four stalls) should be strategically distributed throughout the area to minimize walking distances to residences. Depending on the street design, the parking areas may be more easily isolated and the impervious surface rendered ineffective by sloping the pavement to adjacent bioretention swales or bioretention cells.

Road Layout

One type of road layout cannot be used in all situations, so it is usually necessary for a designer to explore different strategies and decide which ones will work best for the existing site. At a minimum, the following types of layouts must be considered:

- Grid layouts: Grid patterns provide multiple access routes to each parcel and may include alleyways between blocks with garages located at the back of the house. However, it should be noted that the use of alleys may increase the total road network and associated impervious surface, unless permeable pavements are utilized.

- Cul-de-sacs: In instances where cul-de-sacs are used, techniques must be used to reduce or disconnect the impervious area. This can be accomplished by increasing the diameter of the cul-de-sac, but including a bioretention BMP in the center where stormwater can be directed.

- Hybrid road layouts: Hybrid layouts integrate the grid layout and cul-de-sac approach to minimize impervious coverage per dwelling unit and improve fire and safety access. The loop road design in Figure 4.2 provides an example of the hybrid layout and includes bioretention installed in the interior of the loop for stormwater management that also offers a visual buffer for homes.

Road Cross Sections

The objective of modifying road cross sections is to reduce the roadway width to the minimum amount of impervious surface necessary, while still accommodating emergency vehicle access, and utilizing permeable pavements where feasible. Note: Existing applicable road standards still apply except as modified below:

Roads

- For projects that trigger Core Requirements #1 through #5 or #1 through #9 (Chapter 2, Section 2.2), permeable pavement is one option that must be evaluated for on-site stormwater management for roads with very low traffic volumes and very low truck traffic (see Chapter 7, Section 7.4.6 for additional details). If permeable pavement surfaces are used adjacent to conventional impervious road sections for sidewalks or pullout parking, use design techniques described in Chapter 7, Section 7.4.6 to prevent saturation of the impervious road section and migration of aggregate base material from the impervious to the permeable section.

- Cement/concrete pavement strips (1-foot-wide strips of concrete that act as a transition between the traveled lane and non-rigid permeable pavement surfaces adjacent to the traveled way) may be utilized to delineate the traveled lane areas. These delineator strips shall be at least 6 inches thick with expansion joints every 10 feet.

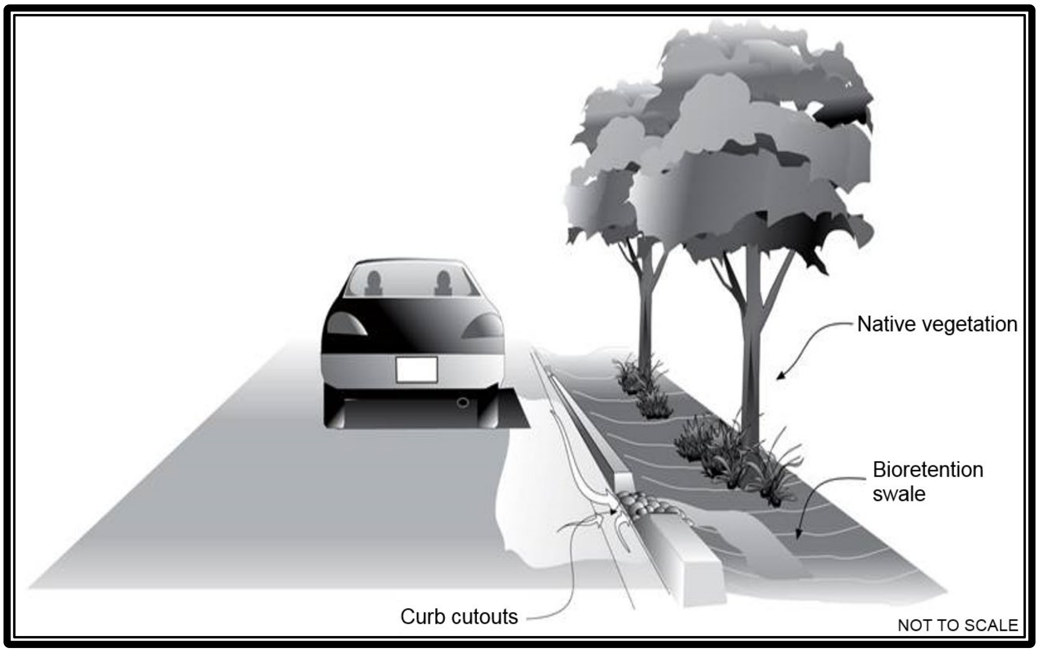
Source: Pierce County

Figure 4.2. Hybrid Road Layout.

- Curbs and gutters are highly discouraged for use as stormwater collection systems in conjunction with catch basins and pipes. Where there is a legitimate need for constructing a curb and gutter system, the "Curb and Gutter Alternatives" subsection below provides guidance for designing curb and gutter alternatives.

The following general requirements apply to curb and gutter applications for LID designs:

- o Curbs are allowed when the sidewalk is adjacent and connected to the traveled way provided they are used only on one side of the road and the road cross slope is away from the curb or if curb cuts are utilized, as shown in Figure 4.3, and drain to a vegetated open channel or bioretention BMP behind the curb.



Source: Pierce County

Figure 4.3. Curb and Gutter Cutouts.

- Alleys shall be constructed with permeable pavement, provided that the runoff through the material will not be directed towards the subgrade of the traveled lane portion of a roadway (unless the subgrade is designed to handle these flows).

- The use of additional pullout parking spaces is required to compensate for narrower road widths, which restrict roadside parking. An example design is provided in Figure 4.4.

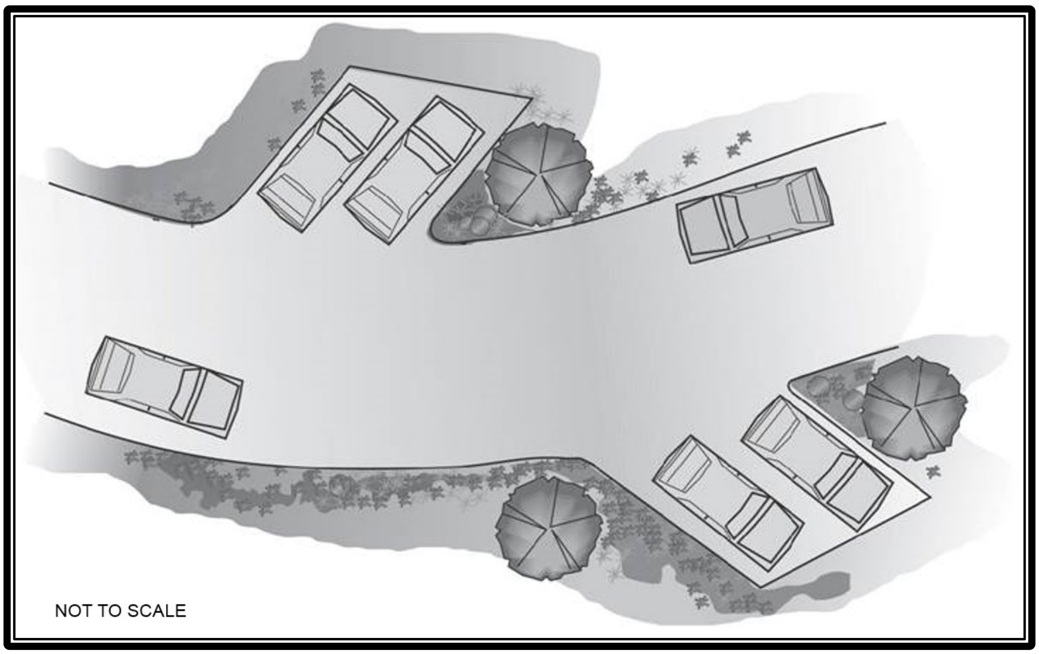
- Bioretention should be incorporated into traffic calming designs associated with retrofit or new streetscapes.

Sidewalks

- Sidewalks and trails must be disconnected from the traveled way portion of the road, to the maximum extent feasible. Every lot shall have pedestrian access to an abutting trail or to a sidewalk located on at least one side of the road. Sidewalks may be separated from the roadway by placement of a vegetated open channel or bioretention BMP between the sidewalk and the roadway.

- Sidewalks and trails shall be constructed of permeable pavement, provided that the runoff through the material will not be directed towards the subgrade of the traveled lane portion of a roadway (unless the subgrade is designed to handle these flows). Permeable pavement with subsurface engineered soil systems can be particularly beneficial in areas surrounding newly planted trees, as they provide soil volume and sustained root development in a manner compatible with pavement and other subsurface infrastructure. Permeable pavement for sidewalks and trails which abut lots, in lieu of a roadside sidewalk, shall be Americans with Disabilities Act (ADA) compliant.

- Where feasible, sidewalks should be "reverse slope" or sloped away from the road and onto adjacent vegetated areas.



Source: Pierce County

Figure 4.4. Alternative Parking.

Parking Lots

The objective of alternative parking lot designs is to eliminate excessive impervious areas dedicated to parking and to minimize the effective impervious area of parking areas, while still providing adequate parking for various land use classifications.

Parking Lot Requirements

- Utilize the minimum off-street parking requirements for non-residential uses (Refer to Chapter 16.72 LMC, Table 16T-13). However, any parking lot space above the required minimum amount shall be constructed of permeable pavement or accommodated in a multi-storied or underground parking structure.

- The designer must incorporate permeable pavement to the maximum extent feasible into the parking lot to promote infiltration of runoff (see also Chapter 7, Section 7.4.6, as well as Chapter 2, Core Requirement #5).
- Bioretention BMPs shall be used to maximize infiltration and attenuation of surface runoff (see also Chapter 7, Section 7.4.4).

Driveways

Driveways are typically constructed with impervious surfaces and as such represent an opportunity to further minimize impervious surfaces and their hydrologic impacts. The following methods shall be used to reduce the amount and hydrologic impact of impervious surfaces associated with driveways:

- Driveways shall be constructed using permeable pavement and graded in such a manner to prevent stormwater runoff from saturating the subgrade of the traveled lane portion of the roadway (if not using permeable pavement for the adjacent road). Surface and subsurface (e.g., discharge from the permeable pavement) stormwater runoff should drain to the adjacent permeable road, vegetated infiltration areas such as soil amended lawns, vegetated open channels, or bioretention BMPs.
- Runoff from driveways constructed of impervious surfaces shall be directed to vegetated infiltration areas such as soil amended lawns, dispersion areas, or bioretention BMPs.
- Minimize driveway width
- Reduce driveway length, where possible
- Design “clusters” of homes with shared driveway

Curb and Gutter Alternatives

The discussion below is intended to give guidance for appropriate LID methods for designing curb and gutter alternatives in situations where there is a need for constructing a curb and gutter system.

Applicability

- Some road types may require use of curb and gutter. Refer to Title 16 LMC and Title 12 LMC to determine if curbs and gutters are required.
- Where curb and gutters are required in all or part of the road network, alternative curb and gutter designs (discussed below) must be considered that will still meet the functional requirements.

Design Criteria

- Where curb and gutters are required in a community to provide a means of separation between the pedestrians and the motorized traffic, an alternative design using placement of a vegetated channel between the sidewalk and the roadway should be considered. In addition, a visual barrier consisting of a 1-foot-wide concrete strip along the edge of the pavement at the same surface elevation of the pavement shall be constructed. This concrete strip gives drivers a visual cue of the edge of the driving surface and can help protect the vegetated channel from tire ruts.

- Another alternative is to provide cuts in the curb at 10- to 15-foot spacing to allow runoff to enter adjacent stormwater management areas. See Chapter 6 for additional flow spreading options.

4.3.3 Better Site Design (Ecology BMP T5.41)

Fundamental hydrological and stormwater management concepts must be applied at the site design phase to help projects better integrate with natural topography and to support the natural site hydrology.

Design Criteria

Knowing how the site processed stormwater historically is important in determining appropriate Better Site Design strategies. This information will aid the designer in determining preferred site layout options, and in deciding what appropriate site design BMPs will help either maintain or restore natural predeveloped stormwater processes.

Initial delineation, site management, and site design strategies to be considered and implemented as feasible include:

Define Development Envelope and Protected Areas

- Based on the site inventory, delineate the best areas to direct development. Building sites, road layout, and other site infrastructure shall be configured within these development areas to minimize soil and vegetation disturbance and take advantage of a site’s natural stormwater processing capabilities.

- Minimize clearing and grading by incorporating natural topographic depressions into the development, and in particular limiting the amount of cut and fill on those portions of the site with permeable soils.

- Delineate natural resource protection areas with appropriate fencing and signage to provide protection from construction activities.

- Eliminate stream crossings with roads and conveyance systems whenever possible.

Minimize Directly Connected Impervious Areas

- Establish limits of disturbance to the minimum area required for roads, utilities, building pads, landscape areas, and the smallest additional area needed to maneuver construction equipment.
- Limit overall impervious land coverage.
- Minimize directly connected impervious areas—i.e., any impervious surfaces that drain directly into a catch basin or other conveyance structure.

Maximize Permeability

- Preserve the existing upper soil horizon to the maximum extent feasible. Where excavation is necessary, excavated topsoil shall be utilized elsewhere on the site to amend areas with sparse or nutrient deficient topsoil.
- Any portion of the site with permeable soils shall be closely considered for preservation to promote infiltration of stormwater runoff.
- Maximize permeability by minimizing impervious areas, paving with permeable pavements (e.g., porous asphalt pavement, pervious concrete pavement, and pavers for roads, driveways, alleys, parking lots, or other types of drivable or walkable coverage), clustering buildings, and reducing the land coverage of buildings by smaller footprints. Applicable strategies shall be reflected at all levels of a project, from site planning to materials selection.
- Layout roads, lots, and other proposed site features to follow topographic contours to minimize soil and vegetation disturbance and loss of topsoil or organic duff layer.

Use Drainage as a Design Element

- Maintain predevelopment flow path lengths in natural drainage patterns whenever possible.
- Where concentrated flow conveyance systems must be used (in lieu of the preferred sheet flow and infiltration approaches), vegetated open channels must be used where feasible instead of piped conveyance systems. Vegetated open channels are most applicable adjacent to roadways where the linear nature of the road can make it difficult to provide enough area within the right-of-way for infiltration or dispersion options.
- Manage stormwater as close to the origin as possible.
- Maximize the use of small, dispersed stormwater management BMPs to capture, store, and infiltrate stormwater on site.

Site Planning and Site Management

- Meet and walk the property with the owner, engineers, landscape architects, and others directing project design to identify problems and concerns that should be evaluated when implementing the site plan.

- Meet and walk the property with equipment operators prior to clearing and grading to clarify construction boundaries and limits of disturbance. Pay particular attention to subgrade preparation for permeable pavement and bioretention installations and techniques to avoid subgrade compaction.

- Encourage erosion and sediment control training for operators.

- See Chapter 5, Section 5.3 for additional requirements specific to protection of LID BMPs during construction (in accordance with Chapter 2, Core Requirement #2, Element #13).

- Finally, designers should also refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012), specifically Chapter 3, for additional guidelines and graphics for better site designs and layouts.

Chapter 5 – Construction Stormwater Management

Table of Contents

Tables

Figures

Chapter 5 – Construction Stormwater Management

5.1 Introduction to Construction Stormwater Pollution Prevention

5.1.1 Purpose of This Chapter

Chapter 5 focuses on managing stormwater impacts associated with construction activities, and contains City of Lacey (City) standards and guidance to address Core Requirement #2: Construction Stormwater Pollution Prevention. 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. This chapter addresses the planning, design, and implementation of BMPs before and during construction projects.

The construction phase of a project is usually a temporary condition, ultimately giving way to permanent improvements and BMPs. However, construction work may take place over an extended period of time. Ensure that all of your BMPs are of sufficient size, strength, and durability to outlast the longest possible construction schedule and the worst anticipated rainfall conditions.

Linear projects, such as roadway construction and utility installations, may present a unique set of stormwater protection challenges. You can adapt or modify many of the BMPs discussed in this chapter to provide the controls needed to address these projects. It may be advantageous to phase portions of long, linear projects and apply all necessary controls to individual phases.

This chapter details BMPs for controlling or maintaining stormwater runoff quality from a developed or artificially altered site during construction. The project applicant or their designated project engineer shall prepare one of the three site development and stormwater submittals; a Stormwater Pollution Prevention Plan (SWPPP) Short Form (See Chapter 3, Appendix 3A), a Drainage Control Plan, or an Abbreviated Drainage Plan. For most projects, a component of the submittal is the Construction SWPPP.

The Construction SWPPP serves as a tool for the site operator to manage the site and to avoid immediate and long-term environmental loss. Additional information on erosion and sedimentation processes as well as factors influencing erosion potential may be found in the Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington* (2019 Ecology Manual).

5.1.2 Content and Organization of This Chapter

Chapter 5 consists of four sections that address the key considerations and mechanics of construction stormwater BMPs.

- **Section 5.1** includes the introduction and purpose of the chapter. The section briefly lists 13 elements of pollution prevention to be considered for all projects. Additional local, state, and federal requirements that may apply to construction sites and their stormwater discharges are noted. This includes the Western Washington Phase II National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit and Washington's water quality standards pertaining to construction stormwater, and explains how they apply to field situations.

- **Section 5.2** provides additional information on requirements for construction erosion control, including seasonal limitations and required components of the Construction SWPPP.

- **Section 5.3** presents practices specifically to protect low impact development (LID) BMPs during construction. These practices are required as part of Element #13 (discussed in the next section).

- **Section 5.4** contains BMPs for construction stormwater control and site management. The first set of BMPs presented in Section 5.4 (i.e., BMPs numbered in the C100s) include BMPs for construction site erosion prevention. The second set of BMPs presented in Section 5.4 (i.e., BMPs numbered in the C200s) include BMPs that addresses construction-site runoff, conveyance, and treatment.

Developers must use various combinations of these BMPs in the Construction SWPPP to satisfy each of the 13 elements applicable to the project. BMP design and sizing information is included within the applicable BMP descriptions in Section 5.4. The project applicant should refer to this chapter to determine which BMPs must be included in the Construction SWPPP, and to design and document application of these BMPs to the project construction site.

5.1.3 Thirteen Elements of Construction Stormwater Pollution Prevention

The **13 elements** listed below must be considered in the development of the Construction SWPPP. 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 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 dewatering
11. Maintain BMPs
12. Manage the project
13. Protect Low Impact Development BMPs

A complete description of each element and associated BMPs is given in Section 5.2.3.

5.1.4 Water Quality Standards

Surface Water Quality Standards

Numerical water quality criteria (Chapter 173-201A Washington Administrative Code [WAC]) specify the levels of pollutants allowed in receiving waters to protect aquatic life. In Washington State, these criteria are designed to protect humans from cancer and other diseases, and are primarily applicable to fish and shellfish consumption and drinking water obtained from surface waters.

In addition to numerical criteria, narrative criteria protect the specific beneficial uses of fresh (WAC 173-201A-600 and -602) and marine (WAC 173-201A-610 and -612) waters in the State of Washington.

Pollutants that might commonly occur in the discharge from construction sites are turbidity, pH, and petroleum products. The numeric surface water quality standards for turbidity and pH for fresh and marine waters designated for various aquatic life uses are specified in WAC 173-201A-200 and -210.

Although there is no specific surface or groundwater quality standard for petroleum products, the narrative surface water quality criteria prohibits any visible sheen in a discharge to surface water.

The groundwater quality criteria require protection from contamination in order to support the beneficial uses of the groundwater, such as for drinking water. Therefore, the primary water quality consideration for stormwater discharges to groundwater from construction sites is the control of contaminants other than sediment. However, sediment control is necessary to protect permanent infiltration BMPs from clogging during the construction phase.

Compliance with Standards

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), groundwater 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 project applicant must apply all known, available, and reasonable methods of prevention, control, and treatment (AKART, as defined in WAC 173-218-030). This includes preparing and implementing a Construction SWPPP, with all appropriate BMPs installed and maintained in accordance with the Construction SWPPP and the terms and conditions of the Construction Stormwater General Permit (CSWGP) (if applicable; see also Chapter 1, Section 1.7.7).

In accordance with Chapter 90.48 RCW (ESSB 6415), compliance with water quality standards is presumed unless discharge monitoring data or other site specific information demonstrates otherwise, when the project applicant fully:

- Complies with applicable permit conditions for planning, sampling, monitoring, reporting, and recordkeeping; and
- Implements the BMPs contained in this manual, 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.

Because Ecology has determined that a local manual may be used where the local requirements for construction sites are at least as stringent as Ecology's, applicants should be able to prepare one Construction SWPPP under this manual to satisfy both the Ecology permit and City permits. However, for sites also subject to Ecology's CSWGP requirements, applicants are responsible for confirming that no additional requirements apply to comply with Ecology's regulations.

5.1.5 Other Applicable Regulations and Permits

In addition to City regulations, other regulations and permits may require the implementation of BMPs to control pollutants in construction site stormwater runoff. These include but may not be limited to the following (principal permitting agency in brackets):

- NPDES Construction Stormwater General Permit – (Ecology) <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Construction-stormwater-permit>
- TMDL or water cleanup plans – (Ecology)
- Endangered Species Act (ESA) – (National Oceanic and Atmospheric Administration Fisheries Service and/or U.S. Fish and Wildlife Service [USFWS])
- Hydraulic project approval permits – (Washington State Department of Fish and Wildlife [WDFW])
- General provisions from the Washington State Department of Transportation – (WSDOT)
- Remediation agreements for contaminated sites (such as Model Toxics Control Act [MTCA] or Voluntary Cleanup Program sites)

See Chapter 1, Section 1.7 for further information.

5.2 Planning

This section provides an overview of the important components of, and the process for, developing and implementing a Construction SWPPP.

Section 5.2.1 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 5.2.2 discusses the two main components of a Construction SWPPP, the narrative and the drawings.

Section 5.2.3 outlines and describes the step-by-step procedure for developing a Construction SWPPP from data collection to finished product. Step 3 in Section 5.2.3 provides a description of each of the Construction SWPPP elements. This procedure is written in general terms to be applicable to all types of projects.

Design standards and specifications for BMPs referred to in this chapter are found in Section 5.4.

The Construction SWPPP is a subset of the submittal requirements outlined in Chapter 3.

5.2.1 General Guidelines

What is a Construction Stormwater Pollution Prevention Plan?

The Construction SWPPP is a 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, usually in the form of BMPs, to take on a construction site to control potential pollution problems. The Construction SWPPP must include a narrative as well as drawings and details (see Chapter 3, Table 3.1, for threshold limits for various plan submittals). Projects that add or replace less than 2,000 square feet of hard surface or disturb less than 7,000 square feet of land (including many single-family building sites) are not required to prepare a full Construction SWPPP, but must still consider all of the 13 elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site. These smaller projects shall use the SWPPP Short Form provided in Chapter 3, Appendix 3A to document compliance with the 13 elements and Core Requirement #2.

As site work progresses, the plan must be modified to reflect changing site conditions, subject to the rules for plan modification by the CSWGP and/or the City. See also Construction SWPPP Element #12 in Section 5.2.3, Step 3.

Who Is Responsible for the Construction SWPPP?

The owner or lessee of the land being developed has the responsibility for Construction SWPPP preparation and submission to the City. The owner or lessee may designate someone (i.e., an engineer, architect, contractor, etc.) to prepare the Construction SWPPP, but they retain 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.

What Is an Adequate Plan?

The Construction SWPPP must contain sufficient information to satisfy the City that the problems of construction pollution have been adequately addressed for the proposed project, for the entire project duration from initial site work to final build-out and site stabilization. The Construction SWPPP should be part of the initial draft Drainage Report submittal (Chapter 3, Section 3.2.2).

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, site specific information about existing conditions, construction schedules, and other pertinent items that are not contained on the drawings. The drawings show, on a site map, the specific BMPs that shall be installed.

Provide text notes on the drawings to describe the performance standards the BMPs must achieve, and actions to take if the performance goals are not achieved.

Reports summarizing the scope of inspections, the personnel conducting the inspections, the date(s) of the inspections, 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. Construction-related site activities may be restricted during the wet season for sites that pose a potential risk to surface waters downstream from the site.

On construction sites that infiltrate all stormwater runoff, the primary concern in the preparation of the Construction SWPPP is the protection of the infiltration BMPs from fine sediments during the construction phase and protection of groundwater 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 13 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 5.2.3 is recommended for the development of Construction SWPPPs. A SWPPP checklist that may be helpful in preparing and reviewing the Construction SWPPP is available from the City.

BMP Standards and Specifications

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
- Groundwater associated with construction activity
- Spillage or leaks
- Sludge or waste disposal
- Drainage from raw material storage.

Sections 5.3 and 5.4 contain standards and specifications for the BMPs commonly used in Construction SWPPPs to address the 13 elements, as well as additional techniques specific to protection of LID BMPs during construction. Construction stormwater BMPs can be used singularly or in combination. If a Construction SWPPP makes use of a BMP, the narrative and drawings must clearly reference the specific BMP title and number.

The standards and specifications in Sections 5.3 and 5.4 are not intended to limit any innovative or creative effort to effectively control erosion and sedimentation. Construction SWPPPs can contain experimental BMPs or make minor modifications to standard BMPs. However, both the City and Ecology must approve such practices before use. All experimental BMPs and modified BMPs must achieve the same or better performance than the BMPs listed in Sections 5.3 and 5.4.

5.2.2 Construction SWPPP Requirements

The Construction SWPPP shall consist of two parts: a narrative and the drawings. The following sections describe the contents of each.

Narrative

Cover Sheet: The Construction SWPPP narrative report shall have a cover sheet with the project name; applicant's name, address, telephone number, and email address; project engineer's name, address, telephone number, and email address; date of submittal; contact's name, address telephone number, and email address; and the name, address telephone number, and email address of contractor and Certified Erosion and Sediment Control Lead (CESCL), if known.

Project Engineer's Certification: For some Abbreviated Drainage Plan submittals, the Construction SWPPP need not be developed by a professional engineer. However, for more complex projects submitting an Abbreviated Drainage Plan with engineering elements (e.g., to support Core Requirement #5, as outlined in Chapter 1) or a Drainage Control Plan, as per the rest of the submittal the Construction SWPPP must be developed by a professional engineer licensed in Washington State. For projects where a PE is required, the Construction SWPPP report shall contain a page with the project engineer's seal with the following statement:

> *"I hereby state that this Construction Stormwater Pollution Prevention Plan for ______________________________________ (name of project) has been prepared by me or under my supervision and meets the standard of care and expertise which is usual and customary in this community for professional engineers. I understand that the City of Lacey does not and will not assume liability for the sufficiency, suitability, or performance of construction stormwater BMPs prepared by me."*

Table of Contents: Show the page number for each section of the report. Show page numbers of appendices.

Certified Erosion Control Lead: Site inspections shall be conducted by a person who is knowledgeable in the principles and practices of erosion and sediment control. For project sites that that require a Construction SWPPP, a CESCL shall be identified in the Construction SWPPP and shall be on site or on call at all times.

For complex projects where a Drainage Control Plan is required or where the Construction SWPPP involves engineering calculations, the City may require a professional engineer to file a *Construction Inspection Report Form* before the project is accepted by the City as being completed. The report consists of a completed form and sufficient additional text to describe all factors relating to the construction and operation of the system to meet on-site stormwater management, runoff treatment, erosion control, flow control, and conveyance requirements and will be implemented on a case-by-case basis.

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 a required 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.
  - *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 hard surfaces.
  - *Adjacent areas* – Describe adjacent areas, including streams, lakes, wetlands, residential areas, and roads that might be affected by the construction project. Describe how upstream drainage areas may affect the site. 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 0.25 mile away. Describe special requirements and provisions for working near or within these areas.
  - *Soil* – Describe the soil on the site, giving such information as soil names, mapping unit, soil classification, erodibility, ability to settle, permeability, depth, texture, and soil structure.
  - *Potential erosion problem areas* – Describe areas on the site that have potential erosion problems.

- **Thirteen Elements:** Describe how the Construction SWPPP addresses each of the 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 Phasing:** Describe the intended sequence and timing of construction activities, as well as 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. Describe the intended sequence and timing of construction activities and any proposed construction phasing (including construction restraints for environmentally sensitive areas). Refer to Section 5.2.3, Element #12, for additional seasonal work considerations that should be reflected in the Construction SWPPP.

- **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).

Drawings

It is the responsibility of the project engineer to ensure that engineering drawings supporting the Construction SWPPP shall be sufficiently clear to construct the project in proper sequence, using specified methods and materials, with sufficient dimensions to fulfill the intent of drainage laws and ordinances and these design guidelines. The Construction SWPPP drawings shall include the following items:

- **Vicinity Map:** Provide a map with enough detail to identify the location of the construction site, show adjacent roads, parcels 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.
  - A legal description of the property boundaries or an illustration of property lines (including distances) on the drawings.
  - The direction of north in relation to the site.
  - Existing structures and roads.
  - The boundaries and identification of different soil types.

- Areas of potential erosion problems.
- Any on-site and adjacent surface waters, critical areas, their buffers, flood plain boundaries, and shoreline management boundaries.
- Existing contours and drainage basins and the direction of flow for the different drainage areas. Contour intervals on the site plan shall be at a minimum as follows:

Slope (percent)	Contour Interval (feet)
0 to 15	2
16 to 40	5
>40	10

- Topography must be field-verified for drainage easements and conveyance systems. Contours shall extend a minimum of 25 feet beyond property lines and shall extend sufficiently to depict existing conditions. If survey is restricted to the project site due to lack of legal access, contours shall be provided by other means, e.g., LiDAR data.
- Final and interim grade contours as appropriate, drainage basins, and the direction of stormwater flow during and upon completion of construction.
- Areas of soil disturbance, including all areas affected by clearing, grading, and excavation.
- Locations where stormwater will discharge to surface waters during and upon completion of construction.
- Existing unique or valuable vegetation and the vegetation that is to be preserved.
- Cut and fill slopes indicating top and bottom of slope catch lines.
- Total cut and fill quantities and the method of disposal for excess material.
- Stockpile; waste storage; and vehicle storage, maintenance, and washdown areas.
- Locations of all joint utility trenches and details of associated erosion and sediment transport control features.

- **Conveyance Systems:** Show on the site map the following temporary and permanent conveyance features:
  - Locations for temporary and permanent swales, interceptor trenches, ditches, or pipes associated with erosion and sediment control and stormwater management

  - Temporary and permanent pipe inverts and minimum slopes and cover
  - Grades, dimensions, and direction of flow in all ditches and swales, culverts, and pipes
  - Details for bypassing off-site runoff around disturbed areas
  - Locations and outlets of any dewatering systems.

- **Location of Runoff Treatment, Flow Control, and On-site Stormwater Management BMPs:** Show on the site map the locations of temporary and permanent runoff treatment, flow control, and/or on-site stormwater management BMPs.

- **Construction Stormwater BMPs:** Show on the site map all major structural and nonstructural BMPs, including:
  - The location of sediment pond(s), pipes, and structures
  - Dimension pond berm widths and inside and outside pond slopes
  - The trap/pond storage required and the depth, length, and width dimensions
  - Typical section views through pond and outlet structure
  - Typical details of gravel cone and standpipe, and/or other filtering devices
  - Stabilization technique details for inlets and outlets
  - Location and type of inlet protection
  - Control/restrictor device location and details
  - Stabilization and cover practices for berms, slopes, and disturbed areas
  - Rock specifications and detail for rock check dam, if used
  - Spacing for rock check dams as required
  - Front and side sections of typical rock check dams
  - The location, detail, and specification for silt fence
  - The construction entrance location and a detail.

- **Detailed Drawings:** Any structural practices used that are not referenced in this manual shall 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. This can include designated concrete washout areas, refueling sites or other BMPs for pollutant control.

- **Monitoring Locations:** Indicate on the site map any required water quality sampling locations. Sampling stations shall be located in accordance with applicable permit requirements.

- **Standard Notes:** Notes addressing construction phasing and scheduling shall be included on the drawings. Standard Construction SWPPP Notes and Standard Notes for BMPs can be found in Chapter 5 of the City of Lacey *Development Guidelines and Public Works Standards* (DG&PWS).

5.2.3 Step-by-Step Procedure

There are four basic steps in producing a Construction SWPPP:

Step 1 – Data Collection

Step 2 – Data Analysis

Step 3 – Construction SWPPP Development and Implementation

Step 4 – Complete *Construction Inspection Report Form* if required prior to final approval

Steps 1 through 4 (described below) are intended for projects that are adding or replacing 2,000 square feet or more of hard surface, or clearing 7,000 square feet or more. Smaller projects (such as most individual single-family home sites) must use the SWPPP Short Form provided in Chapter 3, Appendix 3A, rather than a complete Construction SWPPP. See Chapter 3 for further details on project submittal requirements.

Step 1 – Data Collection

Evaluate existing site conditions and gather information that will help develop the most effective Construction SWPPP.

- **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 (slight, moderate, severe, very severe, or an index value from the Natural Resources Conservation Service [NRCS] or the Web Soil Survey) on the drawing or in the narrative.

Characterize soils for permeability, water holding capacity, percent organic matter, and effective depth. Express these qualities in averaged or nominal terms for the subject site or project. This information is typically available in literature published by qualified soil professionals or engineers, such as the U.S. Department of Agriculture Soil Conservation Service (now the NRCS) Soil Survey of Thurston County or the NRCS' Web Soil Survey website at <websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. For projects that trigger Core Requirements #5, #6, or #7, a more detailed soils investigation is required and must be used for the SWPPP soils characterization.

- **Ground Cover:** Label existing vegetation on the drawing. Show features such as tree clusters, grassy areas, and unique or sensitive vegetation. Unique vegetation may include existing trees above a given diameter. Requirements regarding tree preservation should be investigated; these are primarily found in Chapter 14.32 Lacey Municipal Code (LMC) (see also Chapters 12.20 and 16.80 LMC). In addition, existing denuded or exposed soil areas should be indicated.

- **Critical Areas:** Delineate Chapter 16.54 LMC defined critical areas adjacent to or within the site on the drawing. Show features such as steep slopes, streams, floodplains, lakes, wetlands, sole source aquifers, and geologic hazard areas. Delineate 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) Special Flood Hazard Areas. Some critical areas may require specialist and or a separate permit to develop and locate. Consult with the City's Department of Community Development if site is in a potential critical hazard area.

- **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 construction stormwater BMPs on the drawings.

- **Existing Encumbrances**: Identify wells, existing and abandoned septic drainfields, 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 City. Chapter 6 also includes resources for determining rainfall values.

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:

- **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 construction involves stabilizing one part of the site before disturbing another. In this way, the entire site is not disturbed at once.

- **Topography:** The primary topographic considerations are slope steepness and length. Steeper and longer slopes have greater erosion potential 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 to avoid constructing an artificial drainage system. Properly stabilize constructed ditches and waterways so they do not 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.

  Direct construction away from areas of saturated soil where groundwater 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 groundwater table, permeability, shrink-swell potential, texture, ability to settle, and erodibility. Develop the Construction SWPPP based on known soil characteristics. Protect infiltration sites from clay and silt, which will reduce infiltration capacities and from compaction by heavy traffic.

- **Critical Areas:** Critical areas, per Chapter 16.54 LMC, may include but are not limited to flood hazard areas, geologically sensitive areas, critical aquifer recharge areas, wetlands, stream banks, fish-bearing streams, and other water bodies. **Delineate critical areas and their buffers on the drawings and clearly flag critical areas in the field.** For example, fencing may be more useful than flagging to ensure that equipment operators stay out of critical areas. Only unavoidable work shall take place within critical areas and their buffers. Such unavoidable work will require special BMPs, permit restrictions, and mitigation plans—documented in the Construction 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 BMPs, public infrastructure, or aquatic systems. Select construction stormwater BMPs accordingly.

- **Precipitation Records:** Refer to Chapters 6 and 7 to determine the required rainfall records and the method of analysis for design of BMPs.

- **Timing of the Project:** 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.

Step 3 – Construction SWPPP Development and Implementation

After collecting and analyzing the data to determine the site limitations, a Construction SWPPP can then be developed. **The 13 elements below must be considered and included in the Construction SWPPP. If site conditions render the element unnecessary, the exemption from that element must be clearly justified in the narrative of the Construction SWPPP**.

The Construction SWPPP shall be implemented starting prior to any land disturbance and continue until final stabilization.

Ecology provides a template for preparing the Construction SWPPP at: <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Stormwater-general-permits/Construction-stormwater-permit>. Tables 5.1 and 5.2 in Section 5.4 present recommended BMPs for each of the required elements. The Construction SWPPP shall include standard SWPPP notes and BMP notes, which can be found in Chapter 5 of the DG&PWS.

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.
- Plastic, metal, fabric fence, or other physical barriers may be used to mark the clearing limits. Note the difference between the practical use and proper installation of BMP C233: Silt Fence, and the proper use of BMP C103: High-Visibility Fence.
- If it is not practical to retain the duff layer in place, then stockpile it on site, cover it to prevent erosion, and replace it immediately when you finish disturbing the site. See the postconstruction soil quality and depth BMP in Chapter 7, Section 7.4.1, for more information.

Suggested BMPs

- BMP C101: Preserving Natural Vegetation
- BMP C102: Buffer Zones

- BMP C103: High-Visibility Fence
- BMP C233: Silt Fence

Element #2: Establish Construction Access

- Limit construction vehicle access and exit to one route, if possible. Minimize construction site access points along linear projects, such as roadways.
- Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent BMPs, to minimize tracking of sediment onto roads and accesses.
  - Other equivalent BMPs may include Foreign Object Debris System (FODS) trackout control mats and Track Clean™ Construction Entrance Plates.
- Locate wheel wash or tire baths on site if the stabilized construction access is not effective in preventing tracking sediment onto roads/accesses.
- Sediment must not be tracked off-site. If sediment is tracked off-site, clean the affected roadway/access 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 picking up and transporting 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 to an approved infiltration BMP, or otherwise preventing it from discharging into systems tributary to the City municipal separated storm sewer system (MS4), wetlands, or waters of the State. Options include discharge to the sanitary sewer, or discharge to an approved off-site treatment system.
  - The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. For discharges to the sanitary sewer, permits must be obtained either from the City of Lacey Wastewater Utility Department at (360) 491-5600, or the LOTT Clean Water Alliance at (360) 664-2333. Note that a permit may need to be obtained by either or both entity(ies) depending on the nature of the discharge.

Suggested BMPs

- BMP C105: Stabilized Construction Access
- BMP C106: Wheel Wash
- BMP C107: Construction Road/Parking Area Stabilization

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 infiltration or detention BMPs as one of the first steps in grading. Ensure that detention BMPs function properly before constructing site improvements (e.g., impervious surfaces).

- Sites that must implement flow control for the developed site condition must also control stormwater release rates during construction. Construction site stormwater discharges must meet the discharge requirements listed in Chapter 2, Section 2.2.7.

  This restriction on release rates can affect the size of the storage pond and treatment cells. The City may require designs that provide additional or different stormwater flow control if necessary to address local conditions or to protect properties and waterways downstream from high flow impacts.

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

- Conduct downstream analysis if changes in flows could impair or alter conveyance systems, streambanks, bed sediment, or aquatic habitat. See Chapter 1 for potential off-site analysis guidelines.

- Even gently sloped areas need flow controls such as BMP C235: Wattles or other energy dissipation/filtration structures. Place dissipation BMPs closer together on steeper slopes. These methods prevent water from building higher velocities as it flows downstream within the construction site.

- Control structures designed for permanent detention BMPs are not appropriate for use during construction without modification. If used during construction, modify the control structure to allow for long-term storage of runoff and enable sediment to settle. Verify that the BMP is sized appropriately for this purpose. Restore BMPs to their original design dimensions, remove sediment, and install a final control 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 infiltration or detention BMP designs that provide additional or different stormwater flow control than the designs detailed in this manual. These requirements may be necessary to address local conditions or to protect properties and waterways downstream.

- Velocity of water leaving the site should not exceed 3 feet/second if the discharge is to a stream or ditch. Install velocity dissipation, such as BMP C207: Check Dams or BMP C202: Riprap Channel Lining to ensure reduction of the flow velocity to a non-erosive level.

- If the discharge from a project site 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. Obtain permission from the City before discharging to the public drainage system. Ensure that no downstream pipes are surcharged as a result of increased flows from the project site.

- If the discharge from a project site is directly to a flow control exempt receiving water (Puget Sound or the Nisqually River) or to an infiltration BMP, there is no discharge flow limit.

Suggested BMPs

- BMP C203: Water Bars

- BMP C207: Check Dams

- BMP C209: Outlet Protection

- BMP C235: Wattles

- BMP C240: Sediment Trap

- BMP C241: Sediment Pond (Temporary)

Refer also to Chapter 7 – Flow Control BMPs.

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 construction stormwater BMPs 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 BMP C241: Sediment Pond (Temporary) 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 control flow rates per Element #3: Control Flow Rates.

- 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.

- Provide and maintain natural buffers around surface waters, direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration, unless infeasible.

- 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.

- 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 installing a floating pump structure, include a stopper to prevent the pump basket from hitting the bottom of the pond.

- If a sediment trapping BMP utilizes a control structure that will also be used in a permanent detention BMP application, the control structure must be finalized for the permanent BMP application upon project completion.

- Install sediment controls in a manner that protects the sensitive areas and their buffers marked in accordance with Element #1: Preserve Vegetation / Mark Clearing Limits.

- Where feasible, direct stormwater to vegetated areas to increase sediment removal and maximize stormwater infiltration.

- Seed and mulch earthen structures such as dams, dikes, and diversions according to the timing indicated in Element #5: Stabilize Soils.

- Full stabilization 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 City may inspect and approve areas fully stabilized by means other than pavement or quarry spalls.

Suggested BMPs

- BMP C231: Brush Barrier
- BMP C232: Gravel Filter Berm
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip
- BMP C235: Wattles
- BMP C240: Sediment Trap
- BMP C241: Sediment Pond (Temporary)
- BMP C250: Construction Stormwater Chemical Treatment
- BMP C251: Construction Stormwater Filtration

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 on areas to be paved, and dust control.

- Full stabilization means all soil disturbing activities at the site have been completed and areas where the soil or natural vegetative cover has been disturbed have been properly covered and accepted to meet permanent erosion control. Permanent erosion control can include concrete or asphalt paving; quarry spalls used as ditch lining; application of thick layers of gravel or mulch; or vegetative cover in a manner that will fully prevent soil erosion. Where the term "fully established" is used to describe vegetative cover or plantings, it shall be understood to mean that healthy vegetation covers 90 percent of exposed bare soil. The application of hydroseeding, even in conjunction with a bonded fiber matrix (BFM) or rolled erosion product, will not be accepted as fully established permanent erosion control before the necessary development and ground cover requirements of the plantings are met. The strong root structures of well-established vegetation are an essential mechanism in controlling soil erosion. The City will inspect and must approve all areas as fully stabilized before the release of financial guarantees.

- 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–September 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, locate 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.
- Soil stabilization measures must 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 groundwater.
- Ensure that gravel base used for stabilization is clean and does not contain fines or sediment.
- Prevent wind transport of dust from disturbed soil surfaces onto roadways, drainage ways, and surface waters. Refer to BMP C140: Dust Control.

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 (PAM) for Soil Erosion Protection
- BMP C130: Surface Roughening
- BMP C131: Gradient Terraces
- BMP C140: Dust Control

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 groundwater away from slopes and disturbed areas with interceptor dikes, pipes, and/or swales. Off-site stormwater must 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 be sized to convey the flow rate calculated by one of the following methods:
  - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm

  OR

  - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step.

  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.

- Consider soil type and its potential for erosion.
- Stabilize soils on slopes, as specified in Element #5: Stabilize Soils.
- BMP combinations are the most effective method of protecting slopes with disturbed soils. For example, use both BMP C121: Mulching and BMP C122: Nets and Blankets in combination.

Suggested BMPs

- BMP C120: Temporary and Permanent Seeding
- BMP C121: Mulching
- BMP C122: Nets and Blankets
- BMP C123: Plastic Covering
- BMP C124: Sodding
- 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 (TSD)

Element #7: Protect Drain Inlets

- Protect all storm drain inlets made operable during construction 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).
- Inlets shall be inspected weekly at a minimum and daily during storm events.
- 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 clean. Do not allow sediment and street wash water to enter storm drains without prior and adequate treatment (as defined above) unless treatment is provided before the storm drain discharges to waters of the State.

Suggested BMPs

- BMP C220: Inlet Protection

Element #8: Stabilize Channels and Outlets

- Design, construct, and stabilize all on-site conveyance channels to prevent erosion from the flow rate calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A 10-year, 24-hour frequency storm.

    OR

    - Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step.

    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 shall 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.
- The best method for stabilizing channels is to completely line the channel with BMP C122: Nets and Blankets first, then add BMP C207: Check Dams as necessary to function as an anchor and to slow the flow of water.

Suggested BMPs

- BMP C122: Nets and Blankets
- BMP C202: Riprap Channel Lining
- BMP C207: Check Dams
- BMP C209: Outlet Protection

Element #9: Control Pollutants

Design, install, implement, and maintain effective pollution prevention measures to minimize the discharge of pollutants. The project proponent must:

- 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. Woody debris may be chopped and spread on site.
- 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 percent 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.
- Conduct oil changes, hydraulic system drain down, solvent and degreasing cleaning operations, fuel tank drain down and removal, and other activities that may result in discharge or spillage of pollutants to the ground or into stormwater runoff only when using spill prevention measures, such as drip pans.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, or to the sanitary sewer. For discharges to the sanitary sewer, permits must be obtained either from the City of Lacey Wastewater Utility Department at (360) 491-5600, or the LOTT Clean Water Alliance at (360) 664-2333. The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. Note that a permit may need to be obtained by either or both entity(ies) depending on the nature of the discharge.

- 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: recycled concrete stockpiles, 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.

- Ensure that washout of concrete trucks is performed off-site or in designated concrete washout areas only. Do not wash out concrete truck drums or concrete handling equipment onto the ground, or into storm drains, open ditches, streets, or streams. Washout of small concrete handling equipment may be disposed of in a formed area awaiting concrete where it will not contaminate surface or ground water. Do not dump excess concrete on site, except in designated concrete washout areas. Concrete spillage or concrete discharge directly to ground water or surface waters of the State is prohibited. Do not wash out to formed areas awaiting infiltration BMPs.

- Obtain written approval from Ecology before using chemical treatment other than CO2, dry ice, or food grade vinegar to adjust pH.

- Uncontaminated water from water-only based shaft drilling for construction of building, road, and bridge foundations may be infiltrated provided the wastewater is managed in a way that prohibits discharge to surface waters. Prior to infiltration, water from water-only based shaft drilling that comes into contact with curing concrete must be neutralized until pH is in the range of 6.5 to 8.5 (su).

- Wheel wash and/or tire bath wastewater can be combined with wastewater from concrete washout areas if the wastewaters will be properly disposed of at an off-site location or treatment BMP.

- Do not use upland land applications for discharging wastewater from concrete washout areas.

- Clean contaminated surfaces 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.

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: Treating and Disposing of High pH Water
- See Chapter 9 – Source Control for Developed Sites

Element #10: Control Dewatering

- Discharge foundation, vault, and trench dewatering water, which have similar characteristics to stormwater runoff at the site, into a controlled conveyance system before discharge to BMP C240: Sediment Trap or BMP C241: Sediment Pond (Temporary).
- Discharge clean, non-turbid dewatering water, such as well-point groundwater, to systems tributary to, or directly into surface waters of the State, as specified in Element #8: Characterize Channels and Outlets, provided the dewatering flow does not cause erosion or flooding of receiving waters. Do not route clean dewatering water through stormwater sediment BMPs. 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.
- Dewatering operations must be observed by a site representative at all times to ensure highly turbid or otherwise contaminated dewatering water is not discharged to surface waters of the State.
- Other dewatering treatment or disposal options may include:
    - Infiltration.
    - Transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters.

    - Ecology-approved on-site chemical treatment or other suitable treatment technologies.
    - Sanitary or combined sewer discharge with local sewer district approval, if there is no other option. For discharges to the sanitary sewer, permits must be obtained either from the City of Lacey Wastewater Utility Department at (360) 491-5600, or the LOTT Clean Water Alliance at (360) 664-2333. The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. Note that a permit may need to be obtained by either or both entity(ies) depending on the nature of the discharge.
    - Use of a sedimentation bag that discharges to a ditch or swale for small volumes of localized dewatering.

- Channels must be stabilized, as specified in Element #8: Stabilize Channels and Outlets.
- 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.
- Dewatering water from contaminated sites must be handled separately from stormwater. Direct contaminated stormwater to a sanitary sewer only where allowed by the City of Lacey Wastewater Utility Department, or to other approved treatment.

Suggested BMPs

- BMP C203: Water Bars
- BMP C236: Vegetative Filtration

Element #11: Maintain BMPs

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

- Some temporary construction stormwater BMPs are biodegradable and designed to remain in place following construction. BMP C122: Nets and Blankets is an example of a BMP with biodegradable options.

- 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 BMP shall be 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

- Phase development projects to the maximum degree practicable and take into account seasonal work limitations.

- Inspect, maintain, and repair all BMPs as needed to ensure continued performance of their intended function. Projects regulated under the CSWGP must conduct site inspections and monitoring in accordance with Special Condition S4 of the CSWGP.

- Maintain, update, and implement the Construction SWPPP.

- Project sites that require a Construction SWPPP must have site inspections conducted by a CESCL. The Construction SWPPP must identify the CESCL or inspector, who shall be present on site or on call at all times.

Phasing of Construction

Phase development projects where feasible in order to prevent soil erosion and transporting of sediment from the site during construction. Revegetate exposed areas and maintain that vegetation as an integral part of the clearing activities for any phase.

Clearing and grading activities for developments shall be permitted only if conducted 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 permitted clearing and grading areas. 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.

Seasonal Work Limitations

Construction activity presents an increased risk to water resources during the typically wet fall through spring periods in the Pacific Northwest. As such, particular attention must be given to proper selection, design, and installation of erosion and sediment control BMPs. From October 1 through April 30, clearing, grading, and other soil disturbing activities may be permitted only if shown to the satisfaction of the City that the site operator will prevent silt-laden runoff from leaving the site through activities including but not limited to the following:

- Compliance with Element #5: Stabilize Soils
- Minimization of areas of site disturbance
- Limitation of construction activities that will disturb soil or increase the potential for soil erosion and transport
- Installation and regular inspection of all proposed construction stormwater BMPs.
- Completion, submission, and approval of a wet-season amendment to the SWPPP, which may include additional construction BMPs (e.g., stabilized parking, dewatering provisions etc.), stopping work during the wettest months, and/or a bond for maintenance of the downstream system.

Based on the information provided and/or local weather conditions, the City may expand or restrict the seasonal limitation on site disturbance. The City may 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, potentially causing a violation of the surface water quality standard.
- If clearing and grading limits or construction stormwater BMPs shown in the approved plan are not maintained.

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

- Routine maintenance and necessary repair of construction stormwater BMPs
- Routine maintenance of public BMPs or existing utility structures that do not expose the soil or result in the removal of the vegetative cover to soil
- Activities where there is 100 percent infiltration of surface water runoff within the site in approved and installed construction stormwater BMPs.

Coordination with Utilities and Other Contractors

The primary project applicant 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

All BMPs must be inspected, maintained, and repaired as needed to ensure continued performance of their intended function. Site inspections must be conducted by a person knowledgeable in the principles and practices of erosion and sediment control. The person must have the skills to assess:

1) The site conditions and construction activities that could impact the quality of stormwater, and

2) The effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.

For all project sites that require a construction SWPPP, a CESCL must be identified in the construction SWPPP; this person must be on-site or on-call at all times. Certification must be obtained through an approved training program that meets the erosion and sediment control training standards established by Ecology. See BMP C160: Certified Erosion and Sediment Control Lead.

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.

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 problems identified by:

- Reviewing the Construction SWPPP for compliance with the 13 elements and making appropriate revisions to the Construction SWPPP within 7 days of the inspection during the dry season and within 3 days during the wet season.

- Immediately begin the process of fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible.

    - **During the dry season (May 1 through September 30):** Address the problems 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.

- **During the wet season (October 1 through April 30):** Address the problems within 24 hours upon receiving notification from the City inspector.

- Documenting BMP implementation and maintenance in the site log book (applies only to sites that have coverage under the CSWGP).

The CESCL or inspector must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at the following frequency:

- **During the dry season (May 1 through September 30):** At least once every calendar week and within 24 hours of any discharge from the site. If there are rain showers, the frequency should be at least twice per week.
  - For purposes of this condition, individual discharge events that last more than 1 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 during the dry season only.
- **During the wet season (October 1 through April 30):** At least once every other day and within 24 hours of any discharge from the site.

Note that additional requirements may apply per the project specific SWPPP and/or permits, as applicable.

Maintaining an Updated Construction SWPPP

- Retain the Construction SWPPP on site or within reasonable access to the site.
- Modify the Construction SWPPP 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 Construction SWPPP must be modified if, during inspections or investigations conducted by the owner/operator, the City, or state regulatory authority, it is determined that the Construction SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges from the site. Modify the Construction SWPPP as necessary to include additional or modified BMPs designed to correct problems identified. Complete revisions to the Construction SWPPP within 7 days following the inspection.

Suggested BMPs

- BMP C150: Materials On Hand
- BMP C160: Certified Erosion and Sediment Control Lead
- BMP C162: Scheduling

Element #13: Protect Low Impact Development BMPs

The primary purpose of On-Site Stormwater Management is to reduce the disruption of the natural site hydrology through infiltration. BMPs used to meet CR5: On-Site Stormwater Management (often called LID BMPs) are permanent BMPs.

- Protect all LID BMPs (including, but not limited to BMP T7.30: Bioretention, BMP T5.14: Rain Gardens, and BMP T5.15: Permeable Pavements) from sedimentation through installation and maintenance of erosion and sediment control BMPs on portions of the site that drain into the LID 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.

- Maintain the infiltration capabilities of LID BMPs by protecting against compaction by 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 BMP T5.15: Permeable Pavements. Do not allow muddy construction equipment on the base material or permeable pavements. Do not allow sediment-laden runoff on the base material or permeable pavements. Do not stockpile material on the base material or permeable pavements.

- Permeable pavement fouled with sediments or no longer passing an initial infiltration test must be cleaned using procedures in accordance with Chapter 7 of this manual, Maintenance Standards in Chapter 10, or the manufacturer's procedures.

- Keep all heavy equipment off existing soils under LID BMPs that have been excavated to final grade to retain the infiltration rate of the soils.

- See Section 5.3 and Chapter 5: Precision Site Preparation, Construction & Inspection of LID Facilities in the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for more details on protecting LID integrated management practices.

  Note that the *Low Impact Development Technical Guidance Manual for Puget Sound* is for additional informational purposes only. You must follow the guidance within this manual if there are any discrepancies between this manual and the *Low Impact Development Technical Guidance Manual for Puget Sound*.

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)
- BMP C231: Brush Barrier
- BMP C233: Silt Fence
- BMP C234: Vegetated Strip

Step 4 – Complete Construction Inspection Report Form Prior to Final Approval

None of the BMPs listed in this chapter 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.

Construction sites are subject to inspections by the City as follows:

- Prior to clearing and construction, on all sites that are determined by the City to have a high potential for sediment transport;
- During construction, on all sites, to verify proper installation and maintenance of required erosion and sediment control BMPs; and
- Upon completion of construction and prior to final approval, on all sites, to ensure proper installation of permanent stormwater controls.

5.3 Protection of Infiltration and Dispersion BMPs During Construction

5.3.1 Introduction

To ensure that all infiltration and dispersion BMPs, including LID BMPs, will be fully functional after construction, it is important to protect these BMPs during construction activities. Protecting native soil and vegetation, minimizing soil compaction, and retaining the hydrologic function of infiltration and dispersion BMPs during the site preparation and construction phases are some of the most important practices during the development process.

The purpose of this section is to provide designers, builders, and inspectors with guidance and tools for meeting Core Requirement #2, Element #13: Protect Low Impact Development BMPs. This section does not provide guidance on construction or design of infiltration and dispersion BMPs (see Chapters 7 and 8), or cover all Construction SWPPP practices (see Section 5.4), but rather focuses on how to most efficiently reduce impacts on infiltration and dispersion BMPs specifically during construction. **The practices specified in this section must be applied to protect infiltration and dispersion BMPs, unless the given practice does not apply to the project site conditions or activities.**

Additional guidance and requirements related to UICs can be found in Appendix 7C.

5.3.2 General Construction Stormwater BMPs Applicable to Infiltration

Overall Construction Stormwater Pollution Prevention Plan (SWPPP) requirements are specified in Chapter 1, Core Requirement #2 and Chapter 5. In general, construction stormwater BMPs limit the impact of site disturbance, erosion, and sediment deposition during construction. Some construction stormwater BMPs (presented in more detail in Section 5.4) focus on providing a physical barrier or deterrent to help minimize construction-related site disturbance and/or erosion, while other construction stormwater BMPs help protect the site from concentrated (i.e., erosive) flows. General construction stormwater BMPs and their application for protection of infiltration and dispersion BMPs in particular are summarized below. These BMPs must be considered for projects subject to Core Requirement #2 that are proposing to construct infiltration and dispersion BMPs, including LID BMPs.

Construction Stormwater BMP	Application
BMP C103: High-Visibility Fence	Use fencing to limit clearing; prevent disturbance of sensitive areas, their buffers, and other areas; limit construction traffic; and protect areas where marking with flagging may not provide adequate protection
BMP C200: Interceptor Dike and Swale	Use an interceptor dike and/or swale to intercept the runoff from unprotected areas and direct it to areas where erosion can be controlled
BMP C201: Grass-Lined Channels	Use grass lined channels where concentrated runoff may cause erosion and flooding of the site
BMP C207: Check Dams	Use check dams in swales or ditches to reduce the velocity and dissipate concentrated flow
BMP C208: Triangular Silt Dike (TSD)	Use triangular silt dikes as check dams, for perimeter protection, temporary soil stockpile protection, drop inlet protection, or as a temporary interceptor dike
BMP C231: Brush Barrier	Use brush barriers to decrease flow velocities and reduce transport of coarse sediment from overland flow

Construction Stormwater BMP	Application
BMP C233: Silt Fence	Use silt fences to decrease flow velocities and reduce transport of sediment from overland flow
BMP C234: Vegetated Strip	Use vegetated strips to decrease flow velocities and reduce transport of sediment from overland flow

5.3.3 Infiltration Capacity Preservation

For infiltration BMPs, infiltration capacity of the BMP must be preserved during construction. As stated in Element #11: Maintain BMPs, if sediment enters a BMP during construction, it shall be removed, and the BMP shall be returned to the conditions specified in the construction documents. Performance verification may be required for infiltration BMPs to ensure they are performing as designed per Chapter 7, Section 7.2.2.

5.3.4 Additional Construction Techniques for Infiltration and Dispersion BMPs

In addition to the general construction stormwater BMPs presented in Section 5.3.2, this section outlines specific construction-phase techniques to protect infiltration and dispersion BMPs. Infiltration and dispersion BMP protection is still a somewhat new and evolving practice, therefore the specific protection measures outlined below are not explicitly called out in Section 5.4. Rather, the techniques presented in this section supplement the construction stormwater BMPs presented in Section 5.3.2 and those presented in Section 5.4.

Construction Site Planning and Sequencing

Construction site planning and sequencing is a procedural BMP that is critical to successful installation and long-term operation of infiltration and dispersion BMPs. Proper site planning and construction sequencing will minimize the impact of construction on permanent stormwater BMPs by reducing the potential for soil erosion and compaction. Site planning and sequencing techniques to be used as practicable for protection of infiltration and dispersion BMPs include:

Construction Site Planning and Sequencing Requirements	Construction Site Planning and Sequencing Techniques
Limit clearing and grading activities	• Keep grading to a minimum by incorporating natural topographic depressions into the development. • Shape final lot grades and topographic features early (i.e., at the site development stage) where feasible. • Limit the amount of cut and fill in areas with permeable soils. • Limit clearing to road, utility, building pad, lawn areas, and the minimum amount of extra land necessary to maneuver machinery (e.g., a 10-foot perimeter around a building).

Construction Site Planning and Sequencing Requirements	Construction Site Planning and Sequencing Techniques
Limit construction activity in areas designated for infiltration and dispersion BMPs	• Clearly document—and plan to meet and walk through the site with equipment operators prior to construction—to clarify construction boundaries, limits of disturbance, and construction activities in the vicinity of infiltration and dispersion BMPs. • General/primary contractor must inform other sub-contractors of applicable infiltration and dispersion BMP protection requirements. This is particularly important when working around permeable pavement.
Limit clearing and grading during heavy rainfall seasons	• Time construction activities to start during the summer (lowest precipitation) and end in the fall (when conditions are favorable for the establishment of vegetation), if feasible.
Minimize the amount and time that graded areas are left exposed	• Complete construction and erosion control activities in one section of the site before beginning activity in another section.
Utilize permeable and nutrient rich soils	• Preserve any portion of the site with permeable soils to promote infiltration of stormwater runoff. • Leave areas of rich topsoil in place, or if excavated, utilize elsewhere on the site to amend areas with sparse or nutrient deficient topsoil.
Reduce impact of construction access roads	• Reduce the number and size (width/length) of construction access roads. • Locate construction access roads in areas where future roads and utility corridors will be placed (unless utilizing permeable pavement).
Promote sheet flow and minimize concentrated runoff	• Avoid grading that results in steep, continuous slopes, especially in areas contributing runoff to LID BMPs.
Infiltration and dispersion BMP activation	• Infiltration and dispersion BMPs shall not begin operation until all erosion-causing project improvements (including use of access roads that may contribute sediment) are completed and all exposed ground surfaces are stabilized by revegetation or landscaping in upland areas potentially contributing runoff to the BMP.

Activities During Construction

Many common construction-phase activities pose a risk to infiltration and dispersion BMPs. The following techniques will help minimize these impacts. Techniques to be used for protection of infiltration and dispersion BMPs include:

Erosion Control Requirements	Erosion Control Techniques
Protect native topsoil during the construction phase, and reuse on site	• Where practicable, protect areas of rich topsoil. If excavation is necessary, stockpile native soils that can be used on the site after construction. • Stockpile materials in areas designated for clearing and grading (such as parking areas and future impervious roadways) and away from infiltration, dispersion, and other stormwater BMPs. • Cover small stockpiles with weed barrier material that sheds moisture yet allows air transmission. Large stockpiles may need to be seeded and/or mulched. • Do not relocate topsoil or other material to areas where they can cover critical root zones, suffocate vegetation, or erode into adjacent streams.
Use effective revegetation methods	• Use native plant species adapted to the local environment. • Plant during late fall, winter, or early spring months when vegetation is likely to establish quickly and survive. • Utilize proper seedbed preparation. • Fertilize and mulch to protect germinating plants. Apply 1 inch of compost topped with 2 inches of mulch. • Protect areas designated for revegetation from soil compaction by restricting heavy equipment. • Provide proper soil amendments where necessary (refer to Chapter 7, Section 7.4.1). • During storage, plants should be protected by solar screens when possible to prevent overexposure and excessive drying.
Perform preconstruction, routine, and postconstruction inspections	• Conduct a preconstruction inspection to verify that adequate barriers have been placed around vegetation retention areas, infiltration, and dispersion BMPs (as needed), and structural controls are implemented properly. • Conduct routine inspections to verify that structural controls are being maintained and effectively protecting infiltration and dispersion BMPs throughout construction. • Conduct a final inspection to verify that revegetation areas are stabilized and that permanent infiltration and dispersion BMPs are in place and functioning properly.

5.3.5 BMP-Specific Construction Techniques

This section outlines construction-phase BMP protection techniques specific to *categories* of BMPs (including dispersion BMPs) as well as *specific* infiltration BMPs (e.g., permeable pavement, bioretention areas/rain gardens). The BMP protection techniques presented in Section 5.3.3 are applicable to the overall construction site to help protect infiltration and dispersion BMPs. The techniques outlined in this section are based on the specific BMP functions, targeting typical construction activities that pose a risk to individual BMPs.

Infiltration and Dispersion BMP Construction Techniques

It is critical that appropriate methods are used to protect infiltration and dispersion BMPs from compaction and sediment loading during construction. For infiltration BMPs in particular, the subgrade soils must be protected from clogging and over-compaction to maintain the soil permeability and ensure BMP performance. Techniques for protection of infiltration and dispersion BMPs during various stages of construction are summarized below.

Construction Stage	Techniques for Protecting Infiltration and Dispersion BMPs
Prior to construction	• The infiltration/dispersion area shall be clearly identified (e.g., using flagging or high visibility fencing) and protected prior to construction to prevent compaction of underlying soils by vehicle traffic. • Develop a soil and vegetation management plan showing areas to be protected and restoration methods for disturbed areas before land clearing starts. • The Construction SWPPP sheets must outline construction sequencing that will protect the infiltration/dispersion area during construction. • Construction stormwater BMPs and protection techniques identified in Sections 5.3.2 and 5.3.3 shall be implemented as applicable. In particular, be sure to stabilize upslope construction areas (e.g., using silt fences, berms, mulch, or other construction stormwater BMPs) and minimize overland flow distances.
Excavation	• Excavation of infiltration/dispersion areas shall be performed by machinery operating adjacent to the BMP. No heavy equipment with narrow tracks, narrow tires, or large lugged high pressure tires shall be allowed on the infiltration/dispersion area footprint. • Where feasible, excavate infiltration/dispersion areas to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. (If infiltration areas must be excavated before permanent site stabilization, initial excavation must be conducted to no less than 6 inches of the final elevation of the BMP floor.) • Excavation of infiltration areas shall not be allowed during wet or saturated conditions. • The use of draglines and trackhoes should be considered for constructing infiltration and dispersion areas. • The sidewalls and bottom of an infiltration BMP excavation must be raked or scarified to a minimum depth of 3 inches after final excavation to restore infiltration rates. • Scarify soil along the dispersion flow path if disturbed during construction.
Sediment control	• Bioretention, rain garden, and permeable pavement BMPs shall not be used as sediment control BMPs, and all drainage shall be directed away from the BMP location after initial rough grading. • Direct construction site flow away from the infiltration/dispersion area using applicable construction stormwater BMPs (e.g., temporary diversion swales).

Permeable Pavement

There are many potential applications and site scenarios where permeable pavement can be applied. The following techniques highlight the most broadly applicable techniques to be used to protect permeable pavement BMPs during construction. Refer to the previous section for construction protection methods that are applicable to all infiltration BMPs, as well as Sections 5.3.2 and 5.3.3 for general site protection measures. In addition to those techniques, the following techniques apply specifically for protection of permeable pavement during construction:

- Use procedural BMPs to plan construction. For example, phase construction to minimize compaction, sedimentation, or structural damage to the permeable pavement.
- Use physical erosion and sediment control BMPs and/or grade the site to avoid sediment laden runoff from reaching permeable pavements.
- Place protective surfaces (e.g., waterproof tarps and steel plates) over any permeable pavement areas used for construction staging.
- Do not drive sediment-laden construction equipment on the base material or pavement. Do not allow sediment-laden runoff on permeable pavements or base materials.
- Once the pavement is finished and set, cover the pavement surface with plastic and geotextile to protect from other construction activities. Close and protect the pavement area until the site is permanently stabilized.
- Incorporate measures to protect road subgrade from over compaction and sedimentation if permeable pavement roads are used for construction access.
    - Cover the aggregate base or pavement surface with protective geotextile fabric and protect fabric with steel plates or gravel. Gravel should only be used to protect the fabric placed over aggregate base.
    - Once construction is complete and the site is permanently stabilized, remove protective geotextile, clean, and complete pavement installation.

Refer to the detailed permeable pavement BMP information in Chapter 7, Section 7.4.6, for general permeable pavement construction criteria.

Bioretention Areas and Rain Gardens

As with permeable pavements, there are many potential applications and site scenarios where bioretention and rain garden BMPs can be applied. The following techniques highlight the most broadly applicable techniques to be used to protect bioretention and rain garden BMPs during construction. Refer to the beginning of this section for construction protection methods that are applicable to all infiltration and dispersion

BMPs, as well as Sections 5.3.2 and 5.3.3 for general site protection measures. In addition to those techniques, the following techniques apply specifically for protection of bioretention and rain garden BMPs during construction:

- Excavation:
  - If machinery must operate in the bioretention area for excavation, use lightweight, low ground-contact pressure equipment and rip the base at completion to scarify soil to a minimum of 12 inches.
- Protect bioretention soil mix from compaction during construction
  - Do not place bioretention soil mix if saturated or during wet periods.
  - Check for compaction prior to planting. If compaction occurs, aerate the bioretention soil and then proceed to plant.

Refer to the detailed bioretention and rain garden BMP information in Chapter 7, Sections 7.4.4 and 7.4.5, for general bioretention and rain garden construction criteria.

5.4 Construction SWPPP Best Management Practices Standards and Specifications

The following pages contain standards and specifications for construction stormwater BMPs to be used as applicable during the construction phase of a project. **BMPs shall be designed and installed in accordance with the specifications contained in the descriptions in this chapter, unless specifically approved by both the City and Ecology.** Refer to Ecology's web site for information on manufactured construction stormwater BMPs: <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>

The first set of BMPs presented in this section (BMPs numbered in the C100s) focus on construction site erosion prevention (referred to as "construction source control" BMPs in the 2019 Ecology Manual). Erosion prevention BMPs typically prevent erosion and associated pollution from occurring. Examples of erosion prevention BMPs include methods as various as using mulches and covers on disturbed soil, providing dust control, and specifying construction material handling procedures.

The second set of BMPs (BMPs numbered in the C200s) focus on construction-site runoff conveyance and treatment (referred to as "construction runoff BMPs" in the 2019 Ecology Manual). These BMPs are designed to minimize erosion associated with concentrated flows and/or to help remove sediment entrained in site runoff (i.e., through sedimentation or filtration).

Often using BMPs in combination is the best method to meet Construction SWPPP requirements.

The standards for each individual BMP are divided into four subsections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Standards.

Note that the “conditions of use” always refer to site conditions. As site conditions change, BMPs must be changed to remain in compliance.

Tables 5.1 and 5.2 show the relationship of the BMPs presented in this section to the Construction SWPPP elements outlined in Section 5.2.3. Detailed BMP descriptions are provided in following the tables.

Table 5.1. Erosion Prevention BMPs by Construction 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 Fence	✓								✓
BMP C105: Stabilized Construction Access		✓							
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 (PAM) 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						✓			

Table 5.1 (continued). Erosion Prevention BMPs by Construction 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 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								✓	

Table 5.2. Runoff Conveyance and Treatment BMPs by Construction SWPPP Element.

BMP or Element Name	Element #3 Control Flow Rates	Element #4 Install Sediment Controls	Element #6 Protect Slopes	Element #7 Protect Storm Drain Inlets	Element #8 Stabilize Channels and Outlets	Element #9 Control Pollutants	Element #10 Control Dewatering	Element #13 Protect Low Impact Development
BMP C200: Interceptor Dike and Swale			✓					✓
BMP C201: Grass-Lined Channels			✓					✓
BMP C202: Riprap Channel Lining					✓			
BMP C203: Water Bars	✓		✓				✓	
BMP C204: Pipe Slope Drains			✓					
BMP C206: Level Spreader			✓				✓	
BMP C207: Check Dams	✓		✓		✓			✓
BMP C208: Triangular Silt Dike (TSD) (Geotextile Encased Check Dam)			✓					✓
BMP C209: Outlet Protection	✓				✓			
BMP C220: Inlet Protection				✓				
BMP C231: Brush Barrier		✓						✓
BMP C232: Gravel Filter Berm		✓						
BMP C233: Silt Fence		✓						✓
BMP C234: Vegetated Strip		✓						✓
BMP C235: Wattles	✓	✓						
BMP C236: Vegetated Filtration							✓	
BMP C240: Sediment Trap	✓	✓						
BMP C241: Sediment Pond (Temporary)	✓	✓						
BMP C250: Construction Stormwater Chemical Treatment		✓				✓		
BMP C251: Construction Stormwater Filtration		✓				✓		
BMP C252: Treating and Disposing of High pH Water						✓		
BMP C253: pH Control for High pH Water						✓		

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 to 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 must be preserved on steep slopes, near perennial and intermittent watercourses or swales, and on building sites in forested areas.
- As required by the City or other agencies.

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. City ordinances to save natural vegetation and trees should be reviewed.
- 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 to 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 Pacific madrone 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 (e.g., fir, hemlock, pine, soft maples) is not advised as sap forms a natural healing barrier.

BMP C102: Buffer Zones

Purpose

Delineation of an area to remain undisturbed 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 incorporated into the natural landscaping of an area.

Critical-areas buffer zones shall not be used as sediment treatment areas. These areas shall remain completely undisturbed. The City 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. High-visibility 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 City or other state or federal permits or approvals.

Maintenance Standards

- Inspect the area frequently to make sure fencing or flagging remains in place and remains undisturbed. Replace all damaged fencing or flagging immediately.

BMP C103: High-Visibility Fence

Purpose

Fencing is intended to:

- Restrict clearing to approved limits
- Prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed
- Limit construction traffic to designated construction entrances, exits or internal roads
- Protect areas where marking with flagging/survey tape may not provide adequate protection

Conditions of Use

To establish clearing limits plastic, fabric, or metal 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

Design and Installation Specifications

- High-visibility plastic fence shall be composed of a high-density polyethylene material and shall be at least 4 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 6 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 pounds/feet using the American Society for Testing and Materials (ASTM) D4595 testing method.
- If appropriate install fabric silt fence in accordance with BMP C233 to act as High-Visibility Fence. Except that the silt fence shall be at least 3 feet high and must be highly visible to meet the requirements of this BMP.
- Metal fences are the least preferred but might be appropriate to address security concerns. Metal fencing shall be designed and installed according to the manufacturer’s specifications.

- Metal fences shall be at least 4 feet high and must be highly visible.
- Fences shall not be wired or stapled to trees.

Maintenance Standards

- If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.

BMP C105: Stabilized Construction Access

Purpose

Stabilized construction accesses are 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 and exits for construction sites.

Conditions of Use

Construction entrances shall be stabilized wherever traffic will be entering or leaving a construction site if paved roads or other paved areas are within 1,000 feet of the site.

For residential construction, provide stabilized construction accesses for each residence, rather than only at the main subdivision entrance. Stabilized surfaces shall be of sufficient length/width to provide vehicle access, based on lot size and configuration.

Design and Installation Specifications

- See Figure 5.1 for details. Note: the 100 foot 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 feet).

- Construct stabilized construction accesses 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. For single-family residential lots, pad may be reduced in length to fit site, to no less than 20 feet long, and in depth, to 6 inches thick with 4-inch to 6-inch quarry spalls, provided that performance standards are still met.

- Ecology's functionally equivalent technologies (i.e., FODS and Track Clean™ Construction Entrance Plates) are acceptable.

- 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 pounds per square inch (psi) minimum

    - Grab Tensile Elongation (ASTM D4632): 30 percent maximum

    - Mullen Burst Strength (ASTM D3786-80a): 400 psi minimum

    - AOS (ASTM D4751): 20 to 45 (U.S. standard sieve size)

- High-Visibility Fence (see BMP C103) 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.

Maintenance Standards

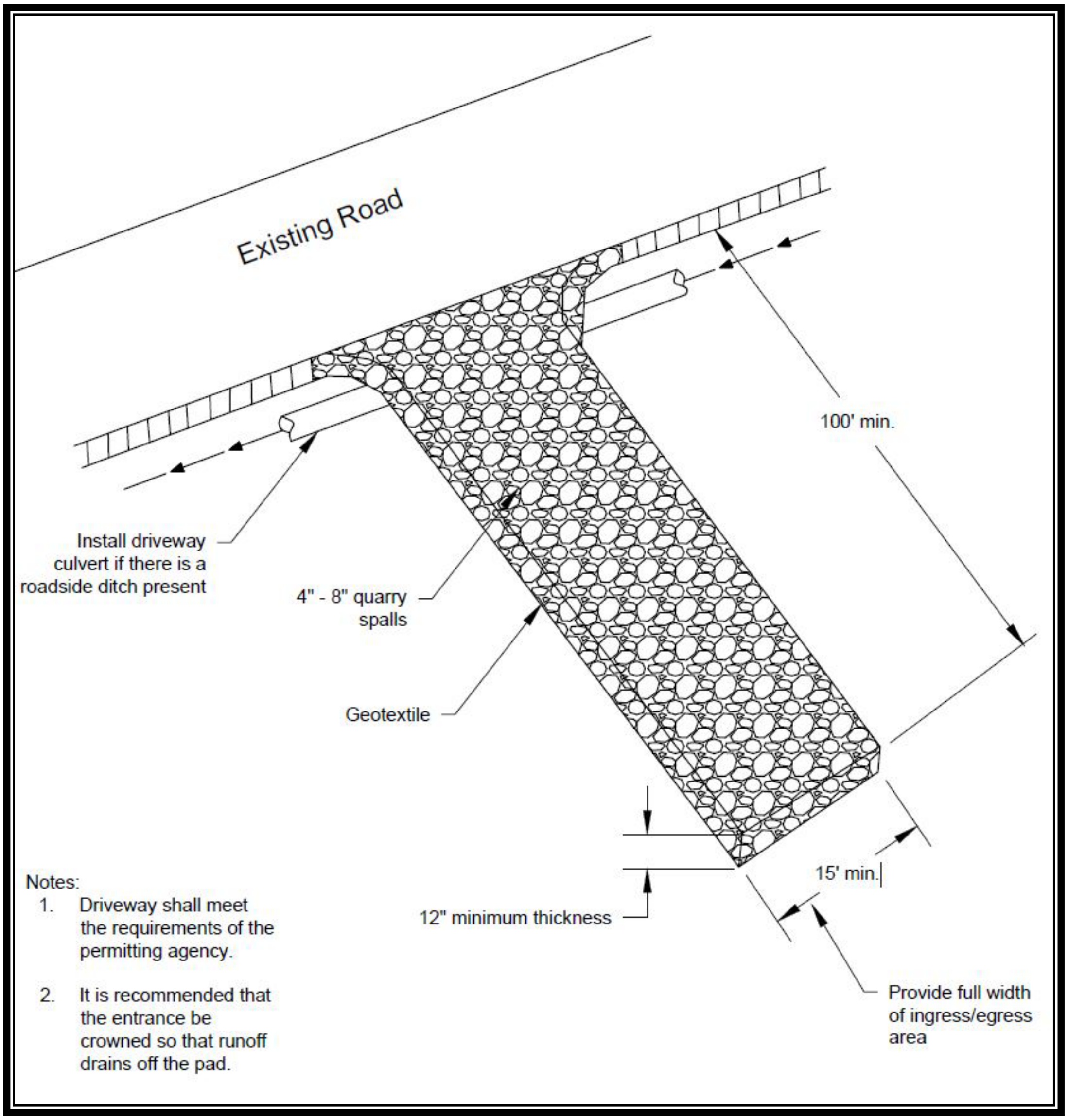
- Quarry spalls shall be added if the pad is no longer in accordance with the specifications.
- On large commercial, highway, and road projects, the designer should include enough extra materials in the contract to allow for additional stabilized entrances not shown in the initial Construction SWPPP. 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.
- 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.
- 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, 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 (as needed) and street sweeping on the same day that the track-out occurs. 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 may be required. The sediment would then be washed into the sump where it can be controlled. Sediment-laden water shall be prevented from entering the stormwater drainage system.
- Perform street sweeping by hand or with a high efficiency sweeper. Do not use a non-high efficiency mechanical sweeper as these sweepers create dust and throw soil into nearby stormwater drainage 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), BMP C103: High-Visibility Fence 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.

Approved as Functionally Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C105. However, the products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The list of products that Ecology has approved as functionally equivalent is available on Ecology's website at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

If a project wishes to use any of the "approved as functionally equivalent" BMPs in the City, the project owner or representative must obtain approval for use of the BMP from the City on a case-by-case basis (i.e., for each project or site) before use.



Source: Ecology

Figure 5.1. Stabilized Construction Access.

BMP C106: Wheel Wash

Purpose

Wheel washes reduce the amount of sediment transported onto paved roads by washing dirt from the wheels of motor vehicles prior to the motor vehicles leaving the construction site.

Conditions of Use

- Use a wheel wash when BMP C105: Stabilized Construction Access is not preventing sediment from being tracked off-site.

- 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.

- Pressure washing combined with an adequately sized and surfaced pad with direct drainage to a large 10-foot by 10-foot sump can be very effective.

- Wheel wash wastewater is not stormwater. It is commonly called process water, and must be discharged to a separate on-site treatment system that prevents discharge to waters of the State, or to the sanitary sewer with City approval. For discharges to the sanitary sewer, permits must be obtained from the City of Lacey Wastewater Utility Department at (360) 491-5600, and/or the LOTT Clean Water Alliance at (360) 664-2333. The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. Note that a permit may need to be obtained by either or both entity(ies) depending on the nature of the discharge.

- Wheel washes may use closed-loop recirculation systems to conserve water use.

- Wheel wash wastewater shall not include wastewater from concrete washout areas.

- When practical, the wheel wash should be placed in sequence with BMP C105: Stabilized Construction Access. Locate the wheel wash such that vehicles exiting the wheel wash will enter directly onto BMP C105: Stabilized Construction Access. In order to achieve this, BMP C105: Stabilized Construction Access may need to be extended beyond the standard installation to meet the exit of the wheel wash.

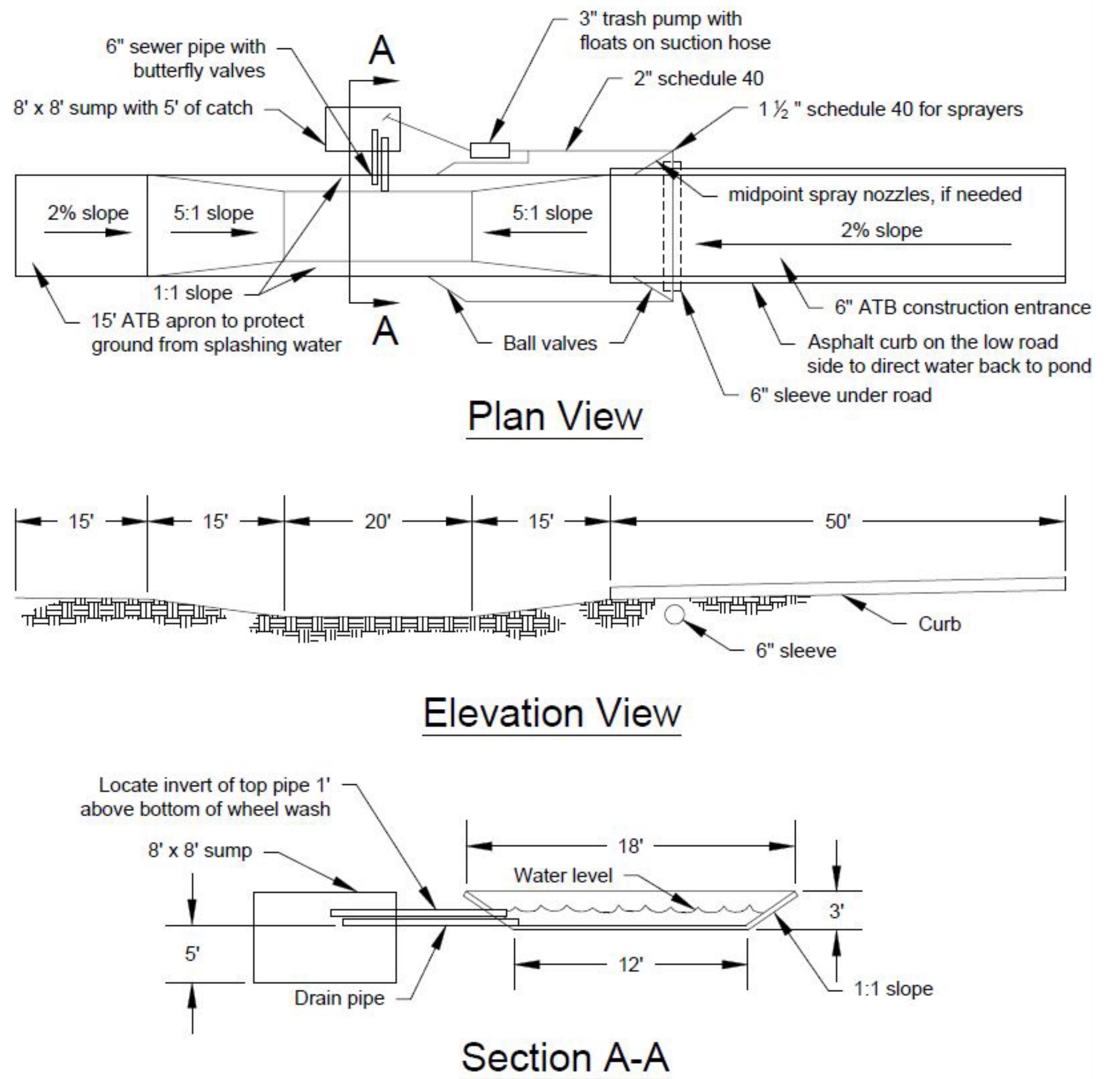
Design and Installation Specifications

- Suggested details are shown in Figure 5.2. A minimum of 6 inches of asphalt treated base 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 shall be designed with a small grade change, 6 to 12 inches for a 10-foot-wide pond, to allow sediment to flow to the low side of pond to help prevent resuspension 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 shall start out each day with fresh water.
- The washwater shall be changed a minimum of once per day. On large earthwork jobs where more than 10 to 20 trucks per hour are expected, the washwater will need to be changed more often.



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 by 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.

Source: Ecology and Pierce County

Figure 5.2. Wheel Wash.

BMP C107: Construction Road/Parking Area Stabilization

Purpose

Stabilizing subdivision roads, parking areas, and other on-site 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.

- BMP C103: High-Visibility Fence shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

- On areas that will receive asphalt as part of the project, install the first lift as soon as possible. However, this is not appropriate when final surface is permeable pavement.

- 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. 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.

- 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.

- 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 that water can flow through, 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 stormwater drainage system (see BMP C220: Inlet Protection).

Maintenance Standards

- Inspect stabilized areas regularly, especially after large storm events.
- Crushed rock, gravel base, hog fuel, 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 preconstruction 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 reduces erosion by stabilizing exposed soils with a well-established vegetative cover. This 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.
- Where the term “fully established” is used to describe vegetative cover or plantings, it shall be understood to mean that healthy vegetation covers 90 percent of exposed soil.
- Inspect 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.
- 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 for mulch; see *Design and Installation Specifications* in this BMP section for seed mix guidance.
- Seed and mulch all disturbed areas not otherwise vegetated at final 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) that will prevent erosion.

Design and Installation Specifications

- Seed infiltration/detention ponds as required.
- Install channels intended for vegetation before starting major earthwork and hydroseeded with a Bonded Fiber Matrix (BFM). 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.

- Confirm the installation of all required surface water control measures to prevent seed from washing away.

- The seedbed should be firm and rough. All soil shall 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 to 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 shall 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 must 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 takes 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 for specifications.

- On steep slopes, 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 to 36 hours to cure before a rainfall and cannot be installed on wet or saturated soils. Generally, these products come in 40- to 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. See also postconstruction soil quality and depth in Chapter 7, Section 7.4.1.
- When installing seed via hydroseeding operations, only about one-third of the seed actually ends up in contact with the soil surface. This reduces the ability to establish a good stand of grass quickly. To overcome this, consider increasing seed quantities by up to 50 percent.
- Enhance vegetation establishment by dividing the hydromulch operation into two phases:
  1. Phase 1 – Install all seed and fertilizer with 25 to 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.

  Or, enhance vegetation by:

  1. Installing the mulch, seed, fertilizer, and tackifier in one lift.
  2. Spread or blow straw over the top of the hydromulch at a rate of 800 to 1,000 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 or MBFM (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, and rates are provided as pounds of pure live seed per acre.
- Other mixes may be appropriate, depending on the soil type and hydrology of the area. Consult the local revegetation experts 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 City may be used.
- Table 5.3 represents the standard mix for areas requiring a temporary vegetative cover.

Table 5.3. Temporary Erosion Control Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
Spike bentgrass	*Agrostis exarata*	0.1
California brome	*Bromus carinatus*	10.5
Tufted hairgrass	*Deschampsia cespitosa*	0.4
Blue wildrye	*Elymus glaucus*	11.4
California oatgrass	*Danthonia californica*	6.0
Native red fescue	*Festuca rubra* var. *rubra*	2.5
Meadow barley	*Hordeum brachyantherum*	8.2
Total		**39.1**

- Table 5.4 lists a recommended mix for landscaping seed.

Table 5.4. Landscaping Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
Sideoats grama	*Bouteloua curtipendula*	7.3
California oatgrass	*Danthonia californica*	6.6
Native red fescue	*Festuca rubra* var. *rubra*	4.2
Prairie Junegrass	*Koeleria macrantha*	0.9
Total		**19.0**

- Table 5.5 lists a low-maintenance turf seed mix that may be used in dry situations where there is little to no watering.

Table 5.5. Low-Growing Turf Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
Hard fescue	*Festuca brevipila*	3.1
Sheep fescue	*Festuca ovina*	3.1
Native red fescue	*Festuca rubra* var. *rubra*	3.5
Prairie Junegrass	*Koeleria macrantha*	0.6
Total		**10.2**

- Table 5.6 lists a mix for bioswales and other intermittently wet areas.

Table 5.6. Bioswale Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
American sloughgrass	*Beckmannia syzigachne*	0.9
Tufted hairgrass	*Deschampsia cespitosa*	0.6
Blue wildrye	*Elymus glaucus*	11.4
Native red fescue	*Festuca rubra* var. *rubra*	2.8
Meadow barley	*Hordeum brachyantherum*	9.8
Northwestern mannagrass	*Glyceria occidentalis*	5.2
Total		**30.7**

- Table 5.7 lists a low-growing seed mix appropriate for very wet areas that are not regulated wetlands. Consult Hydraulic Permit Authority (HPA) for seed mixes if applicable.

Table 5.7. Low Growing Wet Area Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
California brome	*Bromus carinatus*	10.5
Columbia brome	*Bromus vulgaris*	8.7
Tufted hairgrass	*Deschampsia cespitosa*	0.4
California oatgrass	*Danthonia californica*	5.0
Native red fescue	*Festuca rubra* var. *rubra*	2.4
Western manna grass	*Glyceria occidentalis*	3.5
Meadow barley	*Hordeum brachyantherum*	8.2
Total		**38.5**

- Table 5.8 lists a recommended meadow seed mix that is intended 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.

Table 5.8. Meadow Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
Common yarrow	*Achillea millefolium*	0.07
Pearly everlasting	*Anaphalis margartacae*	0.01
California brome	*Bromus carinatus*	7.84
California oatgrass	*Danthonia californica*	3.73
Blue wildrye	*Elymus glaucus*	7.60
Idaho fescue	*Festuca idahoensis*	1.74
Native red fescue	*Festuca rubra* var. *rubra*	1.88
Sickle keeled lupine	*Lupinus albicaulis*	2.22
Fowl bluegrass	*Poa palustris*	0.36
Total		**22.9**

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, an alternate method, such as sodding, mulching, or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the City 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 Functionally Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C120. However, the products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The list of products that Ecology has approved as functionally equivalent is available on Ecology's website at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

If a project wishes to use any of the "approved as functionally equivalent" BMPs in the City, the project owner or representative must obtain approval for use of the BMP from the City on a case-by-case basis (i.e., for each project or site) before use.

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 shall be used:

- For fewer 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 (PAM) or polymers. Any mulch or tackifier product used shall be installed per manufacturer’s instructions. Generally, mulches come in 40- to 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 5.9. Always use a 2-inch minimum mulch thickness; increase the thickness until the ground is 95 percent covered (i.e., not visible under the mulch layer). Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.

Where the option of “compost” is selected, it must be a coarse compost that meets the following size gradations when tested in accordance with the U.S. Composting Council “Test Methods for the Examination of Compost and Composting” Test Method 02.02-B.

Table 5.9. Mulch Standards and Guidelines.

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material.	2″ to 3″ thick; five bales per 1,000 sq. ft. or 2 to 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 to 30 lbs per 1,000 sq. ft. or 1,500 to 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 0.75 to 1 inch clog hydromulch equipment. Fibers should be kept to less than 0.75 inch.
Compost	No visible water or dust during handling. Must be produced per WAC 173-350, Solid Waste Handling Standards, but may have up to 35% biosolids.	2″ thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3 inches. Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Compost used for mulch has a coarser size gradation than compost used for BMP C125 or the postconstruction soil quality and depth BMP see Chapter 7, Section 7.4.1. It is more stable and practical to use in wet areas and during rainy weather conditions. Do not use near wetlands or near phosphorous impaired water bodies.
Chipped Site Vegetation	Average size should 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 percent 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.

Table 5.9 (continued). Mulch Standards and Guidelines.			
Mulch Material	**Quality Standards**	**Application Rates**	**Remarks**
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 “wood straw” or “hog 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 3/8 inch. 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 Standard Specification 9-14.4(4)].

Coarse Compost

- Mulch may be applied at any time of the year and must be refreshed periodically
- Minimum Percent passing 3-inch sieve openings 100 percent
- Minimum Percent passing 1-inch″ sieve openings 90 percent
- Minimum Percent passing 0.75-inch sieve openings 70 percent
- Minimum Percent passing 0.25-inch sieve openings 40 percent

Mulch used within the ordinary high water mark of surface waters must be selected to minimize potential flotation of organic matter. Composted organic materials have higher specific gravities (densities) than straw, wood, or chipped material.

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.

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 shall 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. One hundred 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 to $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 Figures 5.3 and 5.4 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:
    - Complete final grade and track walk up and down the slope.
    - Install hydromulch with seed and fertilizer.
    - Dig a small trench, approximately 12 inches wide by 6 inches deep along the top of the slope.
    - 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.
    - 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.
    - If the blanket is not long enough to cover the entire slope length, the trailing edge of the upper blanket must overlap the leading edge of the lower blanket and be stapled. On steeper slopes, this overlap must 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 site:

  - WSDOT Temporary Erosion and Sediment Control Manual (Section 3.2.4):

    <www.wsdot.wa.gov/publications/manuals/fulltext/M3109/TESCM.pdf>.

- 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.

- One hundred 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.

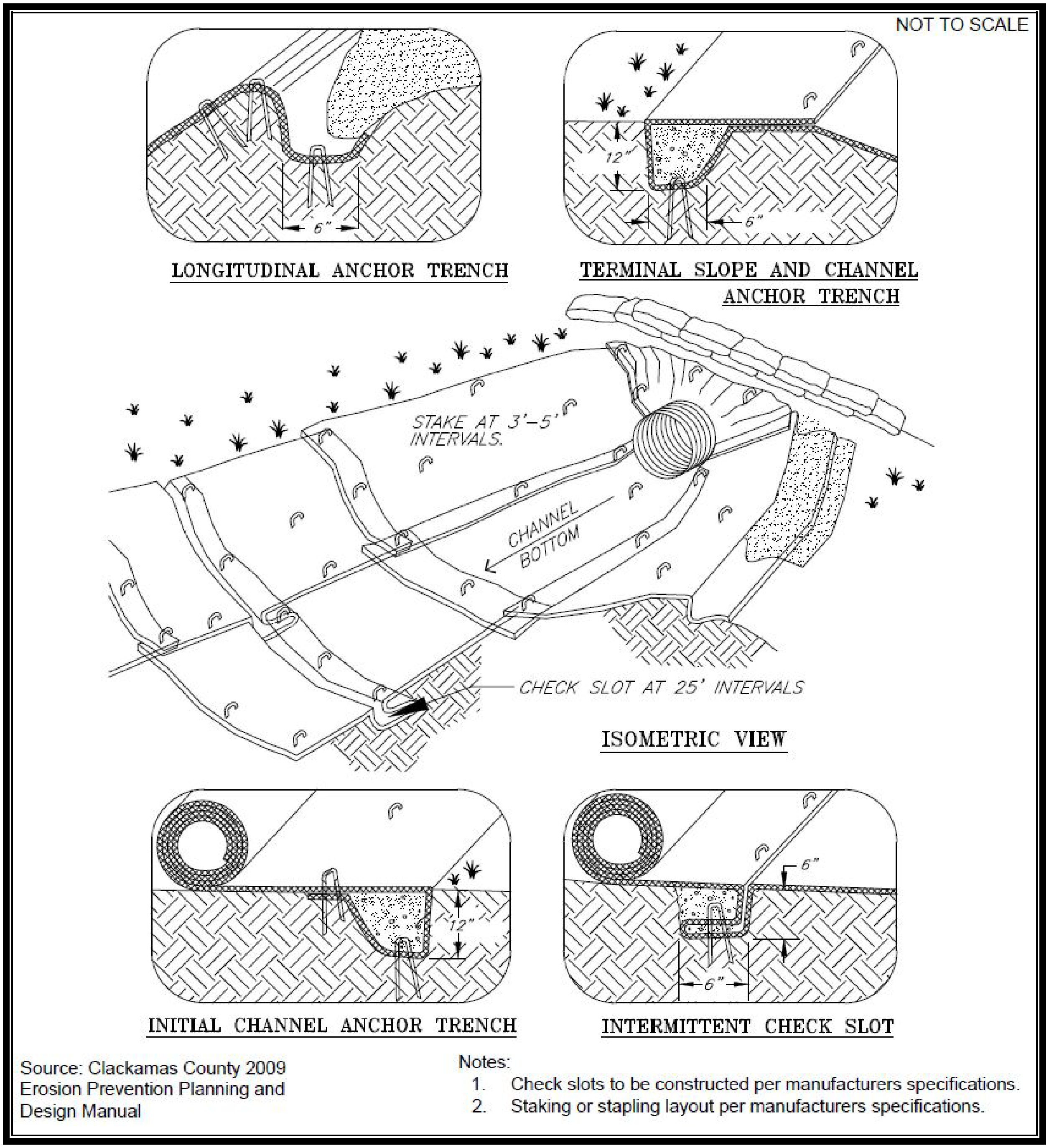
- Most netting used with blankets is photodegradable, meaning they break down under sunlight (not UV stabilized). However, this process can take months or years even under bright sun. Once vegetation is established, sunlight does not reach the mesh. It is not uncommon to find non-degraded netting still 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.

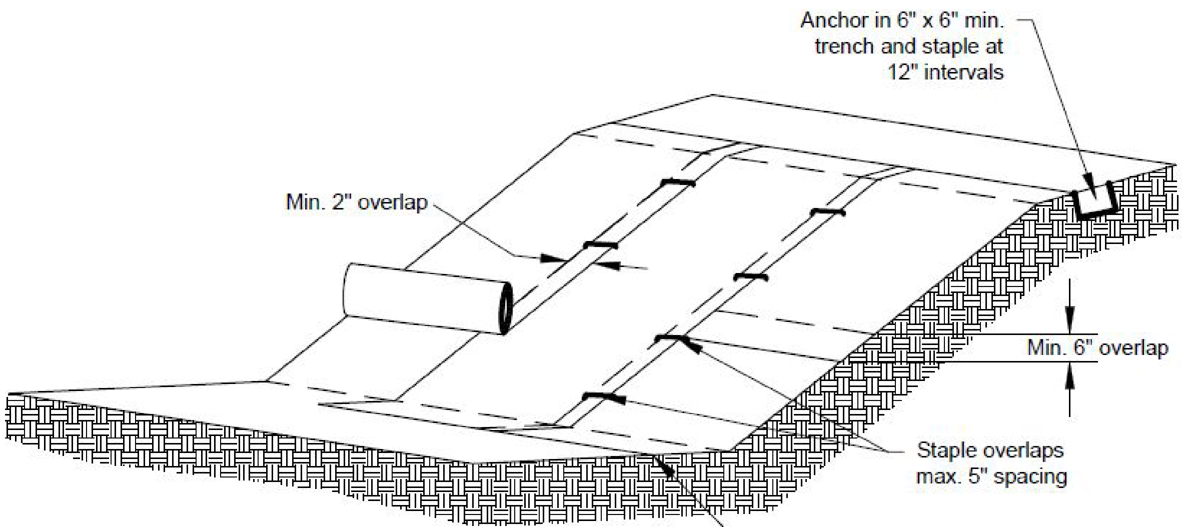
- Repair and staple any areas of the net or blanket that are damaged or not in close contact with the ground.

- Fix and protect eroded areas if erosion occurs due to poorly controlled drainage.



Source: Clackamas County

Figure 5.3. Channel Installation.



Notes:

1. Slope surface shall be smooth before placement for proper soil contact.
2. Stapling pattern as per manufacturer's recommendations.
3. Do not stretch blankets/mattings tight - allow the rolls to mold to any irregularities.
4. For slopes less than 3H:1V, rolls may be placed in horizontal strips.
5. If there is a berm at the top of the slope, anchor upslope of the berm.
6. Lime, fertilize, and seed before installation. Planting of shrubs, trees, etc. should occur after installation.

Source: Ecology

Figure 5.4. Slope Installation.

BMP C123: Plastic Covering

Purpose

Plastic covering provides immediate, short-term erosion protection to slopes and disturbed areas.

Conditions of Use

- Plastic covering may be used on disturbed areas that require cover measures for less than 30 days, except as stated below.
- 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 6 months) applications.
- 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.
- 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.
- To prevent undercutting, trench and backfill rolled plastic covering products.
- While plastic is inexpensive to purchase, the added cost of installation, maintenance, removal, and disposal make this an expensive material, up to $1.50 to $2 per square yard.
- 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 covey 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.
- Other uses for plastic include:
  - Temporary ditch liner
  - Pond liner in temporary sediment pond
  - Liner for bermed temporary fuel storage area if plastic is not reactive to the type of fuel being stored
  - Emergency slope protection during heavy rains
  - Temporary drainpipe (“elephant trunk”) used to direct water.

Design and Installation Specifications

- Plastic slope cover must be installed as follows:
    - Run plastic up and down slope, not across slope.
    - Plastic may be installed perpendicular to a slope if the slope length is less than 10 feet.
    - Minimum of 8-inch overlap at seams.
    - 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.
- Plastic sheeting shall have a minimum thickness of 6 mil.
- 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.

Maintenance Standards

- Torn sheets must be replaced, and open seams repaired.
- Completely remove and replace the plastic if it begins to deteriorate due to ultraviolet radiation.
- Completely remove plastic when no longer needed.
- Dispose of old tires used to weight down plastic sheeting appropriately.

Approved as Functionally Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C123. However, the products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The list of products that Ecology has approved as functionally equivalent is available on Ecology's website at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

If a project wishes to use any of the "approved as functionally equivalent" BMPs in the City, the project owner or representative must obtain approval for use of the BMP from the City on a case-by-case basis (i.e., for each project or site) before use.

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 10 percent or the permeability is less than 0.6 inches per hour. See <https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Waste-reduction-programs/Organic-materials/Managing-organics-compost> 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 re-establish 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. Note that this BMP is functionally the same as the postconstruction soil quality and depth BMP (see Chapter 7, Section 7.4.1), which is required for all disturbed areas that will be developed as lawn or landscaped areas at the completed project site.

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.

Conditions of Use

- 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 condition if functioning properly.

- Areas that already have good topsoil, such as undisturbed areas, do not require soil amendments.

- Restore, to the maximum extent practicable, 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 soil, incorporate amendments into on-site soil, or importing 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 disturbed areas requiring disruption and topsoiling: that will be developed as lawn or landscaped areas at the completed project site:

- 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 percent dry weight in planting beds, and 5 percent 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 shall be limited to 25 percent passing through a U.S. #200 sieve.
    - Mulch planting beds with 2 inches of organic material.
- Accomplish the required organic content, depth, and pH by returning native topsoil to the site, importing topsoil of sufficient organic content, and/or incorporating organic amendments.
    - When using the option of incorporating amendments to meet the organic content requirement, use compost that meets the composted material specification for bioretention (see Chapter 7, Section 7.4.4), with the exception that the compost may have up to 35 percent biosolids or manure.
    - Sections 3 through 7 of *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington* (Stenn et al. 2018) provides useful guidance for implementing whichever option is chosen. It includes guidance for preapproved default strategies and guidance for custom strategies. This document is available at: <www.buildingsoil.org>.

- 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, incorporation of topsoil may favor grasses, while layering with mildly acidic, high-carbon amendments may favor more woody vegetation.

- Allow sufficient time in scheduling for topsoil spreading prior to seeding, sodding, or planting.

- Take care when applying topsoil 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.

- 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 groundwater recharge.

- 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 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 with clear plastic, or other mulching materials.

- Between May 1 and September 30:
  - An interceptor dike with gravel outlet and silt fence shall 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.
- 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:
  - Re-install topsoil within 4 to 6 weeks
  - Do not allow the saturation of topsoil with water
  - Do not use plastic covering.

Maintenance Standards

- 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.

BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection

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.

Although PAM is an Ecology-approved BMP, it is very rarely used in the City. Therefore, details on this BMP are not included in this manual. Refer to the 2019 Ecology Manual for details on BMP C126: Polyacrylamide (PAM) for Soil Erosion Protection.

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.

Use this BMP in conjunction with other BMPs such as seeding, mulching, or sodding.

Conditions of 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 5.5 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.

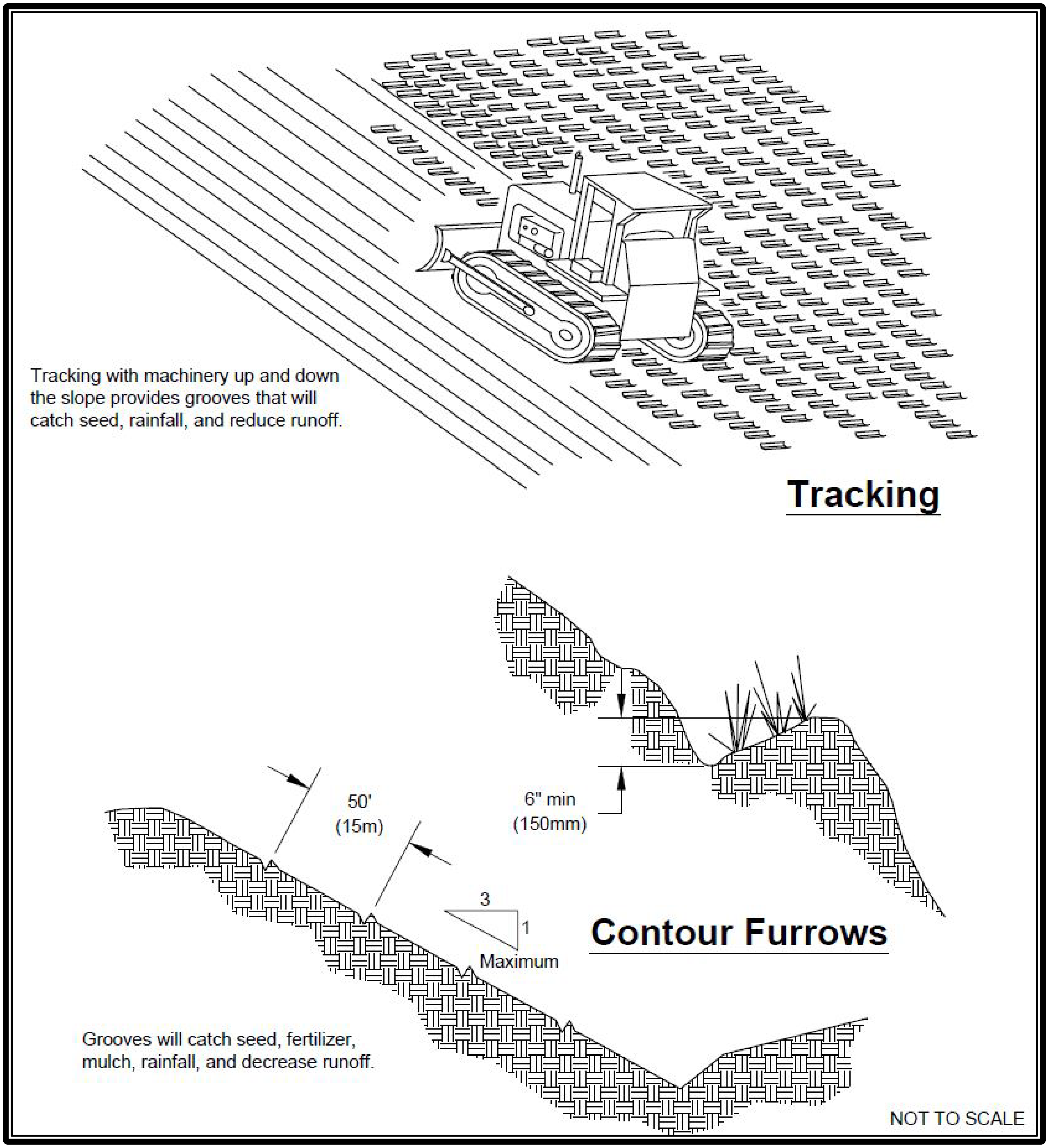
- Disturbed areas that will not require mowing may be stair-step graded, grooved, or left rough after filling.
- Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each “step” catches material that sloughs from above and provides a level site where vegetation can become established. Stairs must 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 3H:1V) may have small furrows left by disking, harrowing, raking, or seed-planting machinery operated on the contour.
- Graded areas with slopes steeper than 3H:1V but less than 2H:1V shall 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.

Maintenance Standards

- 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 regraded and reseeded immediately.



Source: Ecology

Figure 5.5. Surface Roughening by Tracking and Contour Furrows.

BMP C131: Gradient Terraces

Purpose

Gradient terraces reduce erosion damage by intercepting surface runoff and conducting it to a stable outlet at a nonerosive 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 5.6 for gradient terraces.

Design and Installation Specifications

- The maximum spacing of gradient terraces shall 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 erodible 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 (1.5 tons of straw/acre equivalent) is on the surface.

- The minimum constructed cross-section shall meet the design dimensions.

- The top of the constructed ridge shall not be lower at any point than the design elevation plus the specified overfill for settlement. The opening at the outlet end of the terrace must 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 foot per 100-foot length (0.6 percent). For short distances, terrace grades may be increased to improve alignment. The channel velocity shall not exceed that which is nonerosive for the soil type.

- All gradient terraces must 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 foot 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.

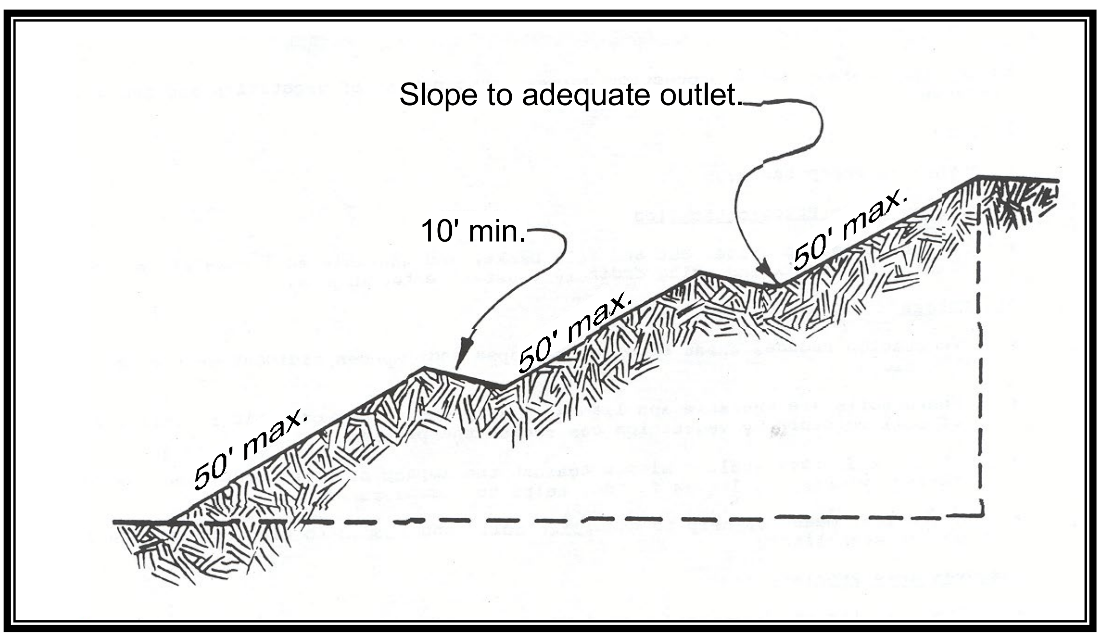
- The drainage area above the top shall not exceed the area that would be drained by a terrace with normal spacing.

- The terrace shall 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 shall include a reasonable settlement factor. The ridge must have a minimum top width of 3 feet at the design height. The minimum cross-sectional area of the terrace channel shall 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 vehicle.

Maintenance Standards

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



Source: Pierce County

Figure 5.6. 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

For use 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

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. 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 BMP C105: Stabilized Construction Access.

- 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. Oil based products are prohibited from use as a dust suppressant. The City may approve other dust palliatives such as calcium chloride or PAM.

- BMP C126: PAM added to water at a rate of 0.5 pounds per 1,000 gallons of water per acre and applied from a water truck is more effective than water alone. This is due to 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. Use of PAM could be a cost-effective dust control method.

Techniques that can be used for unpaved roads and lots include:

- 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 0.075 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 Puget Sound Clean Air Agency <www.pscleanair.gov> for guidance and training on other dust control measures. Compliance with Puget Sound Clean Air Agency guidance and BMPs 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 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 contractor or developer could keep a stockpile of materials that are available 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 must be kept covered and out of both sun and rain.
- Restock 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
- Runways

Disposal options for concrete, in order of preference are:

1. Off-site disposal
2. Concrete washout areas (see BMP 154: Concrete Washout Area)
3. *De minimus* washout to formed areas awaiting concrete

Design and Installation Specifications

- Ensure that washout of concrete trucks, chutes, pumps, and internals is performed at an approved off-site location or in designated concrete washout areas, in accordance with BMP C154: Concrete Washout Area. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or streams.
- 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 as allowed in BMP C154: Concrete Washout Area.

- Wash small concrete handling equipment (e.g., hand tools, screeds, shovels, rakes, floats, trowels, and wheelbarrows) into designated concrete washout areas or into formed areas awaiting concrete pour.

- At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.

- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly drain to natural or constructed stormwater conveyance or potential infiltration areas.

- Do not allow washwater from areas, such as concrete aggregate driveways, to drain directly (without detention or treatment) to natural or constructed stormwater conveyances.

- Contain washwater and leftover product in a lined container when no designated concrete washout areas (or formed areas, allowed as described above) are available. Dispose of contained concrete and concrete washwater (process water) properly.

- Always use forms or solid barriers for concrete pours, such as pilings, within 15 feet of surface waters.

- Refer to BMP C252: Treating and Disposing of High pH Water for pH adjustment requirements.

- Refer to the CSWGP 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 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:

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

Design and Installation Specifications

- 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 including stormwater systems. This may require temporarily blocking catch basins.
- Dispose of collected slurry and cuttings in a manner that does not violate groundwater or surface water quality standards.
- Do not allow process water generated during hydro-demolition, surface roughening or similar operations to drain to any natural or constructed drainage conveyance including stormwater systems. Dispose process water in a manner that does not violate groundwater or surface water quality standards.

- Handle and dispose cleaning waste material and demolition debris in a manner that does not cause contamination of water. Dispose of sweeping material from a pick-up sweeper 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 [PAM])
- 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.
- Safety Data Sheets (SDS) should be supplied for all materials stored. Chemicals should be kept in their original labeled containers.
- Hazardous material storage on site should be minimized.
- Hazardous materials should be handled as infrequently as possible.
- During the wet weather season (October 1 to April 30), consider storing materials in a covered area.
- 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, in secondary containment.
- If drums must be kept uncovered, store them at a slight angle to reduce ponding of rainwater on the lids to reduce corrosion. Domed plastic covers are inexpensive and snap to the top of drums, preventing water from collecting.

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 percent of the total enclosed container volume of all containers, or 110 percent of the capacity of the largest container within its boundary, whichever is greater.
- 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 (October 1 to 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 cleanup material (spill kit).
- The spill kit shall include, at a minimum:
  - 1 water resistant nylon bag
  - 3 oil absorbent socks 3 inches by 4 feet
  - 2 oil absorbent socks 3 inches by 10 feet

- 12 oil absorbent pads 17 inches by 19 inches
- 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.

Conditions of Use

Concrete washout areas 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 truck drums are washed on site.

  Note that auxiliary concrete truck components (e.g., chutes and hoses) and small concrete handling equipment (e.g., hand tools, screeds, shovels, rakes, floats, trowels, and wheel-barrows) may be washed into formed areas awaiting concrete pour.

At no time shall concrete be washed off into the footprint of an area where an infiltration feature will be installed.

Design and Installation Specifications

Implementation

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

- Perform washout of concrete trucks at an approved off-site location or in designated concrete washout areas only.
- Do not wash out concrete onto non-formed areas, or into storm drains, open ditches, streets, or streams.
- Wash equipment difficult to move, such as concrete paving machines, in areas that do not directly drain to natural or constructed stormwater conveyance or potential infiltration areas.
- Do not allow excess concrete to be dumped on-site, except in designated concrete washout areas as allowed above.
- 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.
- Concrete washout areas shall be constructed and maintained in sufficient quantity and size to contain all liquid and concrete waste generated by washout operations.

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 CESCL to oversee and enforce concrete waste management procedures.
- A sign should be installed adjacent to each temporary concrete washout area 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, water bodies, or wetlands.
- Allow convenient access to the concrete washout area for concrete trucks, preferably near the area where the concrete is being poured.
- If trucks need to leave a paved area to access the concrete washout area, prevent track-out with a pad of rock or quarry spalls (see BMP C105: Stabilized Construction Access). These areas should be far enough away from other construction traffic to reduce the likelihood of accidental damage and spills.

- The number of concrete washout areas installed will depend on the expected demand for storage capacity.

- On large sites with extensive concrete work, concrete washout areas must be placed in multiple locations for ease of use by concrete truck drivers.

Concrete Truck Washout Procedures

- Washout of concrete truck drums shall be performed in designated concrete washout areas only.

- Concrete washout from concrete pumper bins can be washed into concrete pumper trucks and discharged into designated concrete washout areas or properly disposed of off-site.

Concrete Washout Area Installation

- Concrete washout areas should be constructed as shown in the figures below, with a recommended minimum length and minimum width of 10 feet, but with sufficient quantity and volume to contain all liquid and concrete waste generated by washout operations.

- Lath and flagging shall be commercial type.

- Plastic lining material should be a minimum of 10 mil polyethylene sheeting and must 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 areas are in place prior to the commencement of concrete work.

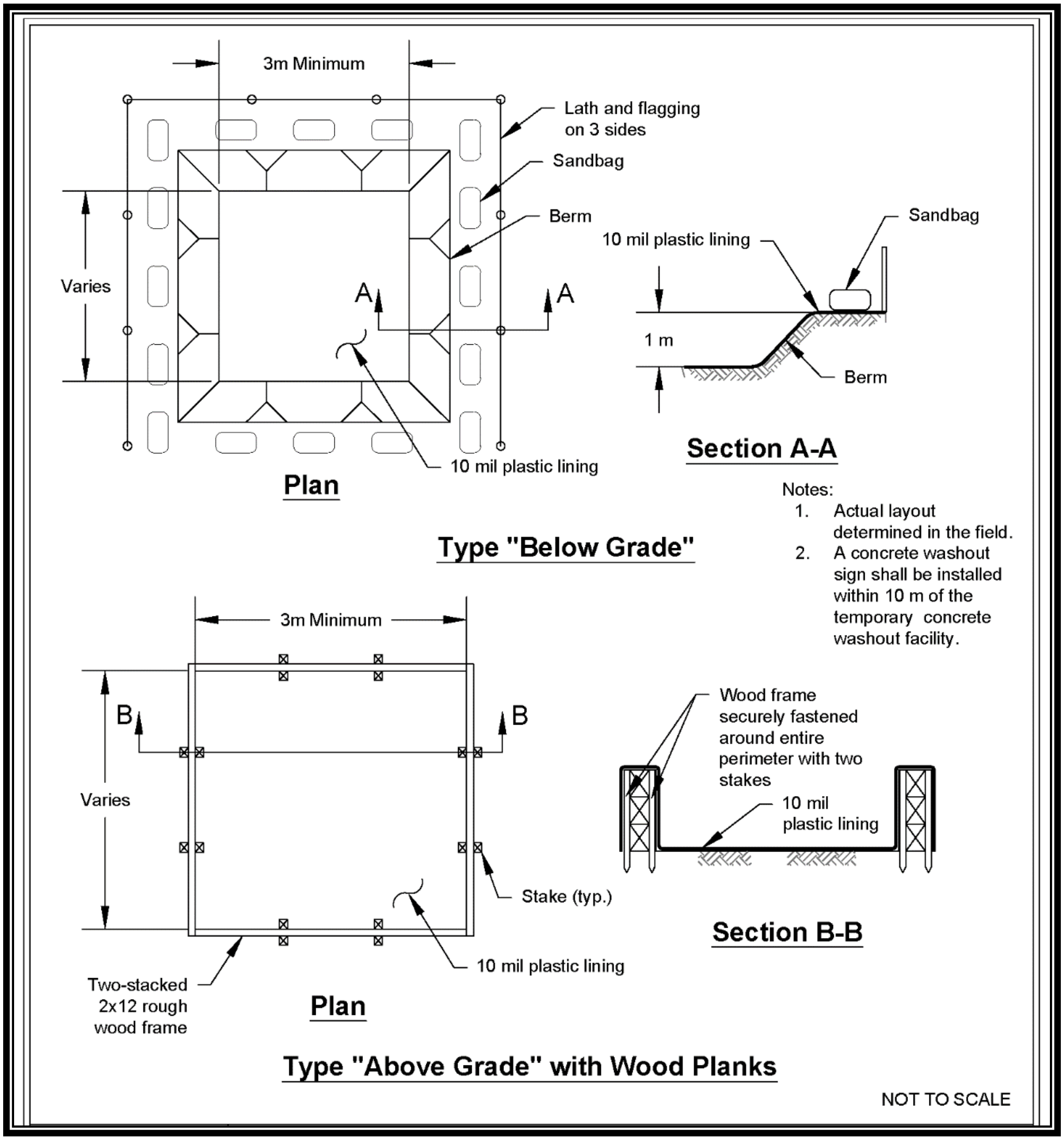
- Once concrete wastes are washed into the designated washout area and allowed to harden, the concrete should be broken up, removed, and disposed of per applicable solid waste regulations. Dispose of hardened concrete on a regular basis.

- During periods of concrete work, inspect the concrete washout areas daily to verify continued performance.
  - Check overall condition and performance
  - Check remaining capacity (percent full)
  - If using self-installed concrete washout areas, verify plastic liners are intact and sidewalls are not damaged
  - If using prefabricated containers, check for leaks.
- Maintain the concrete washout areas to provide adequate holding capacity with a minimum freeboard of 12 inches.
- Concrete washout areas must be cleaned, or new concrete washout areas must be constructed and ready for use once the concrete washout area is 75 percent full.
- If the concrete washout area 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 a permit that must be obtained either from the City of Lacey Wastewater Utility Department at (360) 491-5600, or the LOTT Clean Water Alliance at (360) 664-2333. The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. Note that a permit may need to be obtained by either or both entity(ies) depending on the nature of the discharge.
  - Place a secure, non-collapsing, non-water collecting cover over the concrete washout area 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 Concrete Washout Areas

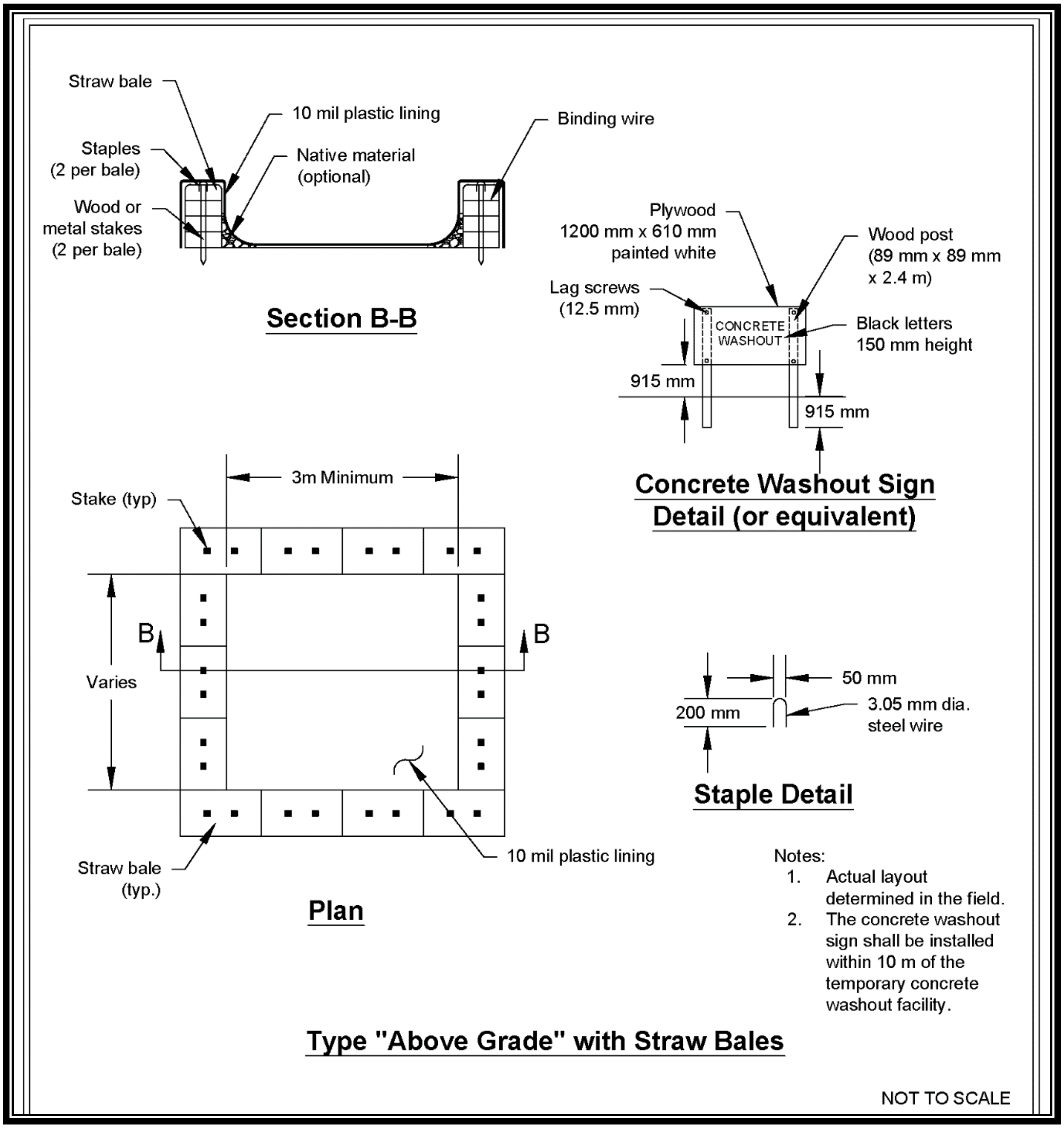
- When concrete washout areas are no longer required for the work, the hardened concrete, slurries, and liquids shall be removed and properly disposed of.
- Materials used to construct concrete washout areas shall be removed from the site of the work and disposed of or recycled.

- Holes, depressions, or other ground disturbance caused by the removal of the concrete washout areas shall be backfilled, repaired, and stabilized to prevent erosion.



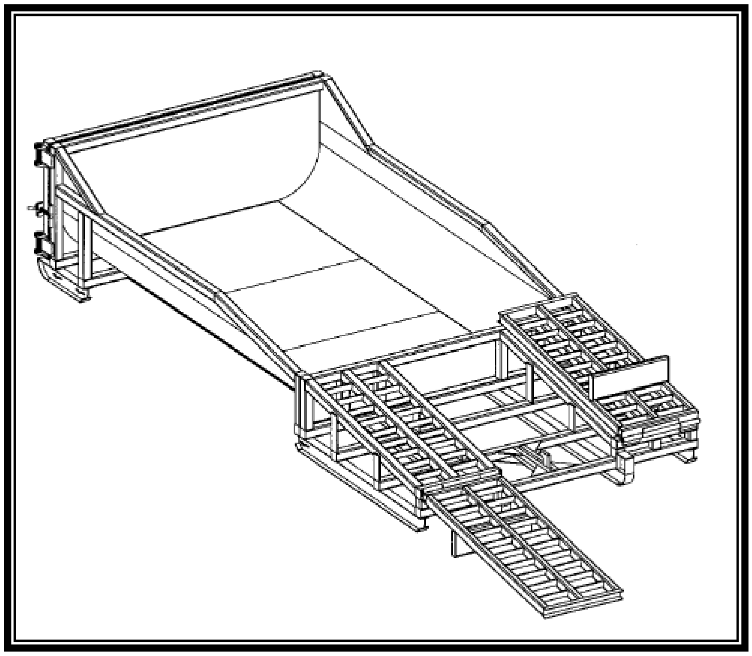
Source: Ecology

Figure 5.7a. Concrete Washout Area with Wood Planks.



Source: Ecology

Figure 5.7b. Concrete Washout Area with Straw Bales.



Source: Ecology

Figure 5.8. Prefabricated Concrete Washout Container with Ramp.

BMP C160: Certified Erosion and Sediment Control Lead

Purpose

The project applicant designates at least one person as the responsible representative in charge of erosion and sediment control, and water quality protection. The designated person shall be the CESCL who is responsible for ensuring compliance with all local, state, and federal Construction SWPPP and water quality requirements.

Conditions of Use

A CESCL shall be made available on projects required to prepare a Construction SWPPP.

The CESCL shall:

- Have a current certificate proving attendance in an erosion and sediment control training course that meets the minimum training and certification requirements established by Ecology.

  Ecology has provided the minimum requirements for CESCL course training, as well as a list of ESC training and certification providers at: <https://ecology.wa.gov/Regulations-Permits/Permits-certifications/Certified-erosion-sediment-control>

OR

- Be a Certified Professional in Erosion and Sediment Control (CPESC); for additional information go to: <http://www.envirocertintl.org/cpesc/>.

Specifications

- Certification shall remain valid for 3 years.
- The CESCL shall have authority to act on behalf of the contractor or developer and shall be available, or on call, 24 hours per day throughout the period of construction.
- The Construction SWPPP shall include the name, telephone number, email address, 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, but must be on site whenever earthwork activities are occurring that could generate release of turbid water.

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

- Maintaining permit file on site at all times, which includes the Construction 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 must include:
  - Inspection date/time.
  - Weather information; general conditions during inspection and approximate amount of precipitation since the last inspection.
  - A summary or list of all BMPs implemented, including observations of all erosion/sediment control structures or practices. The following shall be noted:
    - Locations of BMPs inspected
    - Locations of BMPs that need maintenance
    - Locations of BMPs that failed to operate as designed or intended
    - Locations of where additional or different BMPs are required
  - 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.

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

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.

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 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.

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 stormwater runoff from entering the work area or sediment-laden runoff from leaving the construction site.

Conditions of Use

Where the runoff from an exposed site or disturbed slope must be conveyed to an erosion control BMP that can safely contain the stormwater:

- 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 water to a sediment basin.

Design and Installation Specifications

- 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.
- Subbasin tributary area shall be 1 acre or less.
- Design the dike and/or swale to contain flows calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm or the worst-case land cover condition.

OR

- Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step for the worst-case land cover condition.

Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

- **Interceptor dikes** shall meet the following criteria:
  - Top Width: 2 feet minimum.
  - Height: 1.5 feet minimum on berm.
  - Side Slope: 2H:1V or flatter.
  - Grade: Depends on topography; however, dike system minimum is 0.5 percent, maximum is 1 percent
  - Compaction: Minimum of 90 percent ASTM D698 standard proctor.
  - Horizontal Spacing of Interceptor Dikes:

Average Slope	Slope Percent	Flow Path Length
>20H:1V or flatter	3% to <5%	300 feet
(>10 to 20)H:1V	5% to <10%	200 feet
(>4 to 10)H:1V	10% to <25%	100 feet
(2 to 4)H:1V	25% to 50%	50 feet

  - Stabilization depends on velocity and reach:
    - Slopes less than 5 percent: Seed and mulch applied within 5 days of dike construction (see BMP C121: Mulching).
    - Slopes 5 to 40 percent: Dependent on runoff velocities and dike materials. Stabilization must 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 BMP.
  - Minimize construction traffic over temporary dikes. Use temporary cross culverts for channel crossing.

- **Interceptor swales** shall meet the following criteria:
    - Bottom Width: 2-foot minimum; the cross-section bottom shall be level.
    - Depth: 1-foot minimum.
    - Side Slope: 2H: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: Temporary and Permanent Seeding, or BMP C202: Riprap 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 5.9 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 must 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 volumetric flow rate calculated by one of the following methods:
    - Single Event Hydrograph Method: The peak volumetric flow rate calculated using minute time step from a Type 1A, 10-year, 24-hour frequency storm or the worst-case land cover condition.

OR

- o Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time for the worst-case land cover condition.

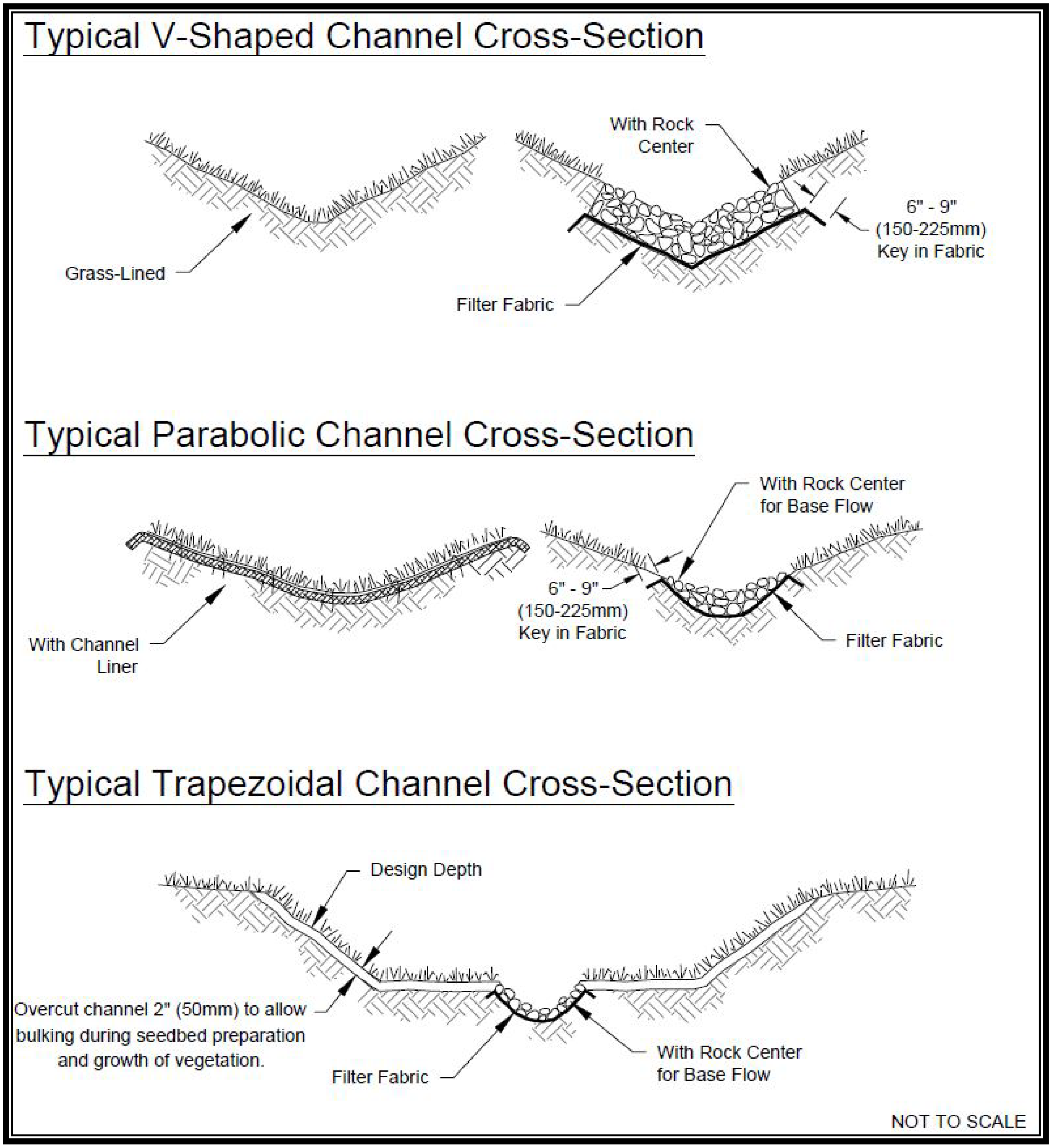
Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

- Where the grass-lined channel will also function as a permanent stormwater conveyance BMP, the channel must meet the drainage conveyance requirements defined in Chapter 6.
- 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 feet/second, a temporary channel liner is required. Geotextile or special mulch protection such as straw or netting provides stability until the vegetation is fully established. See Figure 5.10.
- Check dams shall be removed once the grass roots and aboveground biomass have grown enough to stabilize soils and sufficiently protect the swale bottom and side slopes from erosion. Check dams will remain when swale slopes are greater than 4 percent for long term erosion protection. 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, must carry peak runoff for temporary construction drainage BMPs 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 3H:1V or flatter to aid in the establishment of vegetation and for maintenance.
- Construct channels a minimum of 0.2 foot larger around the periphery to allow for soil bulking during seedbed preparations and sod buildup.

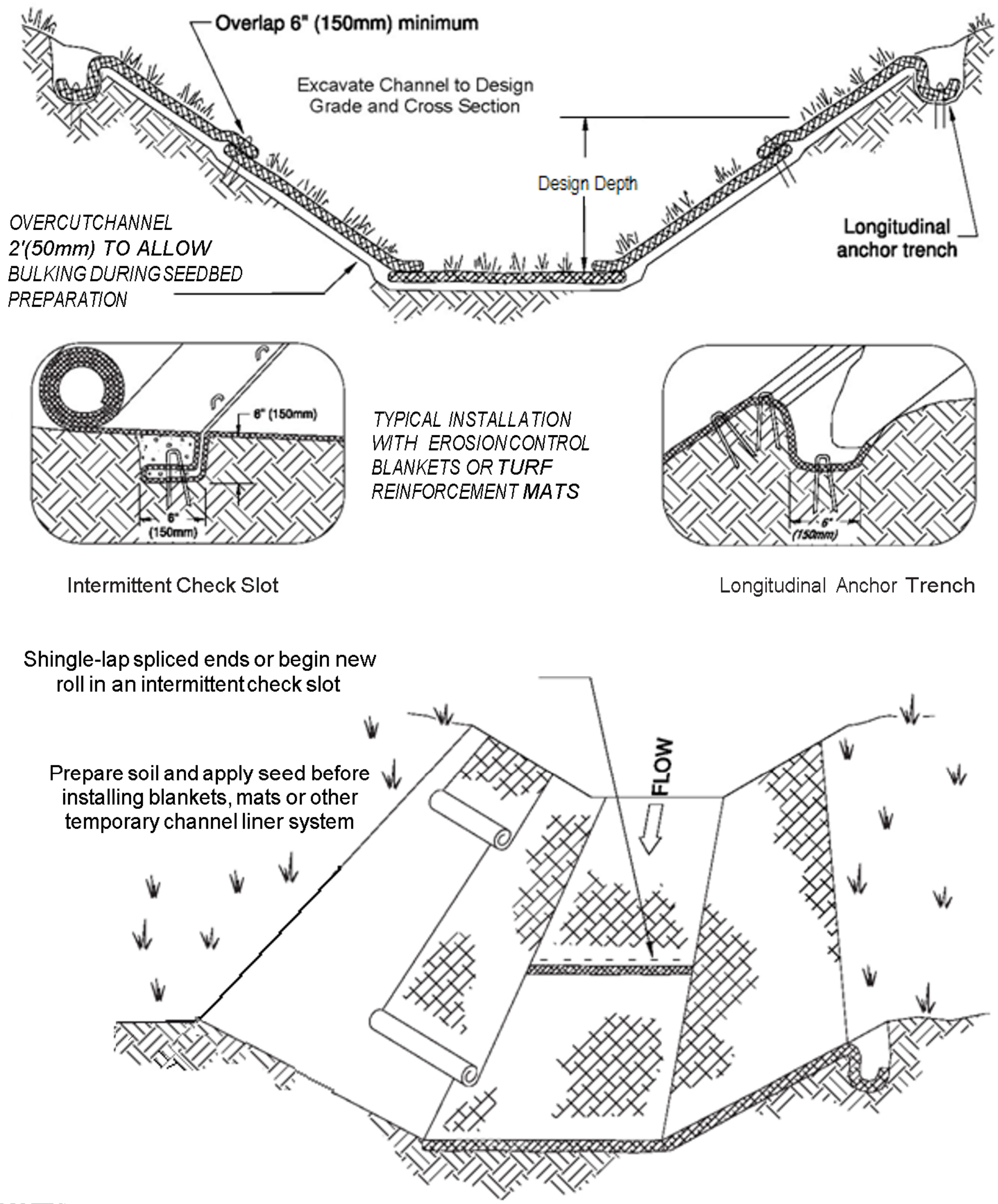
Maintenance Standards

- 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.



Source: Ecology

Figure 5.9. Typical Grass-Lined Channels.



NOTES:

2 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.

3 Grass-lined channels with design velocities exceeding 6 ft/sec (2m/sec) should include turf reinforcement mats.

Source: Ecology and Pierce County

Figure 5.10. Temporary Channel Liners.

BMP C202: Riprap Channel Lining

Purpose

To protect channels by providing a channel liner using riprap.

Conditions of Use

Use this BMP when natural soils or vegetated stabilized soils in a channel are not adequate to prevent channel erosion.

Use this BMP when a permanent ditch or pipe system is to be installed and a temporary measure is needed.

An alternative to riprap channel lining is BMP C122: Nets and Blankets.

The Federal Highway Administration recommends not using flexible liners whenever the slope exceeds 10 percent, or the shear stress exceeds 8 pounds per square foot.

Design and Installation Specifications

- See BMP C122: Nets and Blankets for information on blankets.
- Since riprap is typically used where erosion potential is high, construction must be sequenced so that the riprap is put in place with the minimum possible delay.
- Disturb areas awaiting riprap 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 others 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. See WSDOT’s *Standard Specifications for Road, Bridge, and Municipal Construction*.
- 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 must be keyed in at the top of the bank.

- Filter fabric shall not be used on slopes greater than 1.5H: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.

Maintenance Standards

Replace riprap as needed.

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 5.11.

Conditions of Use

Clearing right-of-way and construction of access for power lines, pipelines, and other similar installations often require long narrow rights-of-way 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:

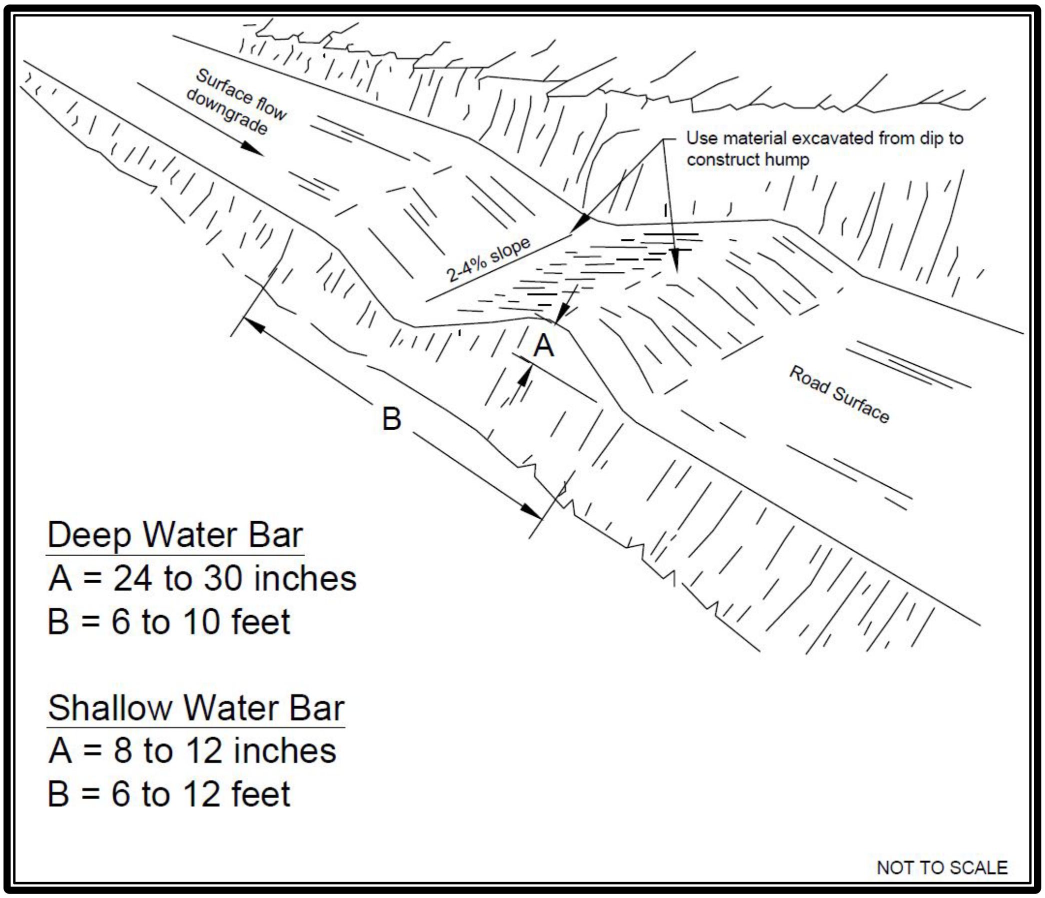
Average Slope	Slope Percent	Spacing (feet)
> 20H:1V or flatter	<5%	125
(> 10 to 20) H:1V	5% to <10%	100
(> 5 to 10) H:1V	10% to <20%	75
(> 2.86 to 5) H:1V	20% to <35%	50
2.86 H:1V or steeper	≥35%	Use rock lined ditch

- Grade of water bar and angle: Select angle that results in ditch slope less than 2 percent.
- Install as soon as the clearing and grading is complete. Reconstruct when construction is complete on a section when utilities are being installed.

- Compact the ridge when installed.
- Stabilize, seed, and mulch the portions 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 dikes, and fill the channel to blend with the natural ground, and appropriately stabilize the disturbed area.



Source: Ecology and Pierce County

Figure 5.11. 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. See also Figure 5.12.

On highway projects, 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 sandbags, or other temporary diversion devices, these will prevent massive amounts of sediment from leaving a project.

Water can be collected, channeled with sandbags, 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.
- Connected to existing downspouts 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 projected flow. The capacity for temporary drains shall be sufficient to handle flows calculated by one of the following methods:

- Single Event Hydrograph Method: The peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the worst-case land cover condition.

OR

- Continuous Simulation Method: The 10-year peak flow rate, as determined by an approved continuous runoff model with a 15-minute time step for the worst-case land cover condition.

Worst-case land cover conditions (i.e., producing the most runoff) should be used for analysis (in most cases, this would be the land cover conditions just prior to final landscaping).

- 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.
- Dike material shall be compacted to 90 percent modified proctor to prevent piping of water through the berm. The entrance area is a common failure location.
- 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. Sandbags 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 must be installed anytime 90 degree or sharper bends are utilized. Depending on size of pipe and flow, these can be constructed with sandbags, straw bales staked in place, T-posts and wire, or ecology blocks.

- Pipe needs to be secured along its full length to prevent movement. This can be done with steel T-posts and wire. A post is installed on each side of the pipe and the pipe is wired to them. This should be done every 10 to 20 feet of pipe length or so, depending on the size of the pipe and quantity of water to be diverted.

- 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 Outlet Protection, for the appropriate outlet material).

- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping BMP.

- Materials specifications for any permanent piped system are listed in Chapter 6, Section 6.3.5, and shall be approved by the City.

Maintenance Standards

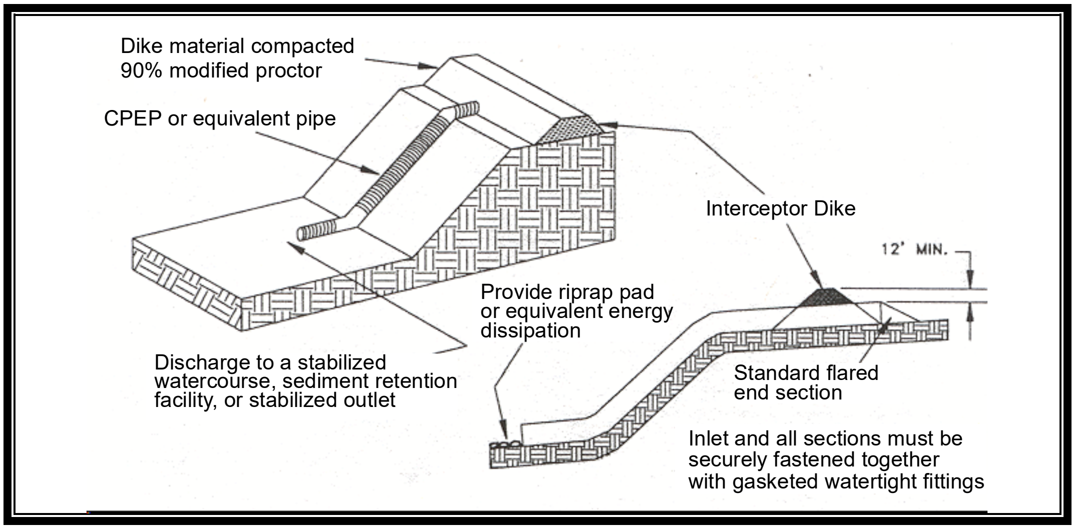
- Check inlet and outlet points regularly, especially after storms.

- The inlet must be free of undercutting, and no water should be going around the point of entry. If there are problems, the headwall shall be reinforced with compacted earth or sandbags.

- The outlet point must 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 windthrow.

- 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.



Source: Ecology

Figure 5.12. Pipe Slope Drain.

BMP C205: Subsurface Drains

Purpose

To intercept, collect, and convey groundwater 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 that may govern the use of subsurface drains.

Design and Installation Specifications

- **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.
    - They are installed along a slope and drain in the direction of the slope
    - They can be installed in a grid pattern, a herringbone pattern, or a random pattern.
- **Interceptor drains** are used to remove excess groundwater from a slope, stabilize steep slopes, and lower the water table immediately below a slope to prevent the soil from becoming saturated.
    - Interceptor drains are installed perpendicular to a slope and drain to the side of the slope
    - They usually consist of a single pipe or series of single pipes instead of a patterned layout.
- **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 groundwater 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 feet/second. 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 feet/second.

  - 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.
- 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 use steel plate or boards to prevent the lines from being crushed. After work is complete the line shall be checked to ensure that it was 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. Will most of the flow discharge to groundwater and not contribute to surface flow?
4. Is there an unstable area downstream that cannot accept additional groundwater?

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 flatter than 5H:1V.
- Outlet to be constructed level in a stable, undisturbed soil profile (not on fill).
- The runoff shall not reconcentrate 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 0.75-inch to 1.5-inch size.

- The spreader length shall be determined by estimating the peak flow expected from the 10-year, 24-hour design storm event assuming a NRCS Type 1A rainfall distribution resolved to 10-minute time steps. Alternatively, use the peak flow from a 10-year, 15-minute time step using an approved continuous runoff model. The length of the spreader shall be a minimum of 15 feet for 0.1 cubic feet per second and shall increase by 10 feet for each 0.1 cubic feet per second thereafter to a maximum of 0.5 cubic feet per second per spreader. Use multiple spreaders for higher flows.

- The width of the spreader must be at least 6 feet.

- The depth of the spreader as measured from the lip must be at least 6 inches and be uniform across the entire length.

- Level spreaders shall be setback 100 feet minimum from the property line unless there is an easement for flow, or the flow is directed to a natural drainage course.

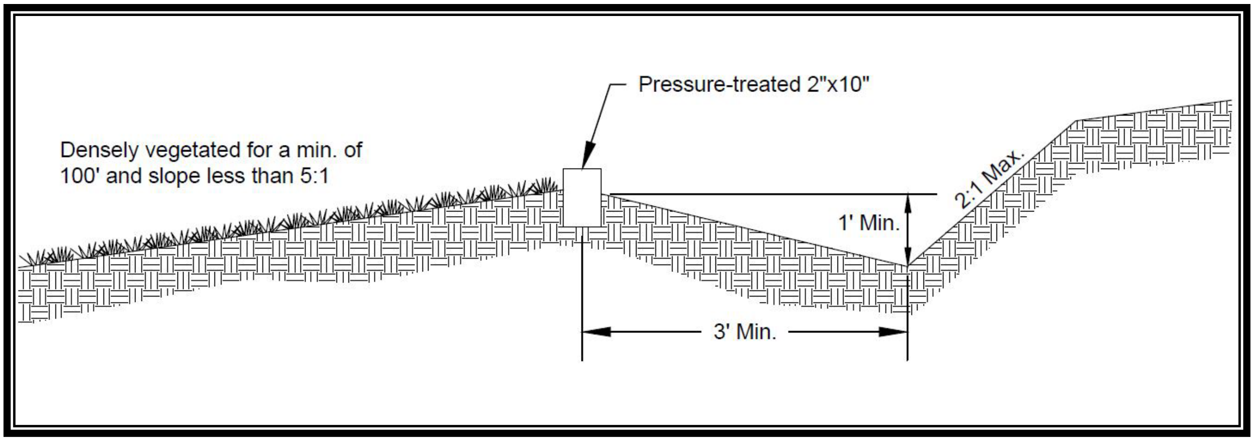
- Level spreaders, when installed every so often in grassy swales, keep the flows from concentrating. Materials that can be used include sandbags, lumber, logs, concrete, and pipe. To function properly, the material needs to be installed level and on contour. Figures 5.13 and 5.14 provide a cross-section 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.

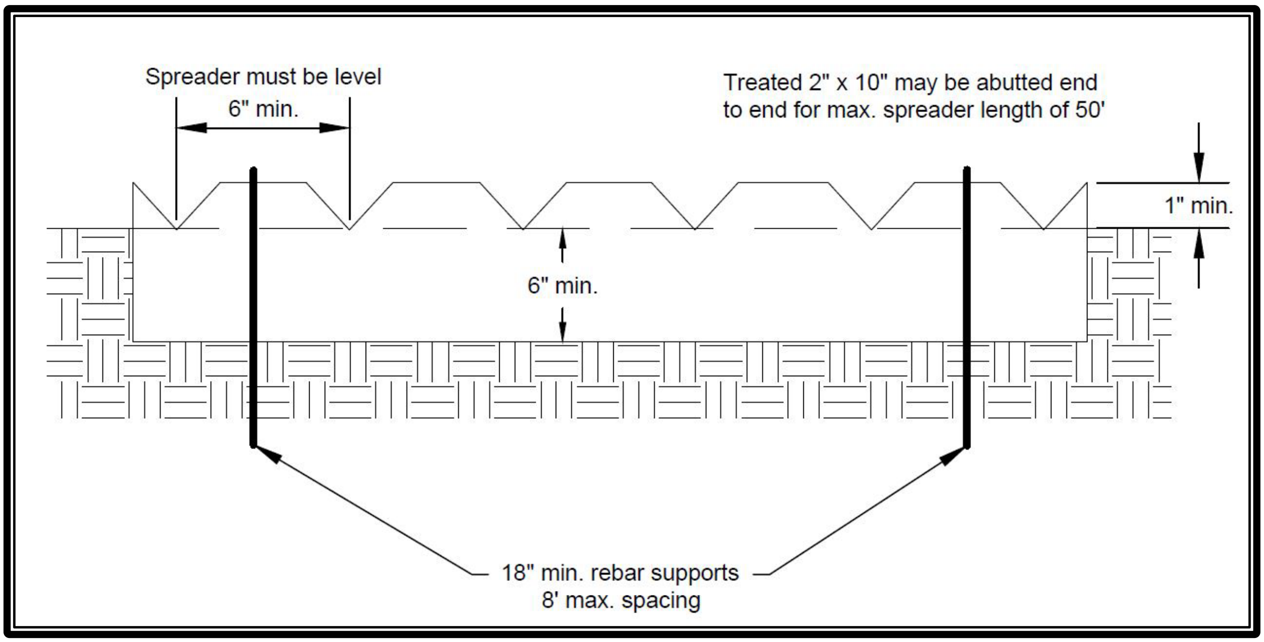
- The contractor should avoid the placement of any material on the structure and shall prevent construction traffic from crossing over the structure.

- If the spreader is damaged by construction traffic, it shall be immediately repaired.



Source: Ecology and Pierce County

Figure 5.13. Cross-Section of Level Spreader.



Source: Pierce County

Figure 5.14. Detail 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 WDFW.
- Check dams may not be placed in wetlands without approval from the appropriate permitting agency.
- Do not place check dams 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.

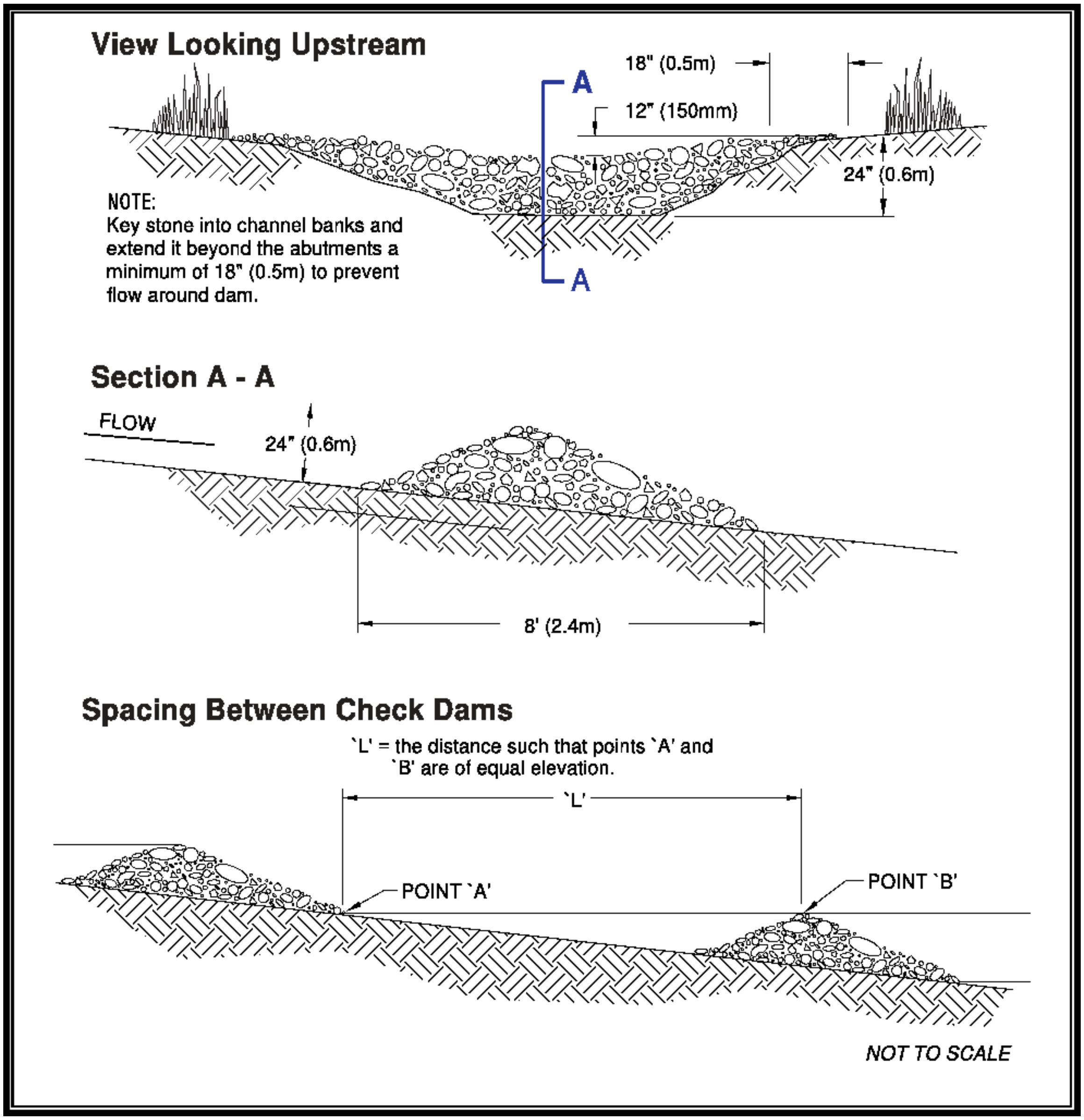
Design and Installation Specifications

- 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 products are also available for this purpose. They tend to be reusable, quick, and easy to install, effective, and cost efficient. Straw bales are not an allowed construction material.
- 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.
- 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 2H: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 sandbag check dam. If a blanket ditch liner is used, filter fabric is not necessary. A piece of organic or synthetic blanket cut to fit will also work for this purpose.
- 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.
- Ensure that channel appurtenances, such as culvert entrances below check dams, are not subject to damage or blockage from displaced stones. Figure 5.15 depicts a typical rock check dam.

Maintenance Standards

- 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.



Source: Ecology

Figure 5.15. Check Dams.

BMP C208: Triangular Silt Dike (TSD)

Purpose

Triangular silt dikes (TSDs) 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

- TSDs may be used on soil or pavement with adhesive or staples
- TSDs have been used to build temporary:
  - Sediment ponds
  - Diversion ditches
  - Concrete washout areas
  - Curbing
  - Water bars
  - Level spreaders
  - Check dams
  - Berms

Design and Installation Specifications

- TSDs are made of urethane foam sewn into a woven geosynthetic fabric.
- TSDs are triangular, 10 inches to 14 inches high in the center, with a 20-inch to 28-inch base. A 2–foot apron extends beyond both sides of the triangle along its standard section of 7 feet. A sleeve at one end allows attachment of additional sections as needed.
- Install with ends curved up to prevent water from flowing around the ends.
- The fabric flaps and check dam units are attached to the ground with wire staples. Wire staples should be No. 11 gauge wire and should be 200 millimeters to 300 millimeters in length.
- When multiple units are installed, the sleeve of fabric at the end of the unit shall overlap the abutting unit and be stapled.

- When used as check dams:
  - TSDs should be located and installed as soon as construction will allow.
  - TSDs should be placed perpendicular to the flow of water.
  - The leading edge of the TSD 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

- Inspect TSDs 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 TSD.
- Anticipate submergence and deposition above the TSD and erosion from high flows around the edges of the TSD. Immediately repair any damage or any undercutting of the TSD.

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 artificial 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 Hydraulics Manual <www.wsdot.wa.gov/Publications/Manuals/index.htm>.)

- 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, BMP C201: Grass-Lined Channels can be an effective alternative for lining material.

- The following shall be used for outlet protection with riprap:

    - If the discharge velocity at the outlet is less than 5 feet per second (pipe slope typically less than 10 percent), use 2-inch to 8-inch riprap. Minimum thickness is 1 foot.

    - For 5 to 10 feet per second discharge velocity at the outlet, use 24-inch to 48--inch riprap. Minimum thickness is 2 feet.

    - For outlets at the base of steep slope pipes (pipe slope greater than 10 percent), use an engineered energy dissipator.

    - Filter fabric or erosion control blankets shall be used under riprap to prevent scour and channel erosion. See BMP C122: Nets and Blankets.

- Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. This work may require a hydraulic project approval (HPA) from the WDFW. See Chapter 6, Section 6.3.5, 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 dissipator if sediment builds up.

BMP C220: Inlet Protection

Purpose

Inlet protection prevents coarse sediment from entering drainage systems prior to permanent stabilization of the disturbed area.

Conditions of Use

Use inlet protection at storm drain inlets that are operational before permanent stabilization of the disturbed drainage area. If these BMPs are used on active roadways, projects shall install appropriate traffic control to ensure vehicle and pedestrian traffic is not exposed to the roadway obstructions. Provide protection for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless conveying runoff entering catch basins to a sediment pond or trap.

Also use 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. Consider erosion protection methods around each finished lawn and yard drain until area is stabilized.

Table 5.10 lists several options for inlet protection. All of the methods for inlet protection tend to plug and require a high frequency of maintenance. Limit drainage areas to 1 acre or less. Possibly provide emergency overflows with additional end-of-pipe treatment where stormwater ponding would cause a hazard.

Table 5.10. 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 may occur	Earthen	Applicable for heavy flows. Easy to maintain. Large area requirement: 30- by 30-feet/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	Paved or Earthen	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	N/A	N/A	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.
  - Provide a depth of 1 to 2 feet as measured from the crest of the inlet structure
  - Slope sides of excavation no steeper than 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
  - 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 5.16.
  - 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 2 by 4 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 0.5-inch openings over all block openings
  - Place washed rock, 0.75- to 3-inch diameter, just below the top of blocks on slopes of 2H:1V or flatter.

- **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 0.5-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
    - Place coarse aggregate over the wire mesh
    - Provide at least a 12-inch depth of gravel over the entire inlet opening and extend at least 18 inches on all sides.
- **Catch Basin Filters:** Use inserts designed by manufacturers for construction sites. The limited sediment storage capacity increases the amount of inspection and maintenance required, which may be daily for heavy sediment loads. To reduce maintenance requirements, combine a catch basin 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. See Figure 5.17.
    - 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 catch basin filter in the catch basin 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 0.5-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 an inlet with concrete blocks and gravel. See Figure 5.18.
    - Use wire mesh with 0.5-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 2 by 4 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 5.19.
    - 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.

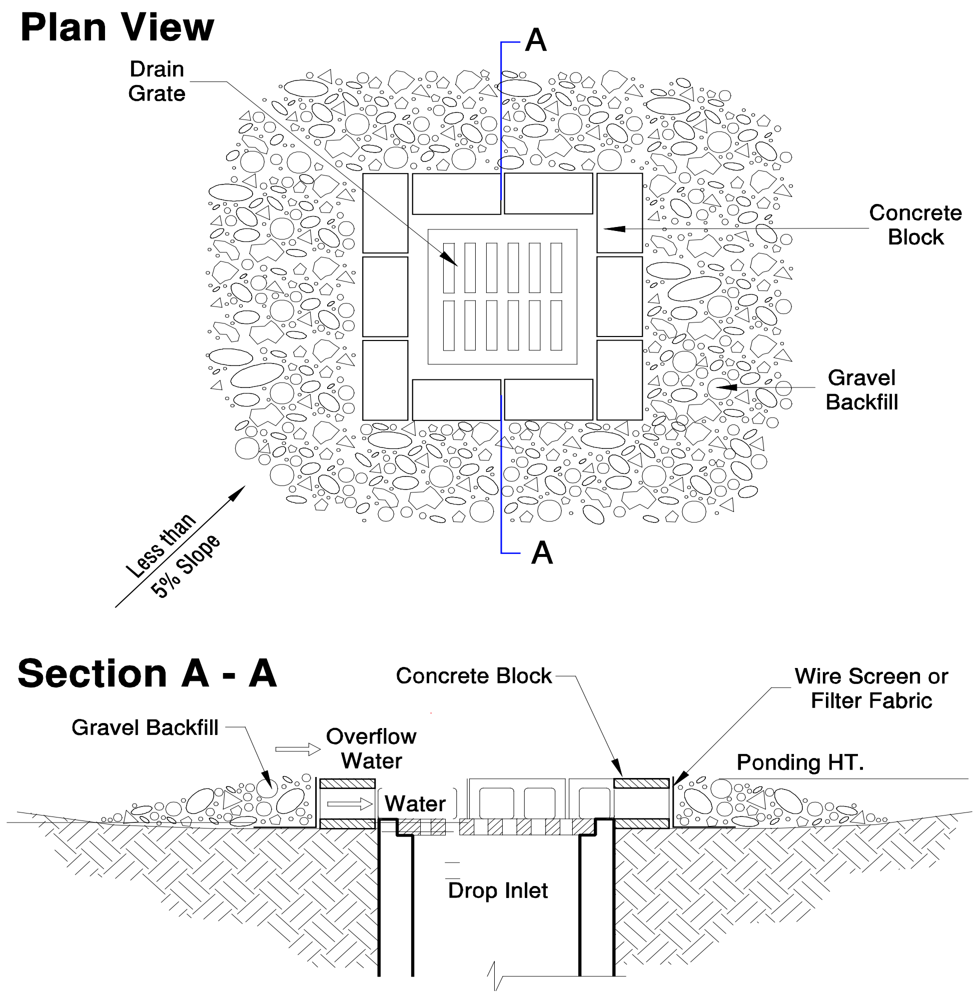
Maintenance Standards

- Inspect all forms of inlet protection frequently, especially after storm events. Clean or replace clogged catch basin filters. For rock and gravel filters, pull away the rocks from the inlet and clean or replace. An alternative approach would be to use the clogged rock as fill and put fresh rock 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.

Approved as Functionally Equivalent

Ecology has approved specific products as able to meet the requirements of BMP C220. However, the products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The list of products that Ecology has approved as functionally equivalent are available on Ecology’s website at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

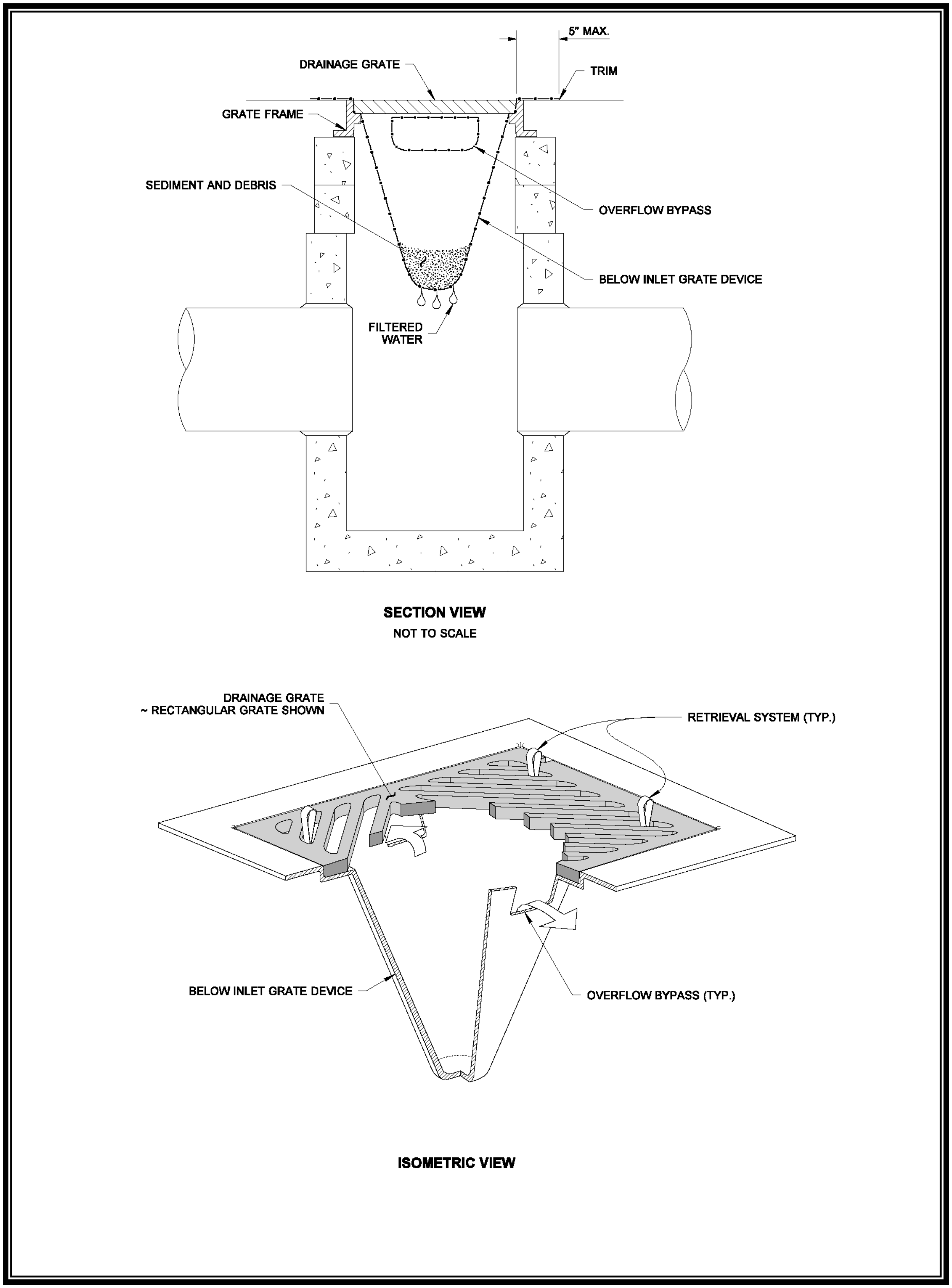
If a project wishes to use any of the "approved as functionally equivalent" BMPs in the City, the project owner or representative must obtain approval for use of the BMP from the City on a case-by-case basis (i.e., for each project or site) before use.



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 (ponding 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.

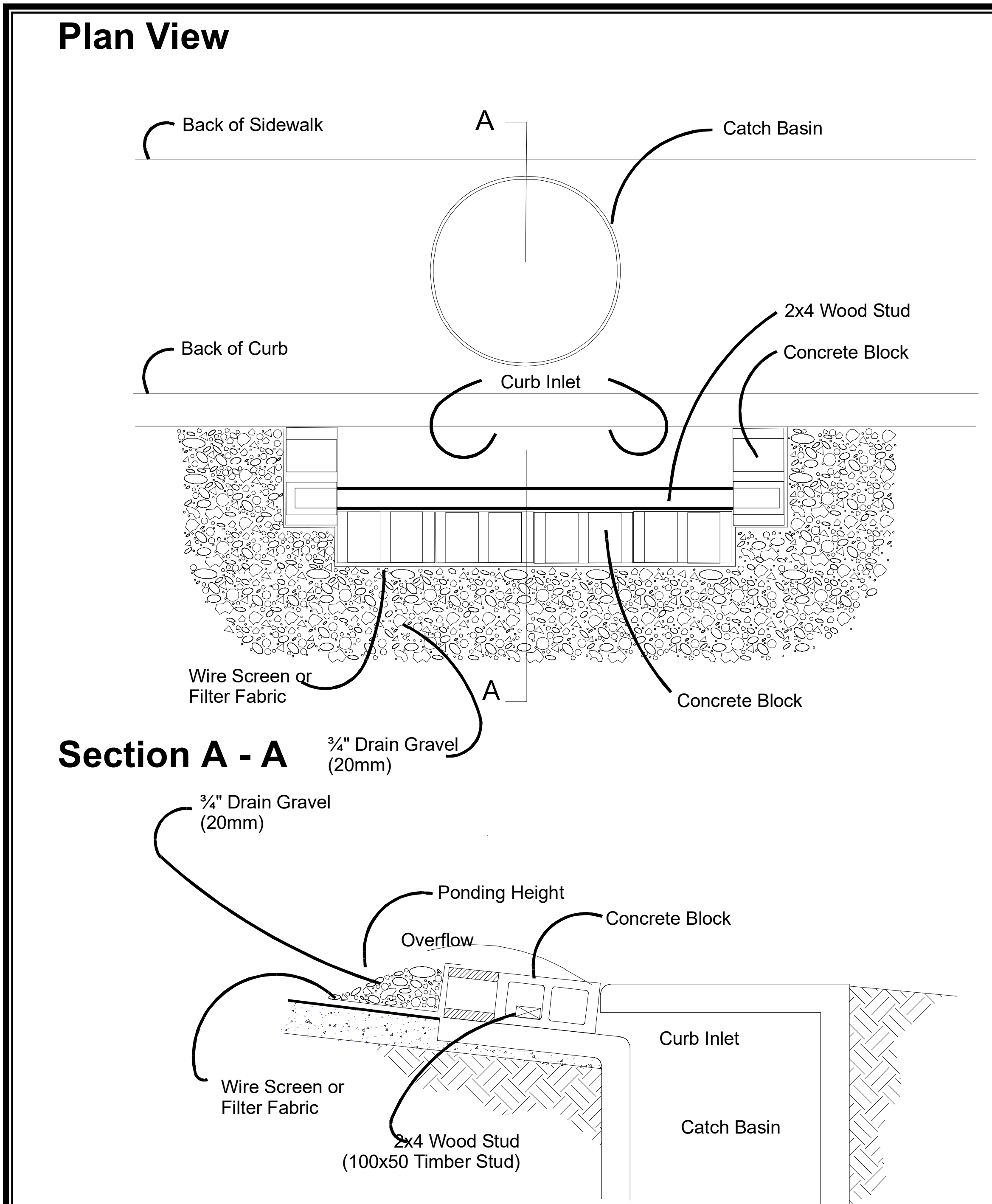
Source: Ecology

Figure 5.16. Block and Gravel Filter.



Source: WSDOT

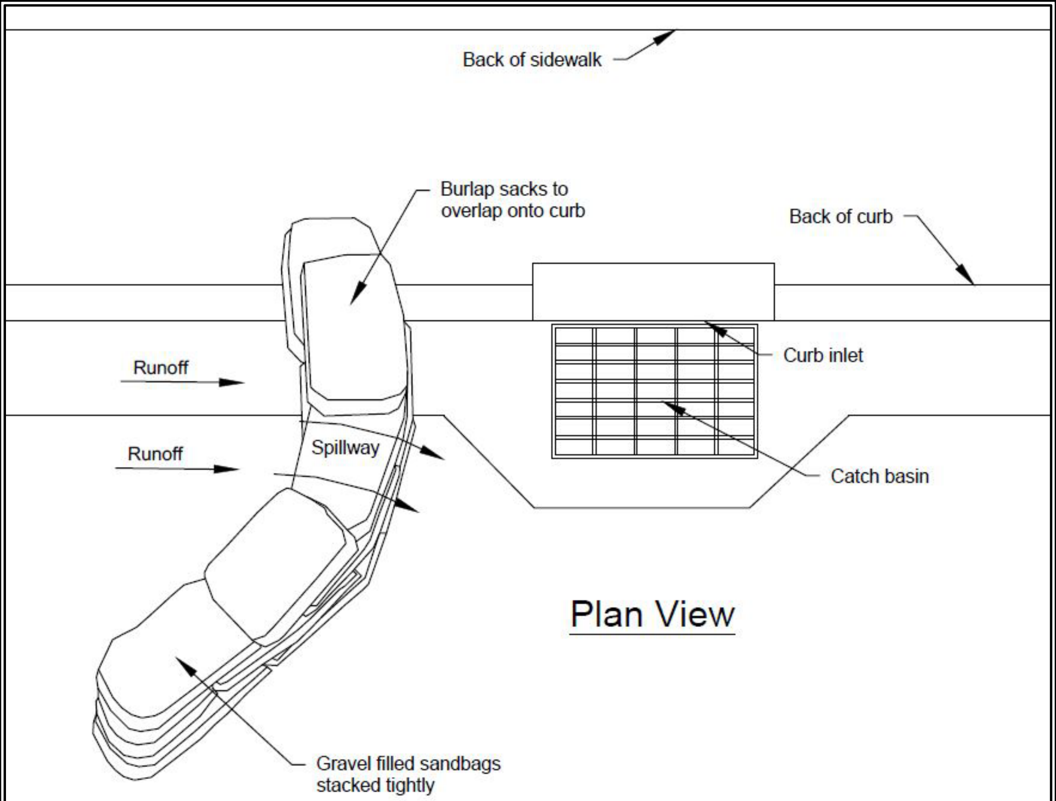
Figure 5.17. Catch Basin Filter Example.



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.

Source: Ecology

Figure 5.18. Block and Gravel Curb Inlet Protection.



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

NOT TO SCALE

Source: Ecology

Figure 5.19. Curb and Gutter 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

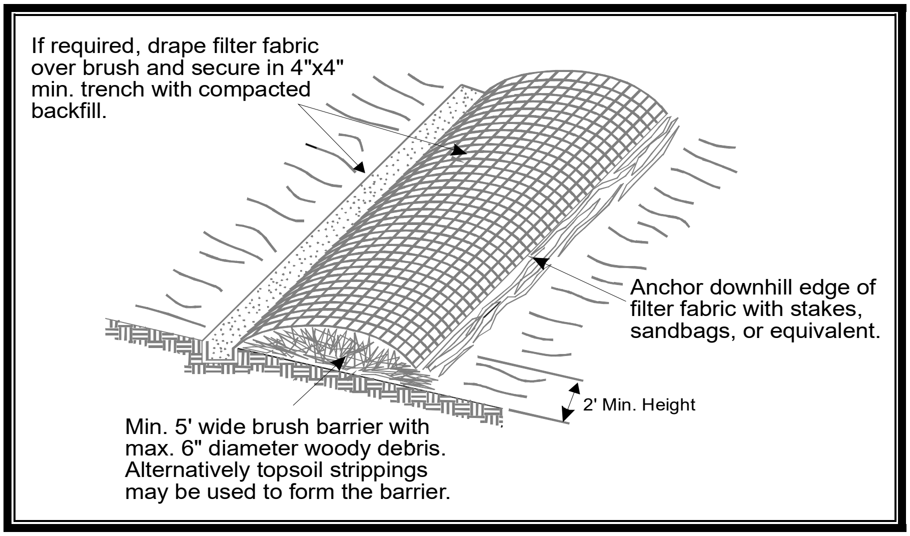
- Brush barriers may be used downslope of all disturbed areas of less than 0.25 acre.
- Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment pond. 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 shall 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, wood-based mulch (hog fuel), or other suitable mulch material 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 5.20 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.



Source: Ecology

Figure 5.20. Brush Barrier.

BMP C232: Gravel Filter Berm

Purpose

A gravel filter berm retains sediment by filtering runoff through a berm of gravel or crushed rock.

Conditions of Use

- Use a gravel filter berm where a temporary measure is needed to retain sediment from construction sites.
- Do not place gravel filter berms in traffic areas; gravel filter berms are not intended to be driven over.
- Place gravel filter berms perpendicular to the flow of runoff, such that the runoff will filter through the berm prior to leaving the site.

Design and Installation Specifications

- Berm material shall be 3/4 to 3 inches in size, washed well-grade gravel or crushed rock with less than 5 percent fines. Do not use crushed concrete.
- Spacing of berms:
  - Every 300 feet on slopes less than 5 percent
  - Every 200 feet on slopes between 5 percent and 10 percent
  - Every 100 feet on slopes greater than 10 percent
- Berm dimensions:
  - 1 foot high with 3H:1V side slopes
  - 8 linear feet per 1 cfs runoff based on the 10-year, 24-hour design storm

Maintenance Standards

- Regular inspection is required.
- Sediment shall be removed, and filter material replaced as needed.

Source: Ecology

Figure 5.21. Gravel Filter Berm.

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 5.22 for details on silt fence construction.

Conditions of Use

- Silt fence may be used downslope of all disturbed areas.
- 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.
- Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Convey any concentrated flows through the drainage system to a sediment trapping BMP.
- Do not construct silt fences in streams or use in V-shaped ditches. Silt fences do not provide an adequate method of silt control for anything deeper than sheet or overland flow.

Design and Installation Specifications

- Use in combination with other construction stormwater BMPs.
- Maximum slope steepness (normal [perpendicular] to fence line) 1H:1V.
- Maximum sheet or overland flow path length to the fence of 100 feet.
- Do not allow flows greater than 0.5 cubic feet per second.
- 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 5.11).

Table 5.11. Geotextile Standards.

Polymeric Mesh AOS (ASTM D4751)	0.60 mm maximum for film wovens (U.S. #30 sieve) 0.30 mm maximum for all other geotextile types (U.S. #50 sieve) 0.15 mm minimum for all fabric types (U.S. #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

- Standard strength geotextiles must be supported with wire mesh, chicken wire, 2-inch by 2-inch wire, safety fence, or jute mesh to increase the strength of the fabric to the 180 lbs minimum threshold. Silt fence materials are available that have synthetic mesh backing attached.

- Silt fence material shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0°F to 120°F.

- Include the following standard notes for silt fence on construction plans and specifications:

  - The contractor shall install and maintain temporary silt fences at the locations shown in the plans.

  - Construct silt fences in areas of clearing, grading, or drainage prior to starting those activities.

  - The silt fence shall have a 2-foot minimum and 2.5-foot maximum height above the original ground surface.

  - The geotextile fabric shall be sewn together at the point of manufacture to form fabric lengths as required. Locate all sewn seams at support 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.

  - Attach the geotextile fabric on the upslope side of the posts and secure with staples, wire, or in accordance with the manufacturer's recommendations. Attach the geotextile fabric to the posts in a manner that reduces the potential for tearing.

- Support the geotextile fabric with wire or plastic mesh, dependent on the properties of the geotextile selected for use. If wire or plastic mesh is used, fasten the mesh securely to the upslope side of the posts with the geotextile fabric upslope of the mesh.

- 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 pounds grab tensile strength. The polymeric mesh must be as resistant to the same level of ultraviolet radiation as the geotextile fabric it supports.

- Bury the bottom of the geotextile fabric 4 inches min. below the ground surface. Backfill and tamp soil in place over the buried portion of the geotextile fabric, so that no flow can pass beneath the fence and scouring cannot occur. The wire or polymeric mesh shall extend into the ground 3 inches min.

- Drive or place the fence posts into the ground 18 inches minimum. A 12-inch minimum depth is allowed if topsoil or other soft subgrade soil is not present and 18 inches cannot be reached. Increase fence post min. depths by 6 inches if the fence is located on slopes of 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.

- 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-inch by 2-inch minimum width and a 3-foot minimum length. Wood posts shall be free of defects such as knots, splits, or gouges.

  - No. 6 steel reinforcement bar 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 pounds/feet.

  - Other steel posts having equivalent strength and bending resistance to the post sizes listed above.

- Locate silt fences 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.

    - If the fence must cross contours, with the exception of the ends of the fence, place check dams perpendicular to the back of the fence to minimize concentrated flow and erosion. The slope of the fence line where contours must be crossed shall not be steeper than 3H:1V.

        - Check dams shall be approximately 1 foot deep at the back of the fence. 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.

        - Check dams shall consist of crushed surfacing base course, gravel backfill for walls, or shoulder ballast. Check dams shall be located every 10 feet along the fence where the fence must cross contours.

- Silt fence installation using the slicing method specification details follow. See also Figure 5.22:

    - The base of both end posts must be at least 2 to 4 inches above the top of the geotextile fabric on the middle posts for ditch check dams to drain properly. Use a hand level or string level, if necessary, to mark base points before installation.

    - Install posts 3 to 4 feet apart in critical retention areas and 6 to 7 feet apart in standard applications. Install posts 24 inches deep on the downstream side of the silt fence, and as close as possible to the geotextile fabric, enabling posts to support the geotextile fabric from upstream water pressure.

    - Install posts with the nipples facing away from the geotextile fabric.

    - Attach the geotextile fabric to each post with three ties, all spaced within the top 8 inches of the geotextile fabric. Attach each tie diagonally 45 degrees through the geotextile fabric, with each puncture at least 1 inch vertically apart. Each tie should be positioned to hang on a post nipple when tightening to prevent sagging.

    - Wrap approximately 6 inches of geotextile fabric around the end posts and secure with three ties.

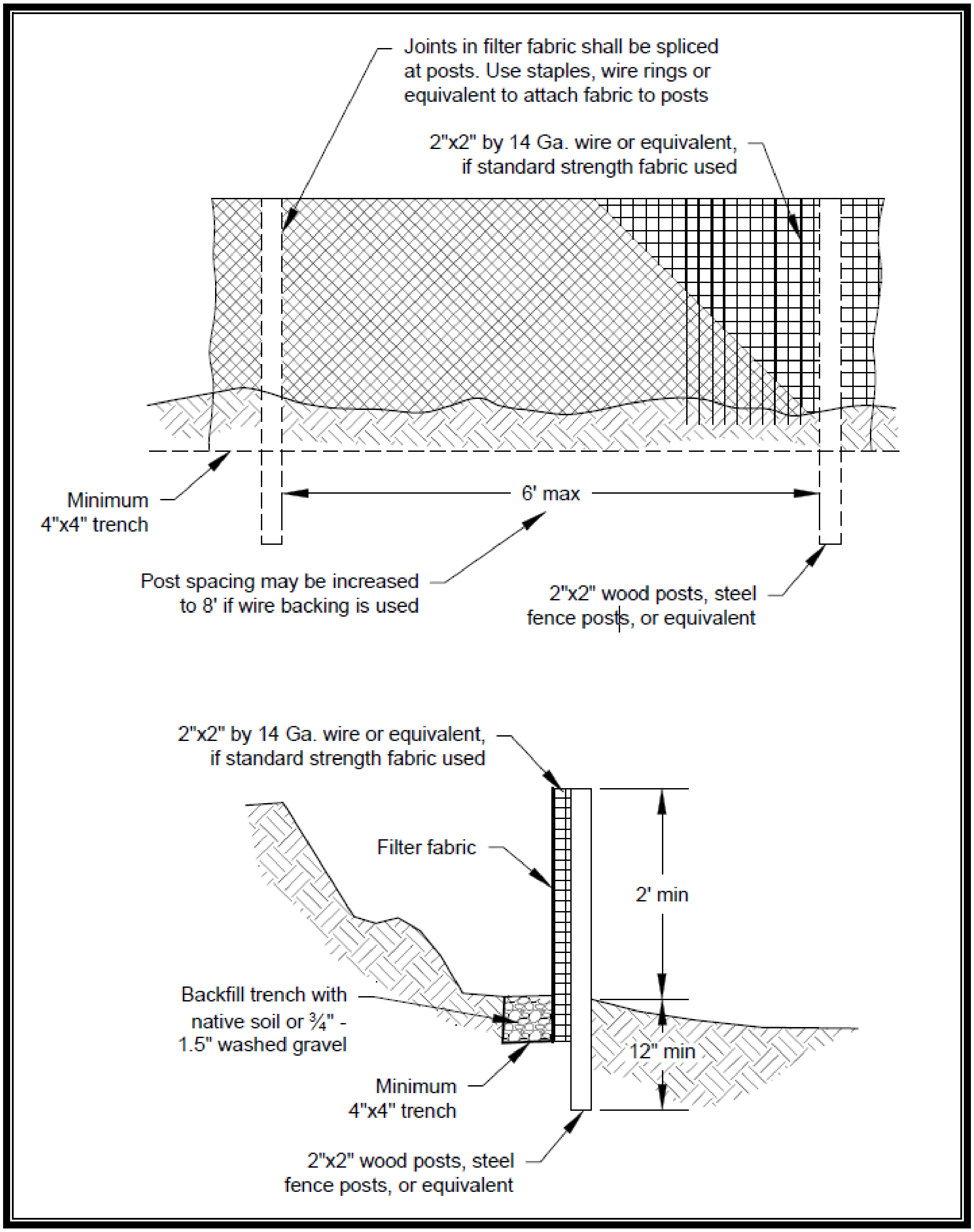
    - Between 24 and 28 inches of a 36-inch geotextile fabric is allowed above ground level, 8 to 12 inches must be buried.

- Compact the soil immediately next to the geotextile 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.

- Remove silt fence upon completion of construction.

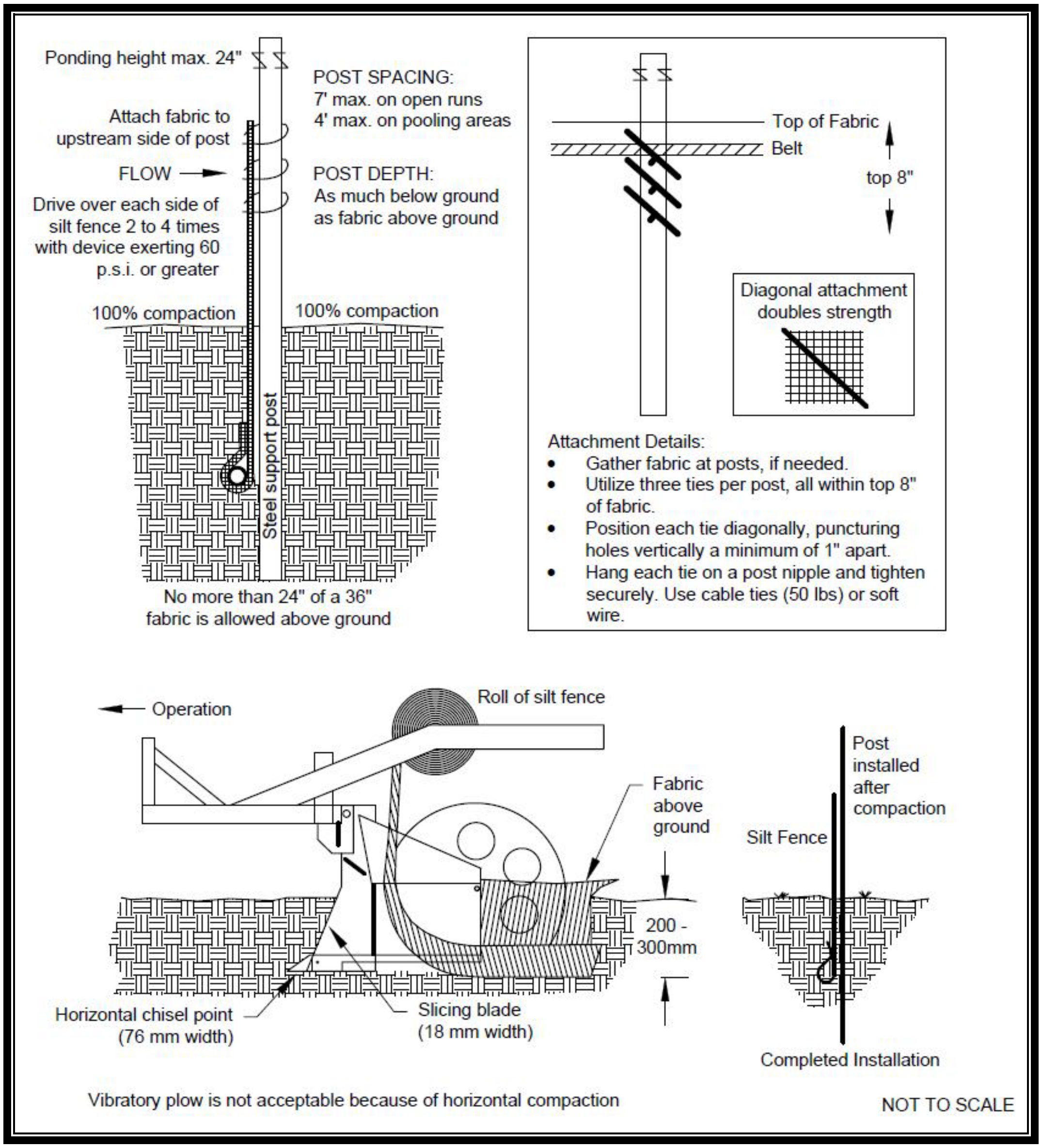
Maintenance Standards

- Repair any damage immediately.
- Intercept and convey all evident concentrated flows uphill of the silt fence to a sediment trapping BMP.
- Check the uphill side of the fence for signs of the silt 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 when the deposit reaches approximately one-third the height of the silt fence or install a second silt fence.
- Replace geotextile fabric that has deteriorated due to ultraviolet breakdown.



Source: Ecology

Figure 5.22. Silt Fence.



Source: Ecology

Figure 5.23. Silt Fence Installation by Slicing Method.

BMP C234: Vegetated Strip

Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a 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 5.12):

Table 5.12. Vegetated Strips.

Average Contributing Area Slope	Average Contributing Area Percent Slope	Maximum Contributing Area Flow Path 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 continuous strip of dense vegetation with topsoil and have a minimum 25-foot-long flowpath. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips should 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: Wattles

Purpose

Wattles are temporary erosion and sediment control barriers consisting of straw, compost, or other material that is wrapped in netting made of natural plant fiber or similar encasing material. They reduce the velocity and can spread the flow of rill and sheet runoff and can capture and retain sediment. See Figure 5.24 for typical construction details.

Conditions of Use

- Wattles shall consist of cylinders of plant material such as weed-free straw, coir, wood chips, excelsior, or wood fiber or shavings encased within netting made of natural plant fibers unaltered by synthetic materials.
- 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.
- The material used dictates the effectiveness period of the wattle. Typically, wattles are effective for one to two seasons.
- Prevent rilling beneath wattles by properly entrenching and overlapping wattles together to prevent water from passing between them.

Design Criteria

- Wattles are typically 8 to 10 inches in diameter and 25 to 30 feet in length.
- Wattles are placed in shallow trenches and staked along the contour of disturbed or newly constructed slopes.
- Install wattles perpendicular to the flow direction and parallel to the slope contour.
- Narrow trenches shall 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 shall be dug to a depth of 5 to 7 inches, or one-half to two-thirds of the thickness of the wattle.
- Start building trenches and installing wattles from the base of the slope and work up. Spread excavated material evenly along the uphill slope and compacted using hand tamping or other methods.

- Construct trenches on contours at intervals of 10 to 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 overlap the ends of adjacent wattles 12 inches behind one another.
- 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.
- Wooden stakes should be approximately 0.75 by 0.75 by 24 inches min. Willow cuttings or 0.375-inch rebar can also be used for stakes. Note: rebar must be removed at end of project if used, while other fasteners may be permitted to remain if all parts of the wattles are biodegradable and shown in plans for permanent erosion control.
- Stakes should be driven through the middle of the wattle, leaving 2 to 3 inches of the stake protruding above the wattle.

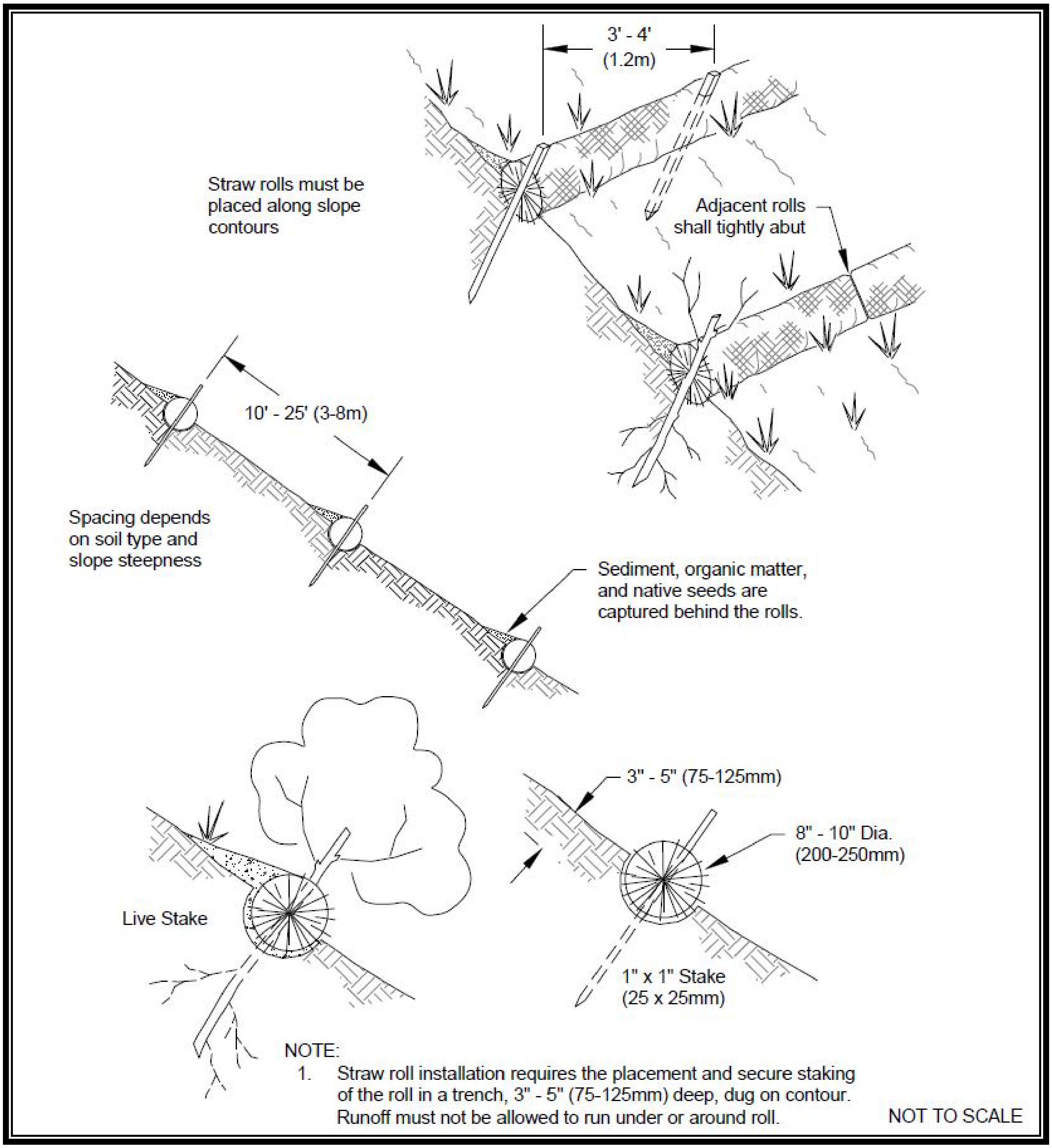
Maintenance Standards

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

Ecology has approved specific products as able to meet the requirements of BMP C235. However, the products did not pass through the Technology Assessment Protocol – Ecology (TAPE) process. The list of products that Ecology has approved as functionally equivalent are available on Ecology's website at <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

If a project wishes to use any of the "approved as functionally equivalent" BMPs in the City, the project owner or representative must obtain approval for use of the BMP from the City on a case-by-case basis (i.e., for each project or site) before use.



Source: Pierce County

Figure 5.24. Straw Wattles.

BMP C236: Vegetative Filtration

Purpose

Vegetative filtration may be used in conjunction with BMP C241: Sediment Pond (Temporary), 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 5 acres of disturbed soil, use 1 acre of grass field, farm pasture, or forested area. Reduce or increase this area depending on project size, groundwater table height, and other site conditions.
- Wetlands shall not be used for vegetative filtration.
- Do not use this BMP in areas with a high groundwater table, or in areas that will have a high seasonal groundwater 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.
- On large projects that phase the clearing of the site, areas retained with native vegetation may be used as a temporary vegetative filtration area.

Design Criteria

- Find an area of the project site that is vegetated, such as a farm field or forested area.
- If the site does not contain enough vegetated field area, consider obtaining an easement from adjacent landowners (especially farm fields) if conditions would allow for proper filtration. An easement is required for any off-site area used to meet the requirements of this BMP.
- 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 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-inch diameter schedule 20 polyvinyl chloride (PVC), swaged-fit common septic tight-lined sewer line, or 6-inch diameter fire hose, which can convey the turbid water out to various sections of the field. See Figure 5.25.
- Determine the branch length based on the field area geography and number of branches. Typically, branches stretch from 200 feet to several thousand feet. Lay the 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 vegetative filtration area, rotate the use of branches or spray heads. Repeat as needed based on monitoring the spray field.

Maintenance Standards

- 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.
- Monitor the vegetated spray field all the way down to the nearest surface water, or farthest spray area, to ensure that the water has not caused overland or concentrated flows and has not created erosion around the spray nozzle(s).
- Do not exceed water quality standards for turbidity.
- The City 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.
- 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.

Flow Path Guidelines for Vegetative Filtration		
Average Slope	**Average Area Percent Slope**	**Estimated Flow Path Length (ft)**
1.5H:1V	67%	250
2H:1V	50%	200
4H:1V	25%	150
6H:1V	16.7%	115
10H:1V	10%	100

Source: Ecology

Figure 5.25. Manifold and Branches in a Wooded, Vegetated Spray Field.

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

- Sediment traps are 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 6 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 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.

- Projects that are constructing permanent flow control or runoff treatment BMPs that use ponding for treatment, may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment trap. When permanent BMP footprints are used as temporary sediment traps, the surface area requirement of a sediment trap must be met. If the surface area requirement of the sediment trap is larger than the surface area of the permanent BMP, then the sediment trap shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

- A floating pond skimmer may be used for the sediment trap outlet if approved by the City.

- Sediment traps may not be feasible on utility projects due to the limited work space or the short-term nature of the work. Portable tanks may be used in place of sediment traps for utility projects.

Design and Installation Specifications

- See Figures 5.26 and 5.27 for details.
- 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:

$$SA = FS(Q2/Vs)$$

Where: Q_2 = Option 1 - Single Event Hydrograph Method:

Q2 = Peak volumetric flow rate calculated using a 10-minute time step from a Type 1A, 2-year, 24-hour frequency storm for the developed condition. The 10-year peak volumetric flow rate shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection.

Option 2 - For construction sites that are less than 1 acre, the Rational Method may be used to determine Q2

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/cm^3 has been selected as the particle of interest and has a settling velocity (Vs) of 0.00096 foot per second.

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

- Therefore, the equation for computing surface area becomes:

$$SA = 2 \text{ x } Q_2/0.00096$$

OR

2,080 square feet per cubic feet per second of inflow

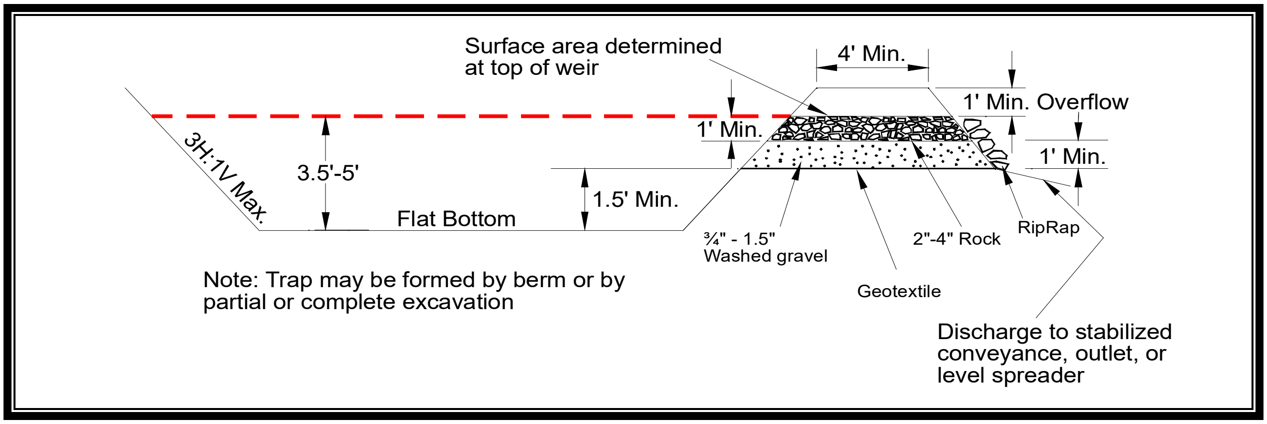
Note: Even if permanent BMPs are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

- Sediment trap depth shall be 3.5 feet minimum from the bottom of the trap to the top of the overflow weir.
- To aid in determining sediment depth, all sediment traps shall have a staff gauge with a prominent labeled mark each 1-foot interval above the bottom of the trap.

- Design the discharge from the sediment trap by using the guidance for discharge from temporary sediment ponds in BMP C241: Sediment Pond (Temporary).

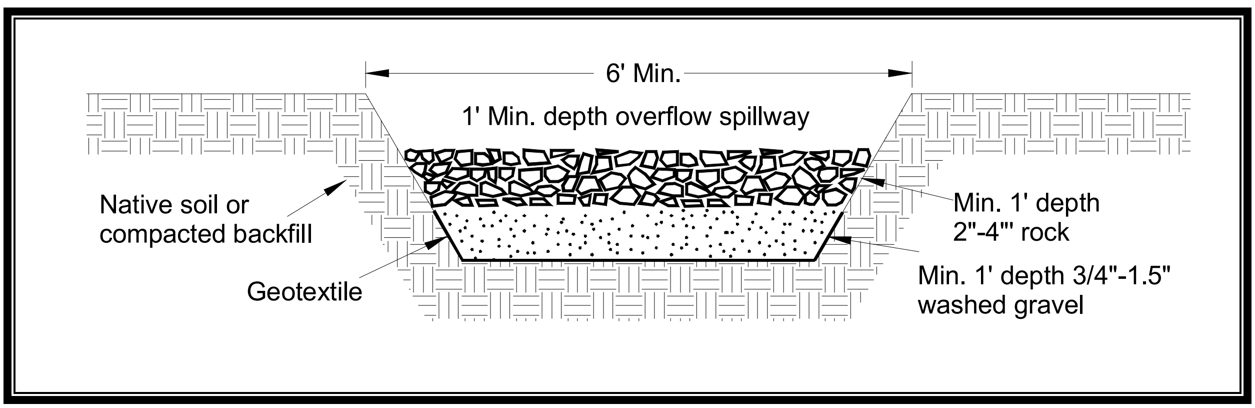
Maintenance Standards

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



Source: Ecology

Figure 5.26. Cross-Section of Sediment Trap.



Source: Ecology

Figure 5.27. Sediment Trap Outlet.

BMP C241: Sediment Pond (Temporary)

Purpose

Sediment ponds are temporary ponds used during construction to 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

- Use a sediment pond where the contributing drainage area is 3 acres or more. Ponds must be used in conjunction with other erosion control BMPs to reduce the amount of sediment flowing into the pond.

- Do not install sediment ponds on sites where failure of the BMP would 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 planned, the type of fence and its location shall be shown on the Construction SWPPP.

- Sediment ponds that can impound 10 acre-feet (435,600 cubic feet) or more, or have an embankment of more than 6 feet, are subject to the Washington Dam Safety Regulations (Chapter 173-175 WAC). See Chapter 7, Section 7.5.1 for more information regarding dam safety considerations for detention ponds. An electronic version of the Dam Safety Guidelines is available at <https://ecology.wa.gov/programs/wr/dams/GuidanceDocs.html>.

- Projects that are constructing permanent flow control or runoff treatment BMPs that use ponding for treatment may use the rough-graded or final-graded permanent BMP footprint for the temporary sediment pond. When permanent BMP footprints are used as temporary sediment ponds, the surface area requirement of the sediment pond must be met. If the surface area requirement of the sediment pond is larger than the surface area of the permanent BMP, then the sediment pond shall be enlarged beyond the permanent BMP footprint to comply with the surface area requirement.

  The permanent control structure must be temporarily replaced with a control structure that only allows water to leave the temporary sediment pond from the surface or by pumping. Alternatively, the permanent control structure may be used if it is temporarily modified by plugging any outlet holes below the riser. The permanent control structure must be installed as part of the permanent BMP after the site is fully stabilized.

Design and Installation Specifications

- See Figures 5.28, 5.29, and 5.30 for details.
- Use of permanent infiltration BMP footprints for temporary sediment ponds during construction tends to clog the soils and reduce their capacity to infiltrate. If permanent infiltration BMP footprints are used, the sides and bottom of the temporary sediment pond must only be rough excavated to a minimum of 2 feet above final grade of the permanent infiltration BMP. Final grading of the permanent infiltration BMP shall occur only when all contributing drainage areas are fully stabilized. Any proposed permanent pretreatment BMP prior to the infiltration BMP should be fully constructed and used with the temporary sediment pond to help prevent clogging of the soils. See Element #13: Protect Low Impact Development BMPs for more information about protecting permanent infiltration BMPs.

Sediment Pond Geometry

To determine the sediment pond geometry, first calculate the surface area (SA) at the pond, measured at the top of the riser pipe. Use the following equation:

$$SA = 2 \text{ x } Q_2/0.00096$$

OR

2,080 square feet per cubic feet per second (cfs) of inflow

- See BMP C240: Sediment Trap for more information on the above equation.
- The basic geometry of the pond can now be determined using the following design criteria:
  - Required surface area SA (from the equation above) at top of riser.
  - Minimum 3.5-foot depth from top of riser to bottom of pond.
  - Maximum 3H:1V interior side slopes and maximum 2H:1V exterior slopes. The interior slopes can be increased to a maximum of 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.

Sediment Pond Discharge

- The outlet for the pond 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 recurrence interval storm. If, due to site conditions and pond geometry, a separate emergency spillway is not feasible, the principal spillway must pass the entire peak runoff expected from the 100-year recurrence interval storm. However, an attempt to provide a separate emergency spillway should always be made. Base the runoff calculations on the site conditions during construction. The flow through the dewatering orifice cannot be utilized when calculating the 100-year recurrence interval 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 pond discharge to the predevelopment discharge limitations as stated in Core Requirement #7: Flow Control. The size of the contributing 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 5.31 for 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 peak volumetric flow rate using a 15-minute time step from a Type 1A, 10-year, 24-hour frequency storm for the developed conditions. Use Figure 5.31 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 using a 10-minute time step from a Type 1A, 100-year, 24-hour frequency storm for the developed condition.

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

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

Where: *Ao* = orifice area (square feet)

As = pond surface area (square feet)

h = head of water above orifice (height of riser in feet)

T = dewatering time (24 hours)

g = acceleration of gravity (32.2 feet/second^2)

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

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

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

Additional Design Specifications

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

- To aid in determining sediment depth, 1-foot intervals above the pond bottom shall be prominently marked on the riser or a staff gauge.

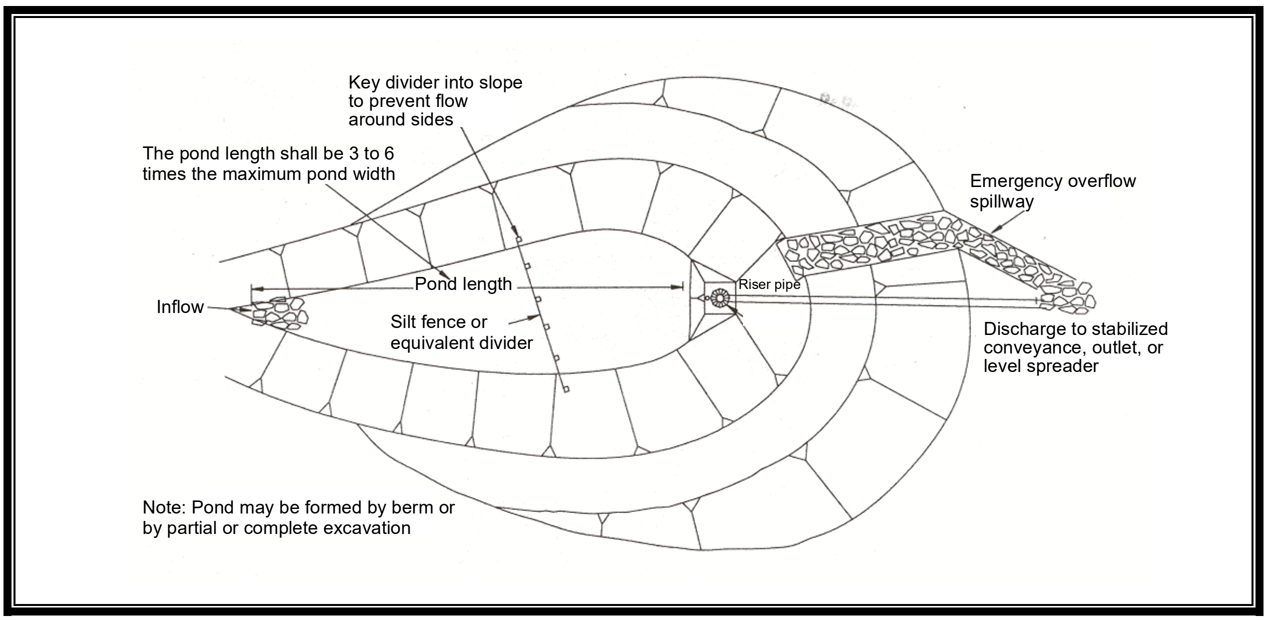
- The most common structural failure of sedimentation ponds is caused by piping. Piping refers to two phenomena: 1) water seeping through fine-grained soil, eroding the soil grain by grain and forming pipes or tunnels; and 2) water under pressure flowing upward through a granular soil with a head of sufficient magnitude to cause soil grains to lose contact and capability for support.

The most critical construction sequences to prevent piping will be:

- o Tight connections between riser and barrel and other pipe connections
- o Adequate anchoring of riser
- o Proper soil compaction of the embankment and riser footing
- o Proper construction of anti-seep devices

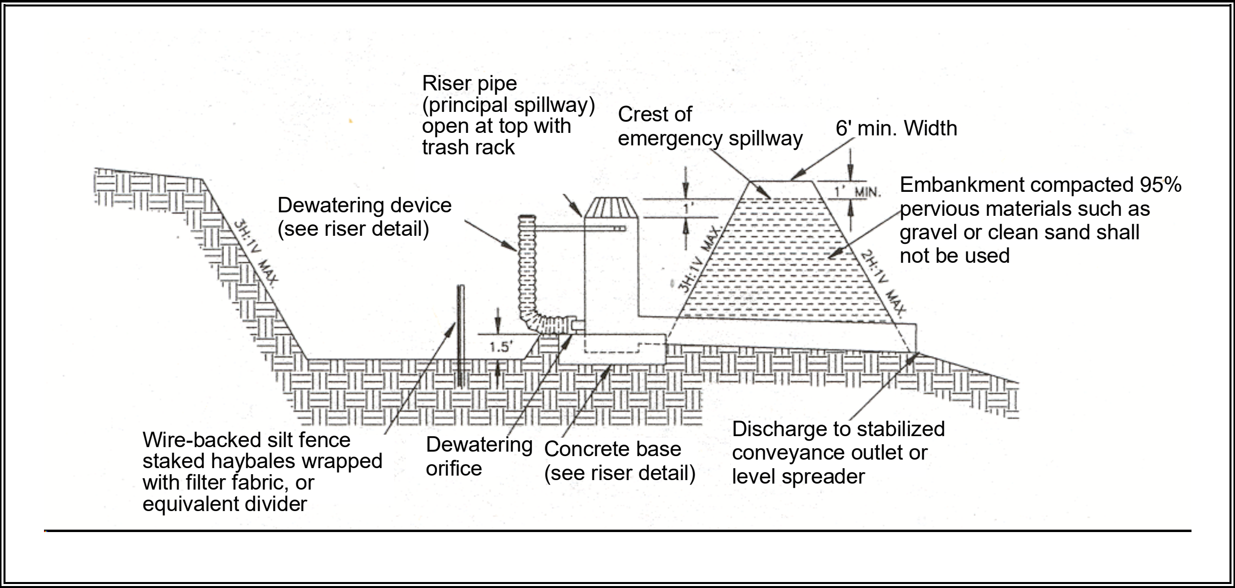
Maintenance Standards

- 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.



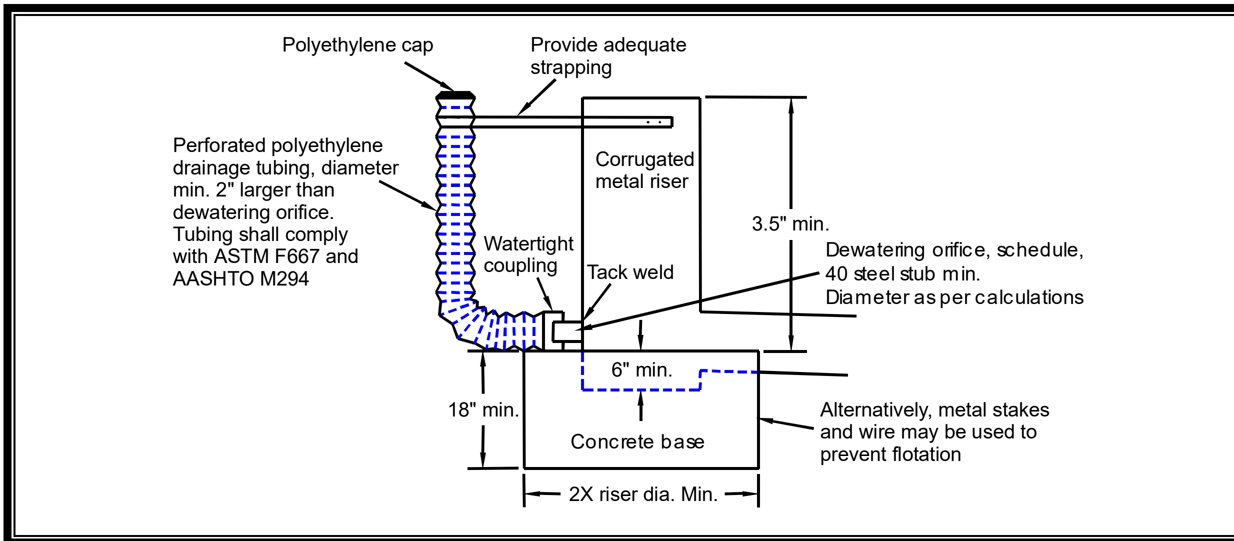
Source: Ecology

Figure 5.28. Sediment Pond Plan View.



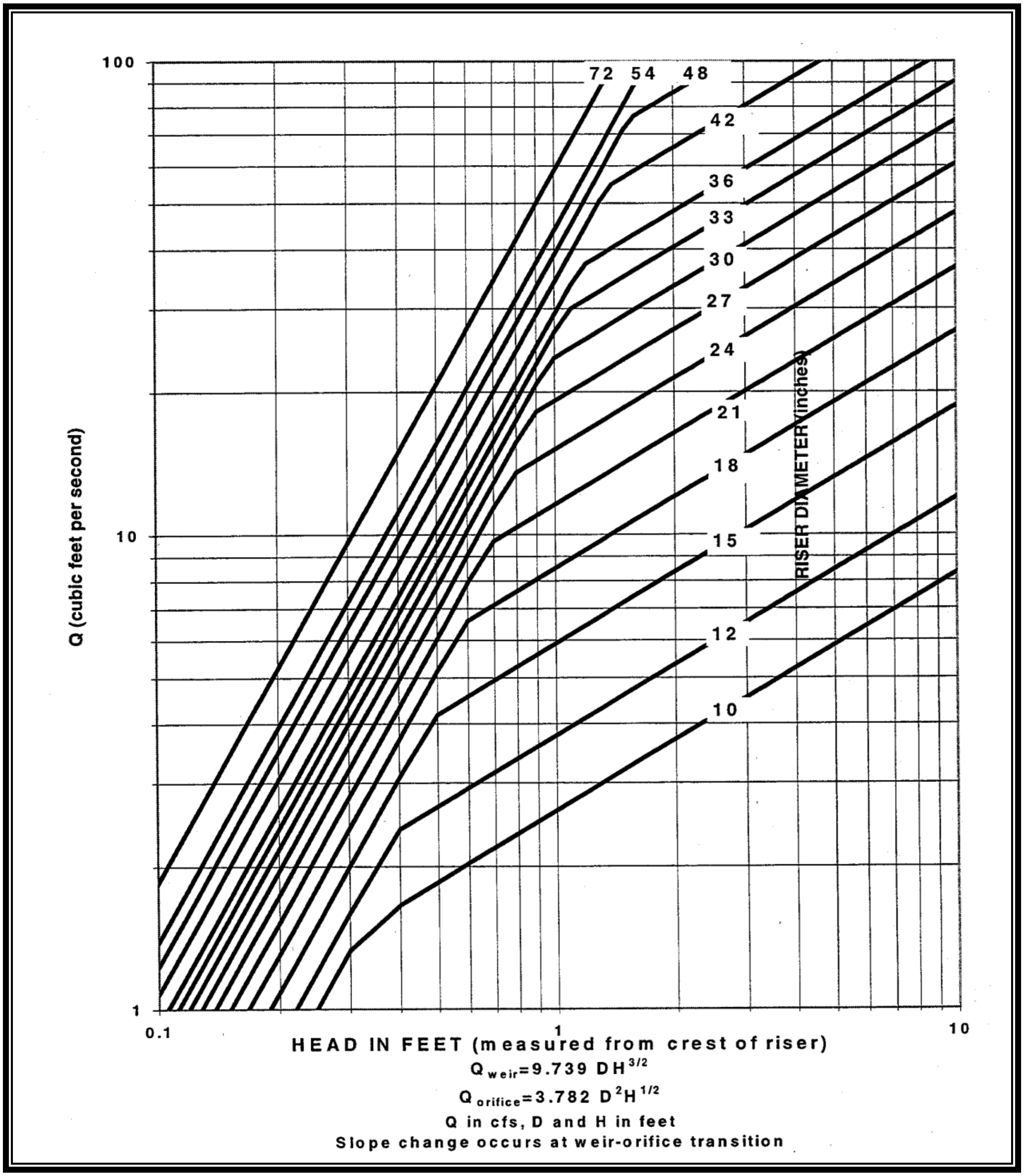
Source: Ecology

Figure 5.29. Sediment Pond Plan View.



Source: Ecology

Figure 5.30. Sediment Pond Riser Detail.



Source: Ecology

Figure 5.31. Riser Inflow Curves.

BMP C250: Construction Stormwater Chemical Treatment

This BMP applies when using chemicals to treat turbidity in stormwater by either batch or flow-through chemical treatment.

Turbidity is difficult to control once fine particles are suspended in stormwater runoff from a construction site. BMP C241: Sediment Pond (Temporary) is effective at removing larger particulate matter by gravity settling, but is ineffective at removing smaller particulates such as clay and fine silt. Traditional construction stormwater BMPs may not be adequate to ensure compliance with the water quality standards for turbidity in the receiving water.

Chemical treatment can reliably provide exceptional reductions of turbidity and associated pollutants. Chemical treatment may be required to meet turbidity stormwater discharge requirements, especially when construction proceeds through the wet season.

Although Construction Stormwater Chemical Treatment is an Ecology-approved BMP, it is very rarely used in the City. Therefore, details on this BMP are not included in this manual. Refer to the 2019 Ecology Manual for details on BMP C250: Construction Stormwater Chemical Treatment.

BMP C251: Construction Stormwater Filtration

Filtration removes sediment from runoff originating from disturbed areas of the site. Traditional construction stormwater BMPs used to control soil erosion and sediment loss from construction sites 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.

Although Construction Stormwater Filtration is an Ecology-approved BMP, it is very rarely used in the City. Therefore, details on this BMP are not included in this manual. Refer to the 2019 Ecology Manual for details on BMP C251: Construction Stormwater Filtration.

BMP C252: Treating and Disposing of High pH Water

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 prior to discharge to surface or groundwater. A pH level range of 6.5 to 8.5 is typical for most natural watercourses, and this neutral 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.

Although Treating and Disposing of High pH Water is an Ecology-approved BMP, it is very rarely used in the City. Therefore, details on this BMP are not included in this manual. Refer to the 2019 Ecology Manual for details on BMP C252: Treating and Disposing of High pH Water.

Chapter 5 References

Hinman, C. and B. Wulkan. 2012. Low Impact Development Technical Guidance Manual for Puget Sound. WSU Puyallup Research and Extension Center and Puget Sound Partnership. December.

Stenn, et al. 2018. Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13 in WDOE Stormwater Management Manual for Western Washington. 2018 Edition. <www.buildingsoil.org>

Washington State Department of Ecology (Ecology). 2019. Stormwater Management Manual for Western Washington. Publication Number 19-10-021. July.

Chapter 6 – Hydrologic Analysis and Conveyance Design

Table of Contents

Tables

Figures

Chapter 6 – Hydrologic Analysis and Conveyance Design

6.1 Purpose, Content, and Organization

This chapter presents the minimum computational standards required for designing flow control and runoff treatment best management practices (BMPs) and stormwater conveyance systems. Section 6.2 addresses hydrologic methodologies required for determining design runoff rates and volumes for flow control and runoff treatment BMPs. Section 6.3 addresses methodologies for analysis and design of conveyance systems. Certain methods are required, as noted, in certain situations. Engineers have some discretion in others. In all instances, the City of Lacey (City) may require more extensive analysis or use of a different methodology if deemed necessary.

6.2 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:

- For the purpose of designing flow control BMPs, a calibrated continuous simulation model based on the HSPF or an approved equivalent model (e.g., Western Washington Hydrology Model [WWHM]) must be used. Ecology's approval status for other continuous simulation models is provided in the "Additional Resources" section of the online 2019 Washington State Department of Ecology (Ecology) Manual: <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm> Flow control BMP design standards and sizing criteria are discussed in detail in Chapter 7. The circumstances under which different methodologies apply are summarized in Table 6.1.

- For the purpose of designing runoff treatment BMPs, a calibrated continuous simulation model based on the HSPF program or an approved equivalent model (e.g., WWHM) must be used to calculate runoff and determine the water quality design flow rates and volumes. Design standards and sizing criteria for runoff treatment BMPs are provided in Chapter 8.

- For conveyance system design, the designer may use an approved continuous simulation model or a single event hydrologic model to determine the peak flow rate. The peak flow rate from a continuous simulation model will vary depending on the time step used in the model. Therefore, the length of the time step must be sufficiently short relative to the time of concentration of the watershed to provide for reasonable conveyance system design flows. For most situations in the City, a 15-minute (maximum) time step will be sufficient for conveyance system design. If the project is in a predominantly urbanized watershed with a time of concentration less than about 15 minutes (roughly 10 acres in size), the conveyance design must either use a 5-minute time step (if available) or use an event-based model for conveyance sizing. Conveyance design is discussed in detail in Section 6.3.

- Ecology has developed the HSPF-based WWHM. By default, WWHM uses rainfall/runoff relationships developed for specific basins in the Puget Sound region to all parts of western Washington.

- Use of other continuous simulation models must receive prior concurrence from the City before being used for BMP design.

Table 6.1. Summary of the Application Design Methodologies.

Method	BMP/Conveyance Designs in Western Washington		
	Treatment	**Flow Control**	**Conveyance**
Continuous Runoff Models: (WWHM or approved alternatives)	Method applies to all BMPs	Method applies throughout Western Washington	Method applies throughout Western Washington
Soil Conservation Service Unit Hydrograph (SCSUH)/ Santa Barbara Urban Hydrograph (SBUH)	Not applicable	Not applicable	Acceptable
Rational Method	Not applicable	Not applicable	Acceptable for certain conveyance design only[a]

[a] Refer to Section 6.2.1.

Where large master-planned developments are proposed, the City may require a basin-specific calibration of HSPF rather than use of the default parameters in the above-referenced models. Basin-specific calibrations may be required for projects that will occupy more than 320 acres.

6.2.1 Discussion of Hydrologic Analysis Methods Used for Runoff Modeling and BMP Design

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 Urban Hydrograph (SBUH), versus continuous simulation models.

The project engineer shall verify that a particular modeling approach will be acceptable. The project engineer shall provide clear and complete information (e.g., input and output files, annotation of key outputs to highlight and clarify key results and conclusions, and discussion of results) to enable the City to conduct its review. See Chapter 3 for additional submittal details and requirements.

Single Event and Continuous Simulation Runoff Models

A continuous simulation runoff 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. 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, which tend to overestimate peak runoff.

A major weakness of the single event model 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 simulation 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 runoff treatment BMPs.

Single Event Storms – Hydrograph

Hydrograph analyses utilize the standard plot of runoff flow versus time for a given single event design storm, thereby allowing the key characteristics of runoff such as peak, volume, and phasing to be considered in the design of stormwater BMPs. 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. Because the only application for single event methods in this manual is to size conveyance systems, only a limited discussion of design storms, curve numbers, and calculating peak runoffs are presented in Appendix 6A. If single event methods are used to size temporary and permanent conveyances, the user should reference other texts and software for assistance. Conveyance systems can be designed using unit hydrograph analysis methods for estimating storm runoff rates. All stormwater storage BMPs shall be designed to meet the Core Requirement #7 for frequency and duration control using a continuous simulation model. If the engineer decides to use a single event runoff model for conveyance design, the preferred method is the SBUH method, or the SCSUH method as a second choice. The rational method may be used for conveyance sizing on sites of 25 acres or less that have a time of concentration of less than 100 minutes.

Western Washington Hydrology Model

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 including low impact development (LID) BMP modeling capability. For example, WWHM2012 includes modeling elements for stormwater LID BMPs. WWHM users should periodically check Ecology's WWHM web page for the latest releases of WWHM, user manuals, and any supplemental instructions. Refer to Volume III, Section 2.2, of the 2019 Ecology Manual for background information on WWHM. Guidance on LID BMP modeling in WWHM can be found in Volume V of the 2019 Ecology Manual.

More information on the WWHM can be found on Ecology's website at: https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Stormwater-manuals/Western-Washington-Hydrology-Model.

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 (Chapter 2, Section 2.1.2, and Chapter 16.54 Lacey Municipal Code [LMC]) 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 Core Requirement #8: Wetlands Protection may apply.

An approved continuous simulation model must be used for closed depression analysis and design of mitigation BMPs. 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 an approved continuous simulation hydrologic model.

6.2.2 Guidance for Flow Control Standards

Flow control standards are used to determine whether or not a proposed stormwater BMP will provide a sufficient level of mitigation for the additional runoff from land development.

There are three flow-related standards stated in Chapter 2 of this manual: Core Requirement #5: On-Site Stormwater Management; Core Requirement #7: Flow Control; and Core Requirement #8: Wetlands Protection.

Core Requirement #5 allows the user to demonstrate compliance with the LID Performance Standard of matching developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 8 percent of the 2-year peak flow to 50 percent of the 2-year peak flow. If the postdevelopment flow duration values exceed any of the predevelopment flow levels between 8 percent and 50 percent of the

2-year predevelopment peak flow values, then the LID Performance Standard has not been met.

Core 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 percent of the 2-year recurrence interval peak flow up to the full 50-year peak flow. (Note that Core Requirement #7 also includes discharge requirements for projects in closed depression areas, discussed in more detail in Section 6.2.1 above, and in Chapter 2.)

- The continuous runoff models compute the predevelopment 2- through 100-year recurrence interval flow values and compute the postdevelopment runoff 2- through 100-year recurrence interval flow values from the outlet of the proposed stormwater BMP.

- The model uses discharge data from the applicable BMP(s) 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 percent and 100 percent of the 2-year recurrence interval 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 percent of the 2-year and 100 percent of the 50-year recurrence interval 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.

Method 2 of Core Requirement #8 specifies that total discharge volume to a wetland must not deviate by more than 20 percent on a daily basis and must not deviate by more than 15 percent on a monthly basis. Flow components feeding the wetland under both pre- and postdevelopment scenarios are assumed to be the sum of the surface, interflow, and groundwater flows from the project site. WWHM2012 includes the capability of modeling flows to wetlands and analyzing the daily and monthly flow deviations (per these requirements). Refer to Core Requirement #8 in Chapter 2 and the 2019 Ecology Manual, Volume I, Appendix I-C for additional requirements related to wetlands.

6.3 Conveyance Design and Analysis

This section presents acceptable methods for the analysis and design of conveyance systems. It also includes sections on hydraulic structures that link the conveyance system to the runoff treatment and flow control BMPs.

This section is separated into the following categories:

- Design and analysis methods (Sections 6.3.1 through 6.3.4)
- Conveyance design (Section 6.3.5 and 6.3.6)
    - Channels
    - Culverts
    - Storm drain system
    - Pipe structures (manholes, catch basins, flow splitters)
    - Outfalls
    - Flow spreaders
    - Private drainage systems

6.3.1 Design Storm Frequency

Ideally, every conveyance system and hydraulic structure would be designed for the largest possible amount of flow that could ever occur. Unfortunately, this would require unusually large structures and would add an unjustifiable cost to the projects; therefore, hydraulic structures are analyzed for a specific storm frequency. When selecting a storm frequency for design purposes, consideration is given to the potential degree of damage to adjacent properties, potential hazard and inconvenience to the public, the number of users, and the initial construction cost of the conveyance system or hydraulic structure. The way in which these factors interrelate can become quite complex.

The design event recurrence interval is related to the probability that such an event will occur in any 1 year. For example, a peak flow having a 25-year recurrence interval has a 4 percent probability of being equaled or exceeded in any future year. A peak flow having a 2-year recurrence interval has a 50 percent probability of being equaled or exceeded in any future year. The greater the recurrence interval is, the lower the probability that the event will occur in any given year.

The design event for each conveyance system category is as follows:

- Conveyance systems shall be designed, at a minimum, to convey the 25-year storm event under fully developed conditions.

- Drains and culverts passing under public roads and arterial streets shall be designed to convey the 25-year storm event under fully developed conditions.
- Culverts for and bridges over natural channels shall be designed to convey the 100-year storm event under fully developed conditions. Culverts and bridges must also be designed to meet fish passage and scour criteria, where applicable.

The City may require an increased level of protection and/or freeboard on a case-by-case basis.

6.3.2 Backwater Analysis

If the City determines that, as a result of the project, runoff for any event up to and including the 100-year, 24-hour storm event would cause damage or interrupt vital services, a backwater (pressure sewer) analysis shall be required. When a backwater calculation is required, the design engineer shall analyze for the 25- and 100-year, 24-hour design storm events.

For the 25-year event, there shall be a minimum of one-half a foot of freeboard between the water surface and the top of any manhole or catch basin.

For the 100-year event, overtopping of the pipe conveyance system may occur; however, the additional flow shall not extend beyond half the lane width of the outside lane of the traveled way and shall not exceed 4 inches in depth at its deepest point. Off-channel storage on private property is allowed with recording of the proper easements (see Section 6.3.4). The additional flow shall be analyzed by open channel flow methods.

A backwater profile analysis computer program such as the King County Backwater (KCBW) computer program by King County Stormwater Services Section is recommended over hand calculations. The subroutine, BPIPE, of King County Backwater may be used for quick computation of backwater profiles, given a range of flows through the existing or proposed pipe system.

6.3.3 Conveyance System Route Design

All pipes shall be located under the pavement flow line or lie outside of the pavement, unless otherwise specified below. Perpendicular crossings and cul-de-sacs are exempted from this requirement. For curved sections only of minor local residential, private roads, and alleys, pipe placement may be located underneath pavement areas, but no closer than 6 feet from the roadway centerline. Pipes under permeable pavement sections will need to ensure flows are prevented from short circuiting through the pipe zone bedding. Location and layout of conveyance piping on roadway retrofit projects will be determined on a case-by-case basis.

New conveyance system alignments that are not in dedicated tracts or right-of-way shall be located in drainage easements that are adjacent and parallel to property lines. The width of the permanent easement must be completely within a single parcel or tract and not split between adjacent properties. Topography and existing conditions are the only conditions under which a drainage easement may be placed not adjacent and parallel to a property line. (Exception: Streams and natural drainage channels cannot be relocated to meet this routing requirement.) Requirements for conveyance system tracts and easements are discussed in Section 6.3.4 below. Refer to Chapter 5 of the City of Lacey *Development Guidelines and Public Works Standards* (DG&PWS) for additional conveyance system requirements.

6.3.4 Easements, Access, and Dedicated Tracts

Natural Channels and Stormwater BMPs

All constructed stormwater BMPs and conveyances and all natural channels (on the project site) used for conveyance of altered flows due to development (including swales, ditches, stream channels, lake shores, wetlands, potholes, estuaries, gullies, ravines, etc.) shall be located within easements or dedicated tracts as required by the City. Easements shall contain the natural features and BMPs and shall allow City access for purposes of inspection, maintenance, repair or replacement, flood control, water quality monitoring, and other activities permitted by law.

All stormwater BMPs such as detention or retention ponds or infiltration systems to be maintained by the City shall be located in separate tracts dedicated to the City. Conveyance systems can be in easements. Stormwater BMPs shall not be located in dedicated public road right-of-way areas, with the exception of City and highway BMPs.

Stormwater BMPs that are designed to function as multi-use recreational facilities shall be located in separate tracts or in designated open space and shall be privately maintained and owned, unless accepted by and dedicated to the City.

Maintenance Access

A maintenance access road (and easement) must be provided for all manholes, catch basins, vaults, or other underground stormwater BMPs. This requirement does not apply to on-site stormwater management BMPs. A minimum 15-foot-wide access easement shall be provided to the BMPs from a public street or right-of-way. Access easements shall be surfaced with a minimum 12-foot width of crushed rock, or other approved surface to allow year-round equipment access to the BMP. See also Chapter 7, Section 7.5.1, for pond access and other detention BMP requirements.

Maintenance shall be through an access easement or dedicated tract. Drainage structures for conveyance without vehicular access must be channeled.

Access to Conveyance Systems

All publicly and privately maintained conveyance systems shall be located in dedicated tracts, drainage easements, or public rights-of-way in accordance with this manual. Exception: roof downspout, minor yard, and footing drains unless they serve other adjacent properties.

Conveyance systems to be maintained and operated by the City must be located in a dedicated tract or drainage easement granted to the City. Any new conveyance system located on private property designed to convey drainage from other private properties must be located in a private drainage easement granted to the contributors of stormwater to the systems to convey surface and stormwater and to permit access for maintenance or replacement in the case of failure.

All drainage tracts and easements, public and private, must have a minimum width of 15 feet. In addition, all pipes and channels must be located within the tract, easement, or rights-of-way so that each pipe face or top edge of channel is no closer than 5 feet from its adjacent easement boundary. Pipes greater than 5 feet in diameter and channels with top widths greater than 5 feet shall be placed in easements adjusted accordingly, so as to meet the required dimensions from the boundaries.

Easement widths as shown in Table 6.2 are minimums for access, inspection, and maintenance of conveyance systems.

Table 6.2. Minimum Easement Widths for Conveyance Systems for Access, Inspection, and Maintenance.

Conveyance Width	Easement Width
Channels ≤ 30 feet wide	Channel Width + 15 feet from top, one side
Channels > 30 feet wide	Channel Width + 15 feet from top, both sides
Pipes/Outfalls ≤ 36 inches	15 feet centered on pipe
Pipes/Outfalls > 36 inches but ≤ 60 inches	20 feet centered on pipe[a]
Pipes/Outfalls > 60 inches	30 feet centered on pipe[a]

[a] The City may allow flexibility, or require larger easements, depending on site-specific conditions.

6.3.5 Design Methods and Criteria

This section describes methods and criteria for sizing of storm drain pipes, channels, revetments, and other drainage structures in the conveyance system. Setbacks and easements for conveyances are found in Section 6.3.4.

Channels

Channels can be either roadside ditches, grass lined swales, or a combination thereof. Consideration must be given to public safety when designing open conveyances adjacent to traveled ways and when accessible to the public. Where space and topography permit, channels are the preferred means of collecting and conveying stormwater.

Channels shall be designed by one of the following methods (refer to Appendix 6A):

- Manning’s Equation (for uniform flow depth, flow velocity, and constant channel cross-section)
- Direct Step Backwater Method (utilizing the energy equation)
- Standard Step Backwater Method (utilizing a computer program).

Velocities must be low enough to prevent channel erosion based on the native soil characteristics or the compacted fill material. For velocities above 5 feet per second, channels shall have either rock-lined bottoms and side slopes to the roadway shoulder top with a minimum thickness of 8 inches or shall be stabilized in a fashion acceptable to the City. Water quality shall not be degraded due to passage through an open conveyance. Channels must be stabilized against erosion in compliance with minimum standards for erosion control set forth in Chapter 5. Table 6.3 provides minimum criteria to prevent damage.

Table 6.3. Design Criteria – Open Channels.

Channel Lining	Maximum Design. Velocity (fps)	Maximum Design Slope H/V	Minimum Filter Blanket (inches)
Vegetation	5	3	NA
Geotextile	Varies[a]	Varies[a]	NA
Lattice Block Paving Systems	12	2	Varies[a]
Quarry Spalls, 18-inch diameter	15[b]	2	4
Hand-placed Riprap, 2-foot thick	12	2	4
Gabions	30	Varies[a]	4
Concrete	30	Design	NA

[a] Per manufacturer's instructions.

[b] See Riprap Design, Journal of Hydraulics, ASCE, July 7, 1989.

[c] See Guide for determining gradation of sand and gravel filters, SMN-1, Soil Conservation Service, 1986.

Channels having a slope less than 6 percent and having peak velocities less than 5 feet per second shall be lined with vegetation. Check dams for erosion and sedimentation control may be used for stepping down channels being used for biofiltration.

Channel side slopes shall not exceed 2:1 for undisturbed ground (cuts) as well as for disturbed ground (embankments). All constructed channels shall be compacted to a minimum 95 percent compaction as verified by a Modified Proctor test. Channel side slopes adjacent to roads shall not exceed 4:1 and must meet all other AASHTO and City road standards.

Channels shall be designed with a minimum freeboard of one-half foot when the design flow is 10 cubic feet per second or less and 1 foot when the design discharge is greater than 10 cubic feet per second.

Culverts

For the purpose of this manual, culverts are single runs of pipe that are open at each end and have no structures such as manholes or catch basins. Approved pipe materials are detailed below in the "Storm Drain System" subsection of Section 6.3.5. Galvanized or aluminized pipe are not permitted in marine environments or where contact with salt water may occur, even infrequently through backwater events.

Flow capacity shall be determined by analyzing inlet and outlet control for headwater depth. Nomographs used for culvert design shall be included in the submitted Drainage Control Plan. Appendix 6B includes several nomographs that may be useful for culvert sizing.

All culverts shall be designed to convey the flows per Section 6.3.1. The maximum design water surface elevation in the conveyance system shall allow for the open conveyance protection requirements outlined in Table 6.4, with no saturation of roadbeds. For culverts that convey streams, the maximum design headwater depth shall be below the culvert crown. Minimum culvert diameters are as follows:

- For cross culverts under public roadways – minimum 18 inches, 12 inches if grade and cover do not allow for 18 inches
- For roadside culverts, including driveway culverts, minimum 12 inches.
- For culverts on private property, minimum 8 inches.

Inlets and outlets shall be protected from erosion by rock lining, riprap, or biostabilization as detailed in Table 6.4.

Table 6.4. Open Conveyance Protection.

Velocity Greater Than (fps)	Velocity Less Than or Equal To (fps)	Protection	Thickness (feet)	Minimum Height Required Above Design Water Surface (feet)
0	5	Grass lining[a]	NA	0.5
5	8	Riprap[a,b]	1	2
8	12	Riprap[c]	2	2
12	20	Slope mattress, gabion, etc.	Varies	1

[a] Bioengineered lining allowed for design flow up to 8 feet per second (fps).

[b] Riprap shall be in accordance with Section 9-13.1 of the WSDOT Standard Specifications.
Riprap shall be a reasonably well-graded assortment of rock with the following gradation:
Maximum stone size 12 inches
Median stone size 8 inches
Minimum stone size 2 inches

[c] Riprap shall be reasonably well graded assortment of rock with the following gradation:
Maximum stone size 24 inches
Median stone size 16 inches
Minimum stone size 4 inches

Note: Riprap sizing governed by side slopes on channel, assumed ~3:1.

Debris and access barriers are required on inlet and outlet ends of all culverts greater than 18 inches in diameter. Culverts greater than 36 inches in diameter within stream corridors are exempt.

Minimum culvert velocity shall be 2 feet per second (fps) and maximum culvert velocity shall be 15 fps. Up to 30 fps may be used with an engineered outlet protection design. The City may waive the minimum requirement in cases where topography and existing drainage systems make it impractical to meet the standard. No maximum velocity for ductile iron or high density polyethylene (HDPE) pipe shall be established but outlet protection shall be provided.

All corrugated polyethylene pipe (CPEP) and polyvinyl chloride (PVC) culverts and pipe systems shall have concrete or rock headwalls at exposed pipe ends.

Bends are not permitted in culvert pipes.

The following minimum cover shall be provided over culverts:

- 2 feet under roads
- 1 foot under roadside applications and on private property, exclusive of roads
- If the minimum cover cannot be provided on a flat site, use ductile iron pipe, and analyze for loadings
- Maximum culvert length: 250 feet
- Minimum separation from other pipes:
    - 6 inches vertical (with bedding) and in accordance with the City of Lacey Wastewater Utility Design criteria
    - 3 feet horizontal.

Trench backfill shall be bank run gravel or suitable native material compacted to 95 percent Modified Proctor test to a depth of 2 feet; 90 percent below 2 feet compacted in 8-inch to 12-inch lifts.

All driveway culverts shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sections to match the side slope. Shallow fords may be substituted for culverts on residential driveway crossings of swales.

Culverts in stream corridors must meet any fish passage requirements of the Washington Department of Fish and Wildlife (WDFW).

Storm Drain System

Analysis Methods

Two methods of hydraulic analysis using Manning's Equation are used for the analysis of pipe systems. The first method is the Uniform Flow Analysis Method, commonly referred to as the Manning's Equation, and is used for the design of new pipe systems and analysis of existing pipe systems. The second method is the Backwater Analysis Method (see Section 6.3.2) and is used to analyze the capacity of both proposed, and existing, pipe systems.

When using the Manning's Equation for design, each pipe within the system shall be sized and sloped such that its barrel capacity at normal full flow is equal or greater than the required conveyance capacity as identified in Section 6.3.1. Table 6.5 provides the recommended Manning's "n" values for preliminary design for pipe systems. (Note: The "n" values for this method are 15 percent higher in order to account for entrance, exit, junction, and bend head losses.) Manning's "n" values used for final pipe design must be documented in the Drainage Control Plan.

Table 6.5. Recommended Manning's "n" Values for Preliminary Pipe Design.

Type of Pipe Material	Analysis Method	
	Backwater Flow	Manning's Equation Flow
A. Concrete pipe and CPEP-smooth interior pipe	0.012	0.014
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2⅔- x ½-inch corrugation (riveted)		
a. Plain or fully coated	0.024	0.028
b. Paved invert (40% of circumference paved):		
(1) Flow full depth	0.018	0.021
(2) Flow 0.8 depth	0.016	0.018
(3) Flow 0.6 depth	0.013	0.015
c. Treatment 5	0.013	0.015
2. 2.3- x 1-inch corrugation	0.027	0.031
3. 3.6- x 2-inch corrugation (field bolted)	0.030	0.035
C. Helical 2⅔- x ½-inch corrugation and CPEP-single wall	0.024	0.028
D. Spiral rib metal pipe and PVC pipe	0.011	0.013
E. Ductile iron pipe cement lined	0.012	0.014
F. High density polyethylene pipe (butt fused only)	0.009	0.009

Nomographs may also be used for sizing the pipes. For pipes flowing partially full, the actual velocity may be estimated from engineering nomographs by calculating Q_{full} and V_{full} and using the ratio of Q_{design}/Q_{full} to find V and d (depth of flow). Appendix 6B includes several nomographs that may be useful for culvert sizing.

Acceptable Pipe Sizes

The minimum diameter in the public right-of-way is 12 inches. Laterals less than 12 inches in diameter must be approved by City staff as supported by situation variables. Storm drain pipe used for private roof/footing/yard drain systems or other on-site stormwater management BMPs can be less than 12-inch diameter and sized according to the application and design standards presented in Section 6.3.6 and Chapter 7.

The SDM Administrator may waive these minima in cases where topography, design flows, and existing drainage systems make it impractical to meet the standard.

Pipe Materials

Refer to Chapter 5 of the DG&PWS for pipe materials specifications.

Pipe Slope and Velocity

The minimum velocity is 2 feet per second at design flow. The City may waive this minimum in cases where topography and existing drainage systems make it impractical to meet the standard. Table 6.6 summarizes minimum pipe slopes based on pipe diameter; however, pipe slopes greater than these are desirable.

Table 6.6. Minimum Pipe Slopes based on Pipe Diameter.

Pipe Diameter (inches)	Minimum Pipe Slope (percent)
8	0.40
10	0.28
12	0.22
14	0.17
15	0.15
16	0.14
18	0.12
21	0.10
24	0.08
27	0.07
30	0.06
36	0.05

Table 6.7 Maximum Pipe Slopes and Velocities.

Pipe Material	Pipe Slope Above Which Pipe Anchors Required and Minimum Anchor Spacing	Maximum Slope Allowed	Maximum. Velocity at Full Flow
Spiral Rib, PVC, CPEP-single wall[a]	20% (1 anchor per 100 LF of pipe)	30%[b]	30 fps
Concrete or CPEP-smooth interior[a]	10% (1 anchor per 50 LF of pipe)	20%[b]	30 fps
Ductile Iron	40% (1 anchor per pipe section)	None	None
HDPE[c]	50% (1 anchor per 100 LF of pipe—cross slope installations only)	None	None

[a] Not allowed in landslide hazard areas.

[b] Maximum slope of 200% allowed for these pipe materials with no joints (one section) with structures at each end and properly grouted.

[c] Butt-fused pipe joints required. Above-ground installation is required on slopes greater than 40% to minimize disturbance to steep slopes.

CPEP = Corrugated high density polyethylene pipe

fps = feet per second

HDPE = High density polyethylene

LF = linear feet

PVC = Polyvinyl chloride pipe

Pipes on Steep Slopes

Steep slopes (greater than 20 percent) shall require all drainage to be piped from the top to the bottom in HDPE pipe (butt-fused) or ductile iron pipe welded or mechanically restrained. They shall not be gasketed, slip fit, or banded. On steep slopes, HDPE pipe may be laid on the surface or in a shallow trench, anchored, protected against sluicing, and hand compacted.

HDPE systems longer than 100 feet must be secured at the upstream end if the slope exceeds 25 percent and the downstream end placed in a 4-foot section of the next larger pipe size. This sliding sleeve connection allows for high thermal expansion/contraction.

Pipe System Layout Criteria

Changes of Pipe Size or Direction

Pipe direction changes or size increases or decreases are allowed only at catch basins and manholes. (On private property, for 4-inch- and 6-inch-diameter pipe, clean-outs at junctions are permissible). This does not apply to detention tanks or vaults.

Downsizing of pipes is only allowed under special conditions (i.e., no hydraulic jump can occur; downstream pipe slope is significantly greater than the upstream slope; velocities remain in the 3 to 8 feet per second range, etc.).

Downsizing of downstream culverts within a closed system with culverts 18-inches in diameter or smaller will not be permitted.

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed, except on private roof/footing/yard drain systems on pipes 8-inches in diameter or less, with cleanouts upstream of each wye or tee. Pipes connecting into a structure shall match crown elevations.

Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction (except for HDPE and Ductile Iron pipe with flanged restrained mechanical joint bends, not greater than 30 degrees, on steep slopes). Curvilinear pipe may be installed in strict accordance with manufacturer’s instructions, which shall be attached to the Drainage Control Plan and shall be available on the job site.

A break in grade or alignment or changes in pipe material shall occur only at catch basins or manholes.

Cover Requirements, Trench Design, Pipe Strength

When calculating pipe loading for pipes over 24 inches in diameter or over 10 feet in depth, submit proof of pipe suitability for the design condition. Assume pipe trench will be opened at 45 degrees to the trench bottom unless trench configuration can be predicted with certainty (e.g., trench boxes will be specified). Refer to Chapter 5 of the DG&PWS for more information on pipe cover requirements.

Trash Racks

Where open channels or ponds discharge into storm drain systems, trash racks are required on all storm drain inlet pipes of 18 inches in diameter or larger. Trash racks must be removable with ordinary hand tools.

Manholes and Catch Basins

Catch basins and inlets shall be placed, to the maximum extent practical, within grass "islands" protected from traffic in off-street parking situations to provide some biofiltration before runoff enters the system. Vegetation surrounding catch basins must be protected from traffic.

For the purposes of this manual, all catch basins, manholes, and connecting pipe sizes shall meet current *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT Standard Specifications) and Plans.

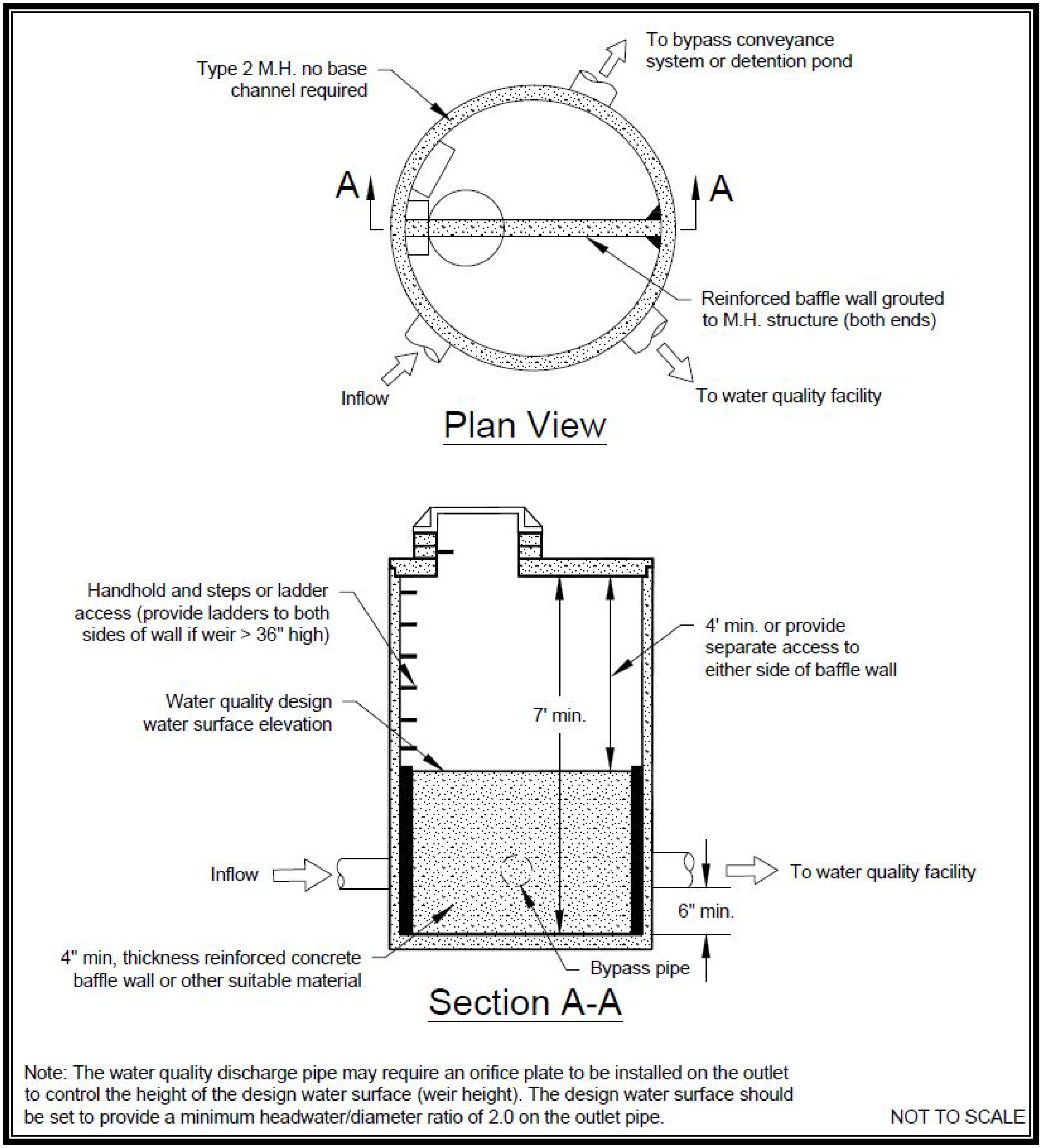
Each catch basin or grated manhole in a storm drain system must have a message pertaining to pollution prevention. Refer to the DG&PWS for details of the applicable standard message.

Flow Splitter Designs

Many runoff treatment BMPs can be designed as flow-through or on-line systems with flows above the water quality design flow or volume simply passing through the BMP at a lower pollutant removal efficiency. However, it is sometimes desirable to restrict flows to runoff treatment BMPs and bypass the remaining higher flows around them through off-line BMPs. This can be accomplished by splitting flows in excess of the water quality design flow upstream of the BMP and diverting higher flows to a bypass pipe or channel. The bypass typically enters a flow control BMP or the downstream receiving drainage system, depending on flow control requirements. In most cases, it is a designer's choice whether runoff treatment BMPs are designed as on-line or off-line; an exception is oil-water separators, which must be designed as off-line.

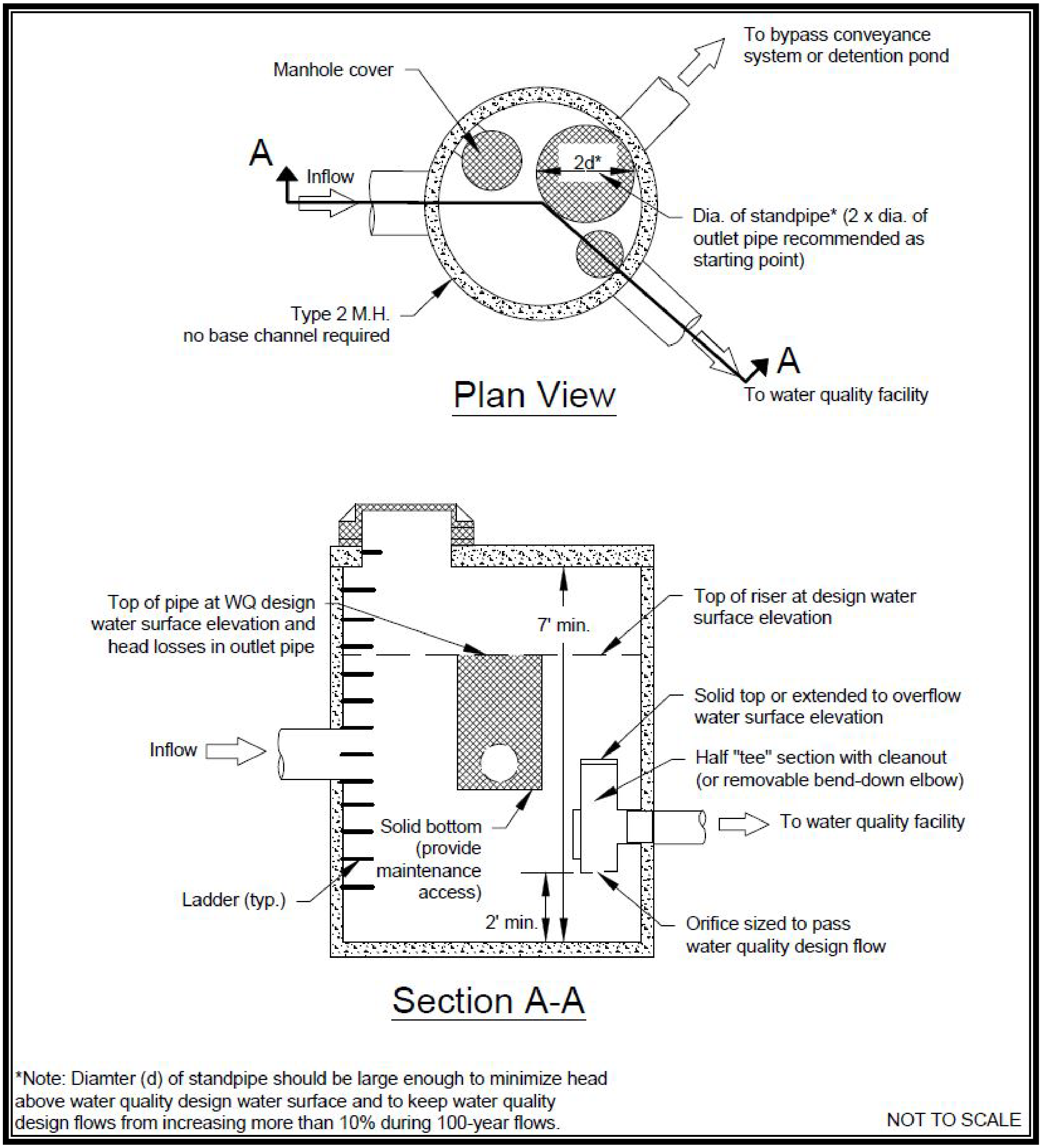
A crucial factor in designing flow splitters is to ensure that low flows are delivered to the runoff treatment BMP up to the water quality design flow rate. Above this rate, additional flows are diverted to the bypass system with minimal increase in head at the flow splitter structure to avoid surcharging the runoff treatment BMP under high flow conditions. Flow splitters may be used for purposes other than diverting flows to runoff treatment BMPs. However, the following discussion is generally focused on using flow splitters in association with runoff treatment BMPs.

Flow splitters are typically manholes or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half T-section with a solid top and an orifice in the bottom of the T-section. A full T option may also be used as described below in the "General Design Criteria." Two possible design options for flow splitters are shown in Figure 6.1 and Figure 6.2. Other equivalent designs that achieve the result of splitting low flows and diverting higher flows around the BMP are also acceptable.



Source: King County

Figure 6.1. Flow Splitter, Option A.



Source: King County

Figure 6.2. Flow Splitter, Option B.

General Design Recommendations

- Unless otherwise specified, a flow splitter shall be designed to deliver the water quality design flow rate specified to the runoff treatment BMP (see also Chapter 8). Flows modeled using a continuous simulation model should use 15-minute time steps.

- The top of the weir shall be located at the water surface for the design flow. Remaining flows enter the bypass line.

- The maximum head should be minimized for flow in excess of the water quality design flow. Specifically, flow to the runoff treatment BMP at the 100-year water surface shall not increase the design water quality flow by more than 10 percent.

- Either design shown in Figure 6.1 or Figure 6.2, or an equivalent design may be used.

- As an alternative to using a solid top plate in Figure 6.2, a full T-section may be used with the top of the T-section at the 100-year water surface. This alternative would route emergency overflows (if the overflow pipe were plugged) through the runoff treatment BMP 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 BMPs, backwater 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, shall be used.

Materials

- The splitter baffle may be installed in a Type 2 manhole or vault.

- The baffle wall shall 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 shall be 4 feet; otherwise, dual access points shall 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 shall not be used because of poor longevity.

Outfalls

All piped discharges to streams, rivers, ponds, lakes, or other open bodies of water are designated outfalls and shall provide for energy dissipation to prevent erosion at or near the point of discharge. Properly designed outfalls are critical to reducing the chance of adverse impacts as the result of concentrated discharges from pipe systems and culverts, both on site and downstream. Outfall systems include rock splash pads, flow dispersal trenches, gabion, or other energy dissipators, 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 for Outfall Features

All energy dissipation at outfalls shall be designed for peak flows from a 100-year, 24-hour storm event. For outfalls with a maximum flow velocity of less than 10 feet per second, a rock splash pad is acceptable. For velocities equal to or greater than 10 feet per second, an engineered energy dissipator must be provided. See Table 6.8 for a summary of the rock protection requirements at outfalls.

Table 6.8. Rock Protection at Outfalls.

Discharge Velocity at Design Flow (fps)	Required Protection				
	Minimum Dimensions[a]				
	Type	Thickness	Width	Length	Height
0 to 5	Rock lining[b]	1 foot	Diameter + 6 feet	8 feet or 4 x diameter, whichever is greater	Crown + 1 foot
5+ to 10	Riprap[c]	2 feet	Diameter + 6 feet or 3 x diameter, whichever is greater	12 feet or 4 x diameter, whichever is greater	Crown + 1 foot
10+ to 20	Gabion outfall[d]	As required	As required	As required	Crown + 1 foot
20+	Engineered energy dissipator required[e]				

[a] These sizes assume that erosion is dominated by outfall energy. In many cases, sizing will be governed by conditions in the receiving waters.

[b] **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 0.75-inch-square sieve: 0 to 10% maximum

[c] **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

[d] Gabion outfalls should not be installed in fish bearing streams.

[e] Energy dissipators shall be located above the Ordinary High Water Mark on fish bearing streams.

fps = feet per second

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

Outfalls must be protected against undercutting. Also consider scour, sedimentation, anchor damage, etc. Pipe and fittings materials shall be corrosion resistant such as aluminum, plastic, fiberglass, high density polyethylene, etc. Galvanized or coated steel will not be acceptable.

The following sections provide general design criteria for various types of outfall features.

General Design Criteria to Protect Aquatic Species and Habitat

Outfall structures shall be located where they minimize impacts to fish, shellfish, and their habitats. However, new pipe outfalls can also 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 dissipator back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream (see Figures 6.3 and 6.4). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows. Potential habitat improvements should be discussed with a WDFW biologist prior to inclusion in design.

Bank stabilization, bioengineering, and habitat features may be required for disturbed areas. Outfalls that discharge to the Puget Sound or a major water body may require tide gates. Contact the City for specific requirements.

Outfalls to streams, wetlands or other waters of the State may be subject to review through the SEPA process, Shorelines Management Act and other applicable regulations. Outfalls also may be subject to hydraulic project permitting requirements of the WDFW, Washington Department of Natural Resources, or the U.S. Army Corps of Engineers, which shall take precedence where more restrictive than those stated herein.

Gabion Outfalls

Gabion outfalls should not be installed in fish bearing streams. One alternative is a four-sided gabion basket located above the Ordinary High Water Mark.

Energy Dissipators

Energy dissipators shall be located above the Ordinary High Water Mark on fish bearing streams.

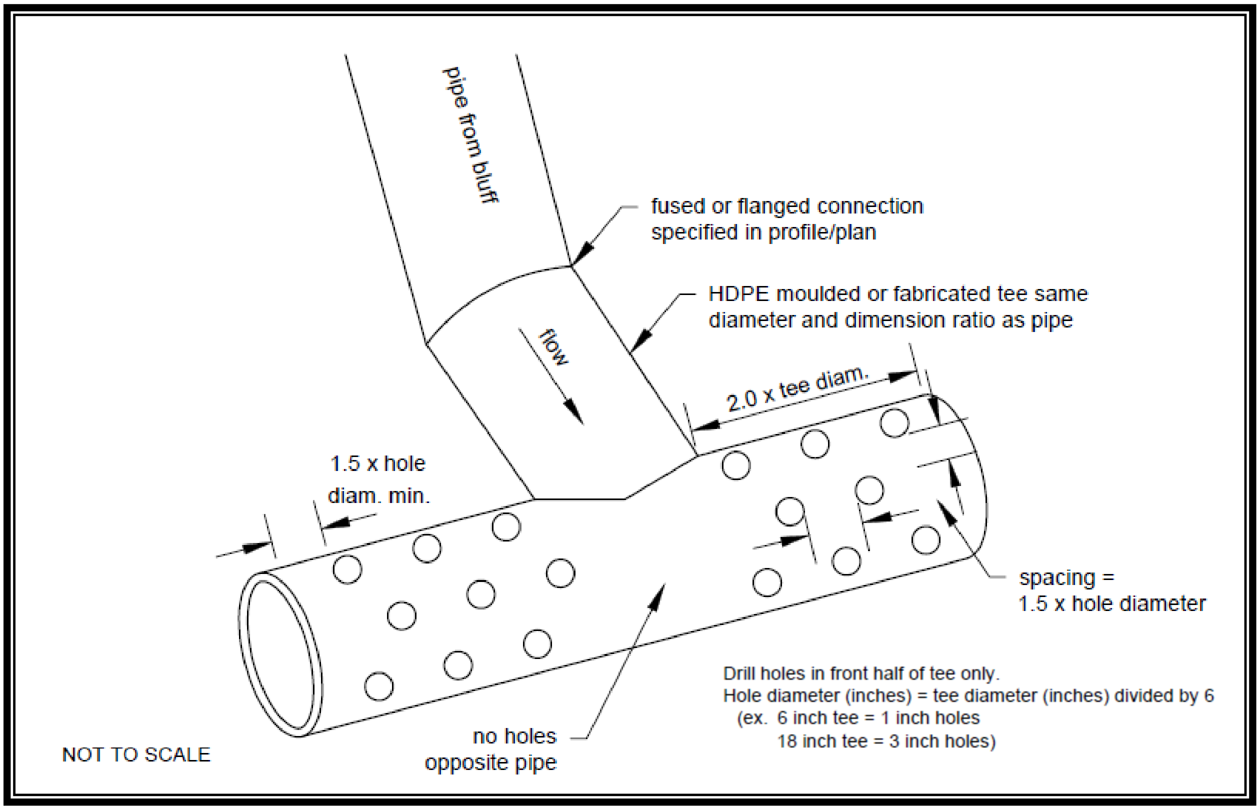
Rock Splash Pad

At a minimum, all outfalls must be provided with a rock splash pad (see Figure 6.5) except as specified below and in Table 6.8.

Flow Dispersal Trench

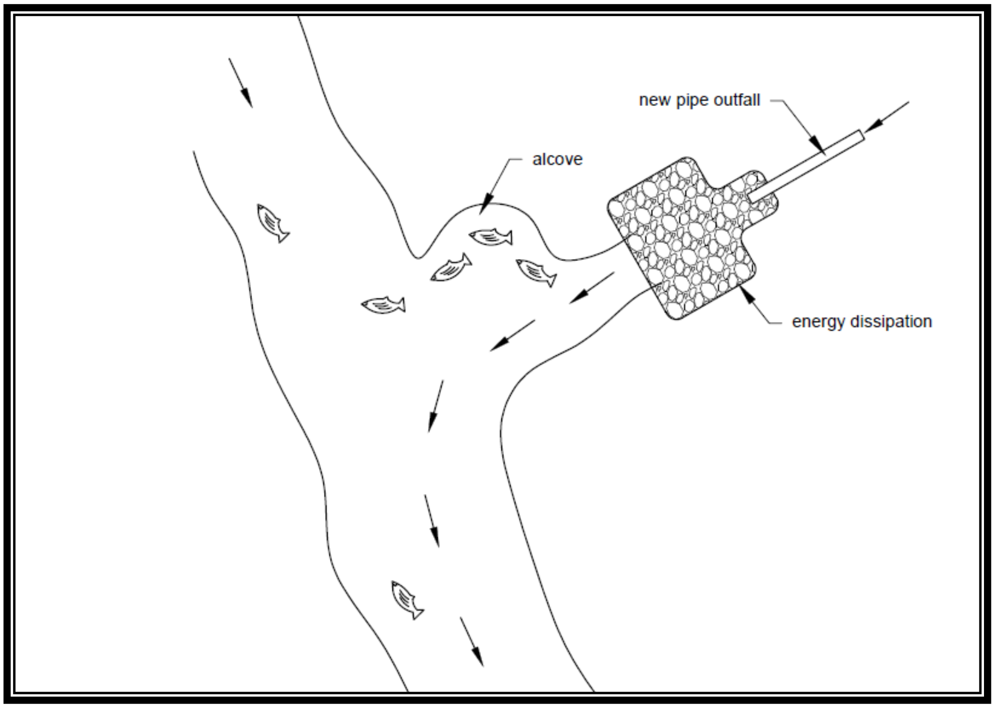
The flow dispersal trenches (see also Figures 6.6 and 6.7) shall only be used when both criteria below are met:

- An outfall is necessary to disperse concentrated flows across uplands where no conveyance system exists, and the natural (existing) discharge is unconcentrated
- The 100-year peak discharge rate is less than or equal to one-half of a cubic foot per second.



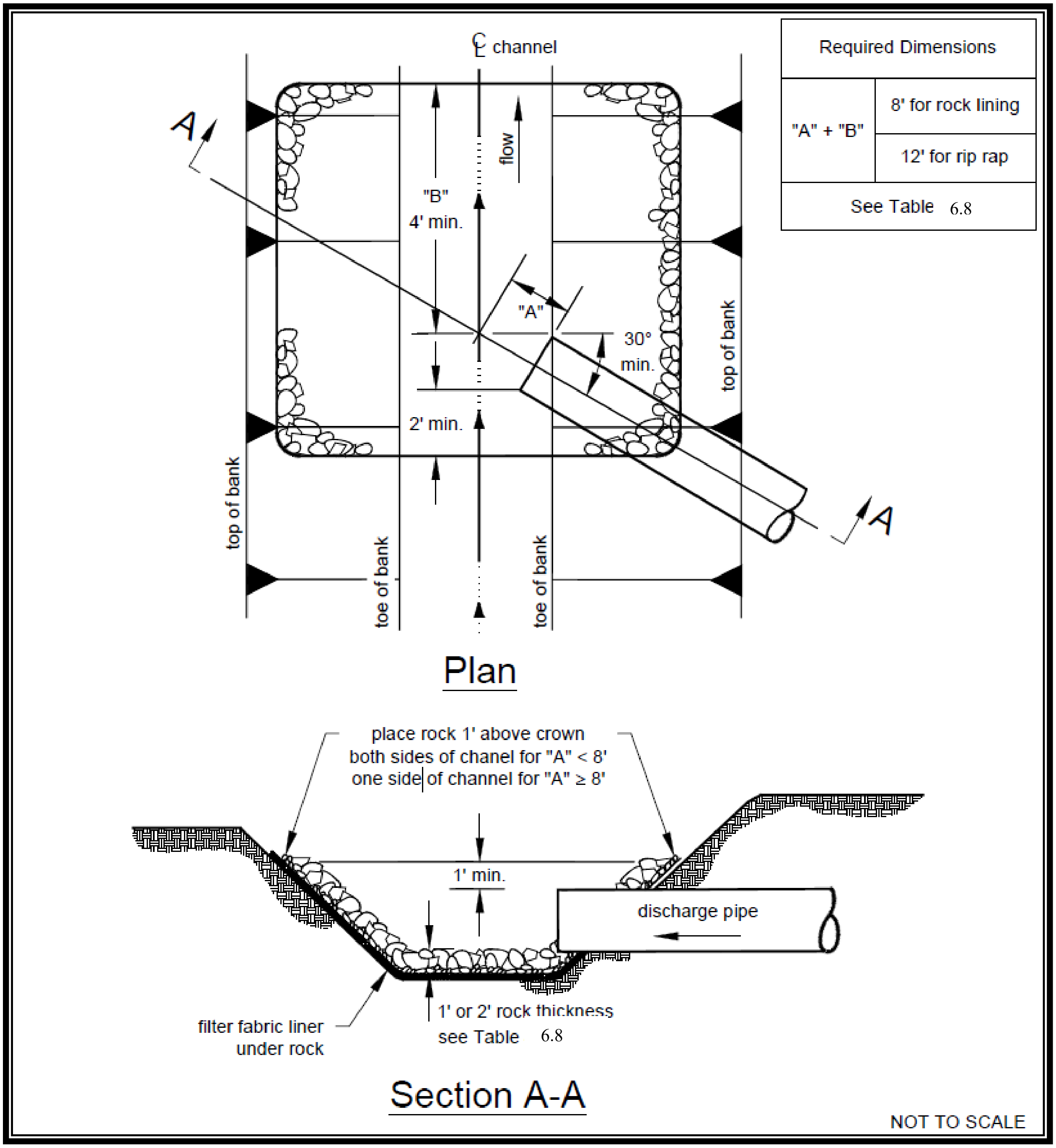
Source: Ecology

Figure 6.3. Diffuser Tee (example of energy-dissipating end feature).



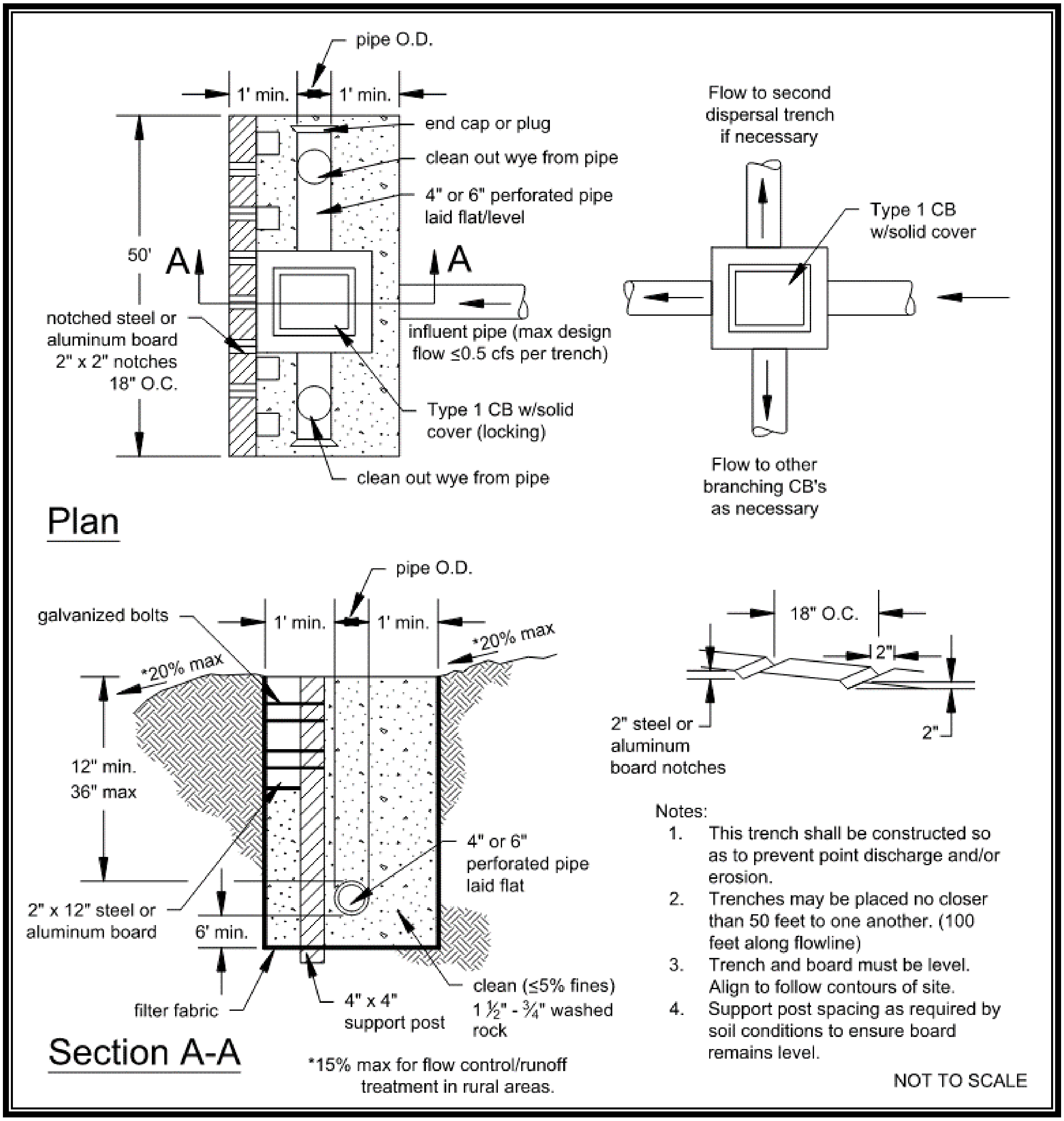
Source: Ecology

Figure 6.4. Fish Habitat Improvement at New Outfalls.



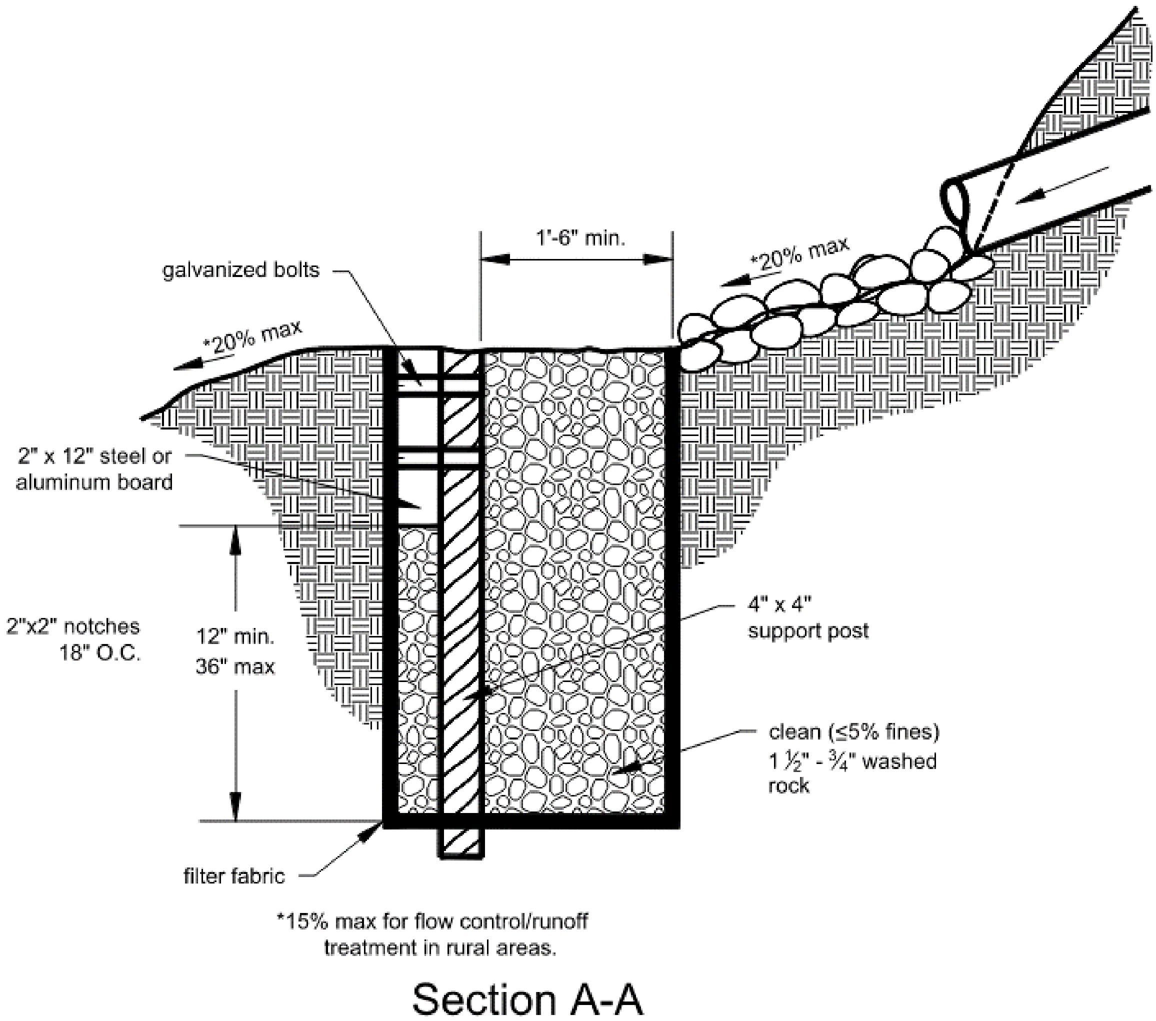
Source: Ecology

Figure 6.5. Pipe/Culvert Outfall Discharge Protection.



Source: Ecology

Figure 6.6. Flow Dispersal Trench.



Notes:

1. This trench shall be constructed so as to prevent point discharge and/or erosion.
2. Trenches may be placed no closer than 50 feet to one another. (100 feet along flowline)
3. Trench and board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure board remains level.

NOT TO SCALE

Source: Ecology

Figure 6.7. Alternative Flow Dispersal Trench.

Tightline Systems

Tightline systems may be needed to prevent aggravation or creation of a downstream erosion problem. The following general design criteria apply to tightline systems:

- Outfall tightlines may be installed in trenches with standard bedding on slopes up to 20 percent. In order to minimize disturbance to slopes greater than 20 percent, it is recommended that tightlines be welded HDPE or restrained joint ductile iron pipe 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 shall 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.

- HDPE pipe 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 shall 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 shall be located as close to the discharge end of the outfall system as is practical.

- Due to the ability of HDPE pipe tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Details of a sample gabion mattress energy dissipator have been provided in Figure 6.8. Flows of very high energy will require a specifically engineered energy dissipator structure.

Flow Spreading Options

Flow spreaders function to uniformly spread flows across the inlet of a runoff treatment BMP (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

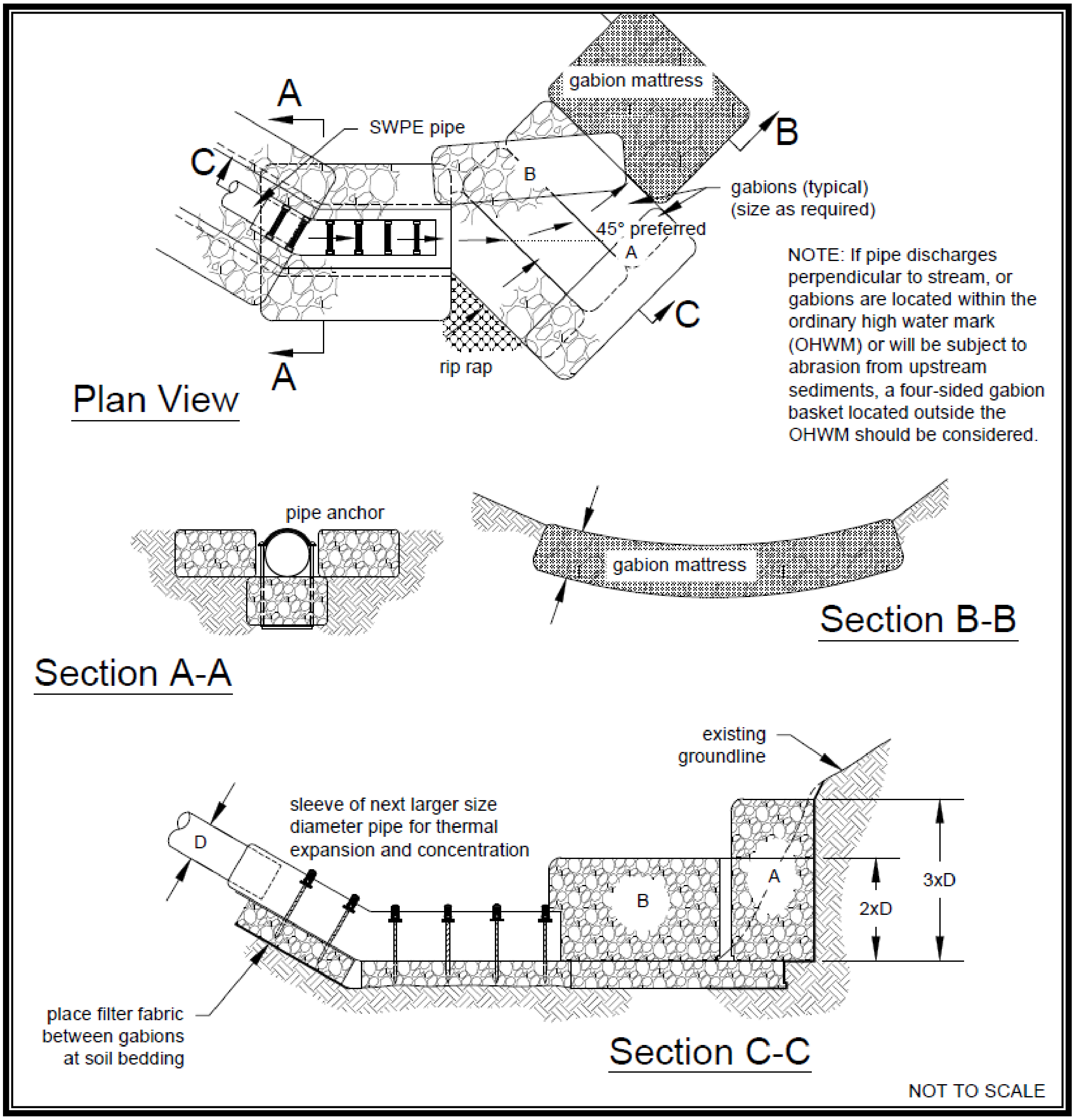
- Option C – Notched curb spreader

- 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 three options can be used when spreading is required by the BMP 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, bioretention area or continuous inflow biofiltration swale. Other flow spreader options are possible with approval from the City.



Source: Ecology

Figure 6.8. Gabion Outfall Detail.

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.

- Flow spreaders are difficult to maintain and continue to evenly distribute flow and should not be used on slopes greater than five percent to prevent recombining of downstream flow that can create rills and gullies. Flow spreaders are not to be used in areas accessible by the public as walking on them can alter their flow characteristics.

- For higher inflows (velocities greater than 5 feet per second for the 100-year recurrence interval storm), a Type 1 catch basin shall be positioned in the spreader and the inflow pipe shall enter the catch basin with flows exiting through the top grate. The top of the grate shall be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the V-notches.

Option A – Anchored Plate (Figure 6.9)

- An anchored plate flow spreader shall 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 shall be lined to reduce erosion and to provide energy dissipation.

- The top surface of the flow spreader plate shall be level, projecting a minimum of 2 inches above the ground surface of the runoff treatment BMP, 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 shall extend horizontally beyond the bottom width of the BMP to prevent water from eroding the side slope. The horizontal extent shall be such that the bank is protected for all flows up to the 100-year recurrence interval flow or the maximum flow that will enter the runoff treatment BMP.

- Flow spreader plates shall 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 shall be 4-inch-square concrete, tubular stainless steel, or other material resistant to decay.

Option B – Concrete Sump Box (Figure 6.10)

- The wall of the downstream side of a rectangular concrete sump box shall 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 shall have "wing walls" at both ends. Side walls and returns shall 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 shall be reinforced with wire mesh for cast-in-place sumps.

- Sump boxes shall be placed over bases that consists of 4 inches of crushed rock, five-eighths-inch minus to help ensure the sump remains level.

Option C – Notched Curb Spreader (Figure 6.11)

- Notched curb spreader sections shall be made of extruded concrete laid side-by-side and level. Typically, five "teeth" per 4-foot section provide good spacing. The space between adjacent "teeth" forms a V-notch.

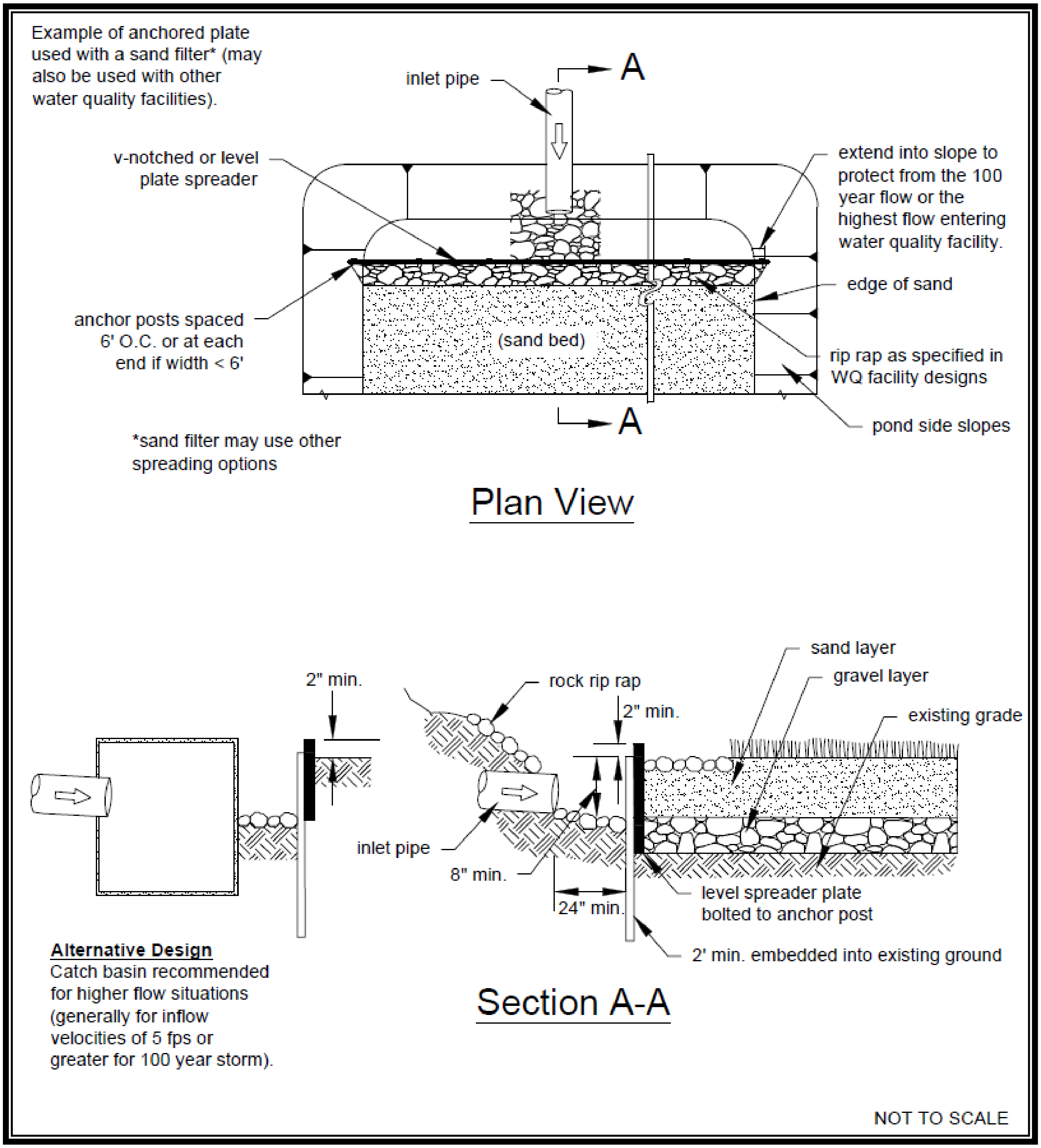
Option D –Through-Curb Ports (Figure 6.12)

- Unconcentrated flows from paved areas entering filter strips, bioretention areas, 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 runoff treatment BMP.

- Openings in the curb shall be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening shall be a minimum of 11 inches. Approximately 15 percent or more of the curb section length shall be in open ports, and no port shall discharge more than about 10 percent of the flow.

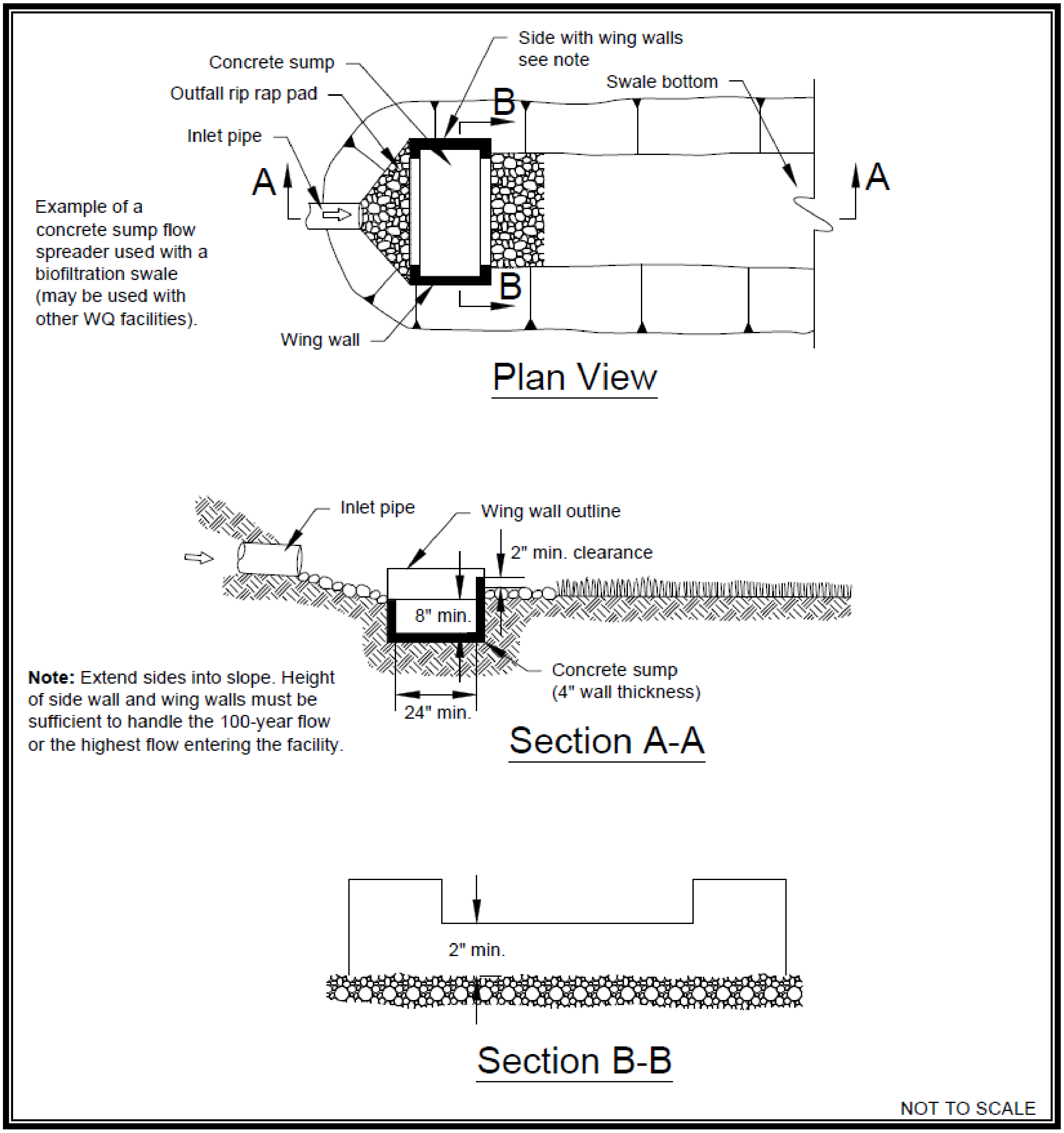
Option E – Interrupted Curb (No Figure)

- Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on BMP) of the treatment area. At a minimum, gaps shall be every 6 feet to allow distribution of flows into the runoff treatment BMP before they become too concentrated. The opening shall be a minimum of 2 inches. As a general rule, no opening shall discharge more than 10 percent of the overall flow entering the BMP.



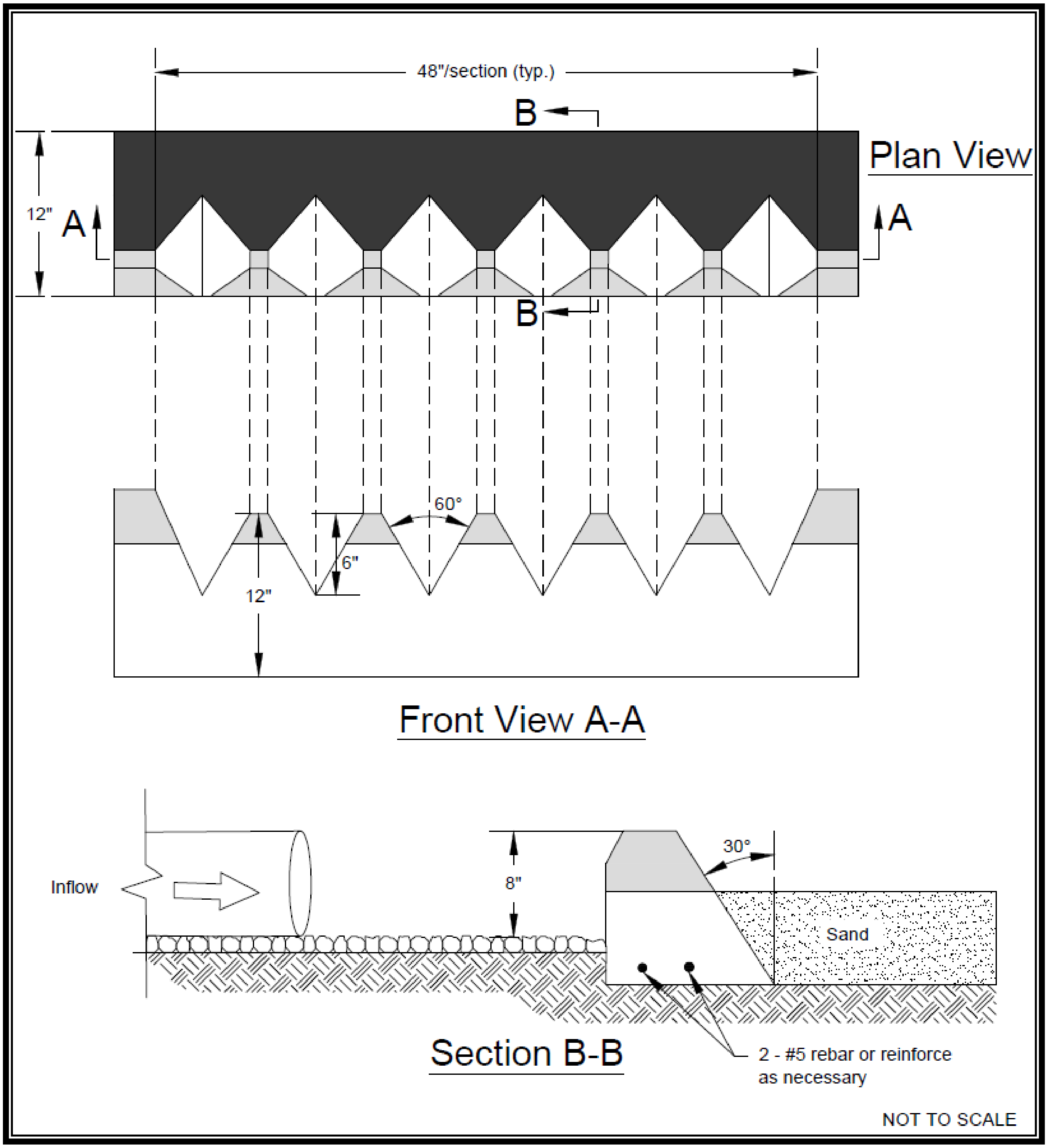
Source: Ecology

Figure 6.9. Flow Spreader Option A: Anchored Plate.



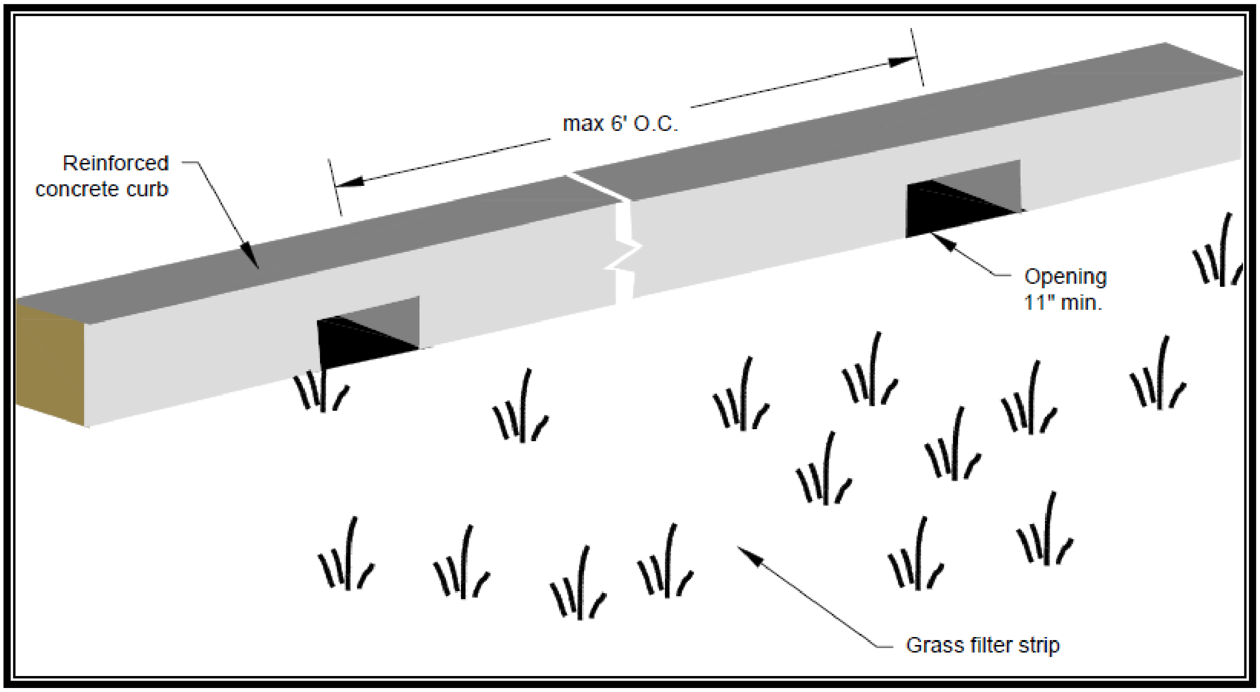
Source: Ecology

Figure 6.10. Flow Spreader Option B: Concrete Sump Box.



Source: Ecology

Figure 6.11. Flow Spreader Option C: Notched Curb Spreader.



Source: Ecology

Figure 6.12. Flow Spreader Option D: Through-Curb Port.

6.3.6 Private Drainage Systems

The engineering analysis for a private drainage system is the same as for a public drainage system. Refer to Section 6.3.5 for conveyance requirements that also apply to private drainage systems.

Private stormwater conveyance piping shall not be located within the public right-of-way. Where soils or other conditions prohibit infiltration on individual parcels (as determined by the City's SDM Administrator), stormwater may be conveyed to the stormwater BMPs associated with the residential or commercial development. In that case, the stormwater conveyance system located in the public right-of-way shall be sized to accommodate the additional stormwater.

Acceptable Pipe Size

The minimum diameter for storm drain pipe on private property is 4 inches. When private stormwater (e.g., roof, lot, or footing drains) cannot be infiltrated on individual lots, the minimum standard piping connection to the public drainage system shall be 8-inch PVC.

Discharge Locations

Stormwater will not be permitted to discharge directly onto public roads or into a public drainage system without the prior approval of the City. Discharges to a public drainage system shall be into a structure such as an inlet, catch basin, manhole, through an approved sidewalk underdrain or curb drain, or into an existing or created public drainage system ditch. Multiple roof drains shall be terminated at a common junction structure outside of the right-of-way (i.e., catch basin or manhole). The connection from the common junction structure to the City's storm drain system shall be through an 8-inch main connecting to a city catch basin or manhole. The 8-inch main used for connection shall begin at the right-of-way, the connection to the catch basin or manhole shall be cored. Concentrated drainage will not be allowed to discharge across sidewalks, curbs, or driveways.

Drainage Stub-Outs

If drainage outlets (stub-outs) are to be provided for each individual lot, the stub-outs shall conform to the requirements outlined below. Note that all applicable core requirements in Chapter 2, in particular Core Requirement #5, must also be addressed for the project site.

- Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved stormwater conveyance system or to an approved discharge location.

- Outlets on each lot shall be located with a 5-foot-high, 2- by 4-inch stake marked "storm" or "drain." For stub-outs to a surface drainage, the stub-out shall visibly extend above surface level and be secured to the stake.

- The developer and/or contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to the utilities (e.g., power, gas, telephone, television).

- All individual stub-outs shall be privately owned and maintained by the property owner including from the property line to the riser on the main line.

Appendix 6A – Design Aids: Design Storm Precipitation Values, Isopluvial Maps, SCS Curve Numbers, Roughness Coefficients, and Soil Types

6A.1 Single Event Model Guidance

The only approved uses of a single event model are for the sizing of construction BMPs and conveyance systems. Approved continuous simulation models must be used for the design of flow control and runoff treatment BMPs.

6A.1.1 SBUH or SCS Methods

The applicant shall use the western Washington SCS curve numbers, not the SCS national curve numbers. These have been included in Table 6A.5 (Tables 6A.1 through 6A.6 can be found at the end of this section, prior to Figures 6A.1 through 6A.3). Individual curve numbers for a drainage area may be averaged into a "composite" curve number for use in either the SCS or SBUH methods.

NRCS has developed "curve number" 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, 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 6A.6 shows the hydrologic soil group of most soils in the City 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).

Isopluvial Maps

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. The applicant has the option of using the National Oceanic and Atmospheric Administration (NOAA) isopluvials for design purposes or utilizing the design storm precipitation values listed in Table 6A.1 below. The listed values can be used to an elevation of 650 feet, Mean Sea Level (MSL). Above 650 feet, MSL, the applicant shall use the NOAA isopluvials for selection of the design storm precipitation, unless otherwise approved by the City.

The professional engineer shall use the best engineering judgment in selecting the runoff totals for the project site.

Time of Concentration

Time of concentration is the sum of the travel times for sheet flow, shallow concentrated flow, and channel flow. For lakes and submerged wetlands, the travel time can be determined with storage routing techniques if the stage-storage versus discharge relationship is known, or it may be assumed to be "zero."

Sheet Flow

With sheet flow, the friction value (n_s) (a modified Manning's effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges and rocks; and erosion and transportation of sediment) is used. These n_s values are for very shallow flow depths of about 0.1 foot and are only used for travel lengths up to 300 feet. Table 6A.3 gives Manning's n_s values for sheet flow for various surface conditions.

For sheet flow of up to 300 feet, use Manning's kinematic solution to directly compute T_t.

$$T_t = \frac{0.42\,(n_s L)^{0.8}}{(P_2)^{0.527}(S_o)^{0.4}}$$

Where:

T_t = travel time (min)

n_s = sheet flow Manning's effective roughness coefficient (Table 6A.3)

L = flow length (ft)

P_2 = 2-year, 24-hour rainfall (in)

S_o = slope of hydraulic grade line (land slope, ft/ft)

The maximum allowable distance for sheet flow shall be 300 feet, the remaining overland flow distance shall be shallow concentrated flow until the water reaches a channel.

Shallow Concentrated Flow

After a maximum of 300 feet, sheet flow is assumed to become shallow concentrated flow. The average velocity for this flow can be calculated using the k_s values from Table 6A.3 in which average velocity is a function of watercourse slope and type of channel.

The average velocity of flow, once it has measurable depth, shall be computed using the following equation:

$$V = k \sqrt{s_o}$$

Where:

V = velocity (ft/s)

k = time of concentration velocity factor (ft/s)

S_o = slope of flowpath (ft/ft)

"k" is computed for various land covers and channel characteristics with assumptions made for hydraulic radius using the following rearrangement of Manning's equation:

$$k = (1.49(R)^{0.667})/n$$

Where:

R = an assumed hydraulic radius

n = Manning's roughness coefficient for open channel flow (see Table 6A.4

Open Channel Flow

Open channels are assumed to begin where surveyed cross-section information has been obtained, where channels are visible on aerial photographs, or where lines indicating streams appear (in blue) on United States Geological Survey (USGS) quadrangle sheets. The kc values from Table 6A.3 used in the Velocity Equation above or water surface profile information can be used to estimate average flow velocity.

Lakes or Wetlands

This travel time is normally very small and can be assumed as zero. Where significant attenuation may occur due to storage effects, the flows shall be routed using a "level pool routing" technique.

Limitations

The following limitations apply in estimating travel time (T_t).

- Manning's kinematic solution shall not be used for sheet flow longer than 300 feet.

- In watersheds with storm drains, carefully identify the appropriate hydraulic flow path to estimate Tc.

- Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or non-pressure flow.

- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. A hydrograph should be developed to this point and a level pool routing technique used to determine the outflow rating curve through the culvert or bridge.

Design Storm Hyetographs

The standard design hyetograph is the NRCS Type 1A 24-hour rainfall distribution resolved into 10-minute (for conveyance sizing) or 15-minute (for BMP sizing) time intervals, with the design storm values as shown in Table 6A.1 below. Various interpretations of the hyetograph are available and may differ slightly from distributions used in other unit hydrograph-based computer simulations. Other distributions will be accepted with adequate justification and as long as they do not increase the allowable release rates.

Subbasin Delineation

Within an overall drainage basin, it may be necessary to delineate separate subbasins based on similar land uses and/or runoff characteristics or when hydraulically “self-contained” areas are found to exist. When this is necessary, separate hydrographs shall be generated, routed, and recombined, after travel time is considered, into a single hydrograph to represent runoff flows into the conveyance system or flow control or runoff treatment BMP.

Hydrograph Phasing Analysis

Where flows from multiple basins or subbasins having different runoff characteristics and/or travel times combine, the design engineer shall sum the hydrographs after shifting each hydrograph according to its travel time to the discharge location of interest. The resultant hydrograph shall be either routed downstream as required in the downstream analysis or routed through the flow control or runoff treatment BMP.

Estimates of Interception

If interception (the volume of precipitation trapped on vegetation) is modeled, the values shown in Table 6A.2 shall be used as user inputs.

Hydrologic Soil Groups

For purposes of runoff computations using NRCS methods, soils in Lacey have the Hydrologic Soil Group designations as listed in Table 6A.6. The two primary soil associations found in the Lacey area are the Spanaway-Nisqually association and the Alderwood-Everett association (asterisked in Table 6A.6 below).

Table 6A.1. Lacey Design Storm Precipitation Values.

Return Frequency 24-Hour Storm Event (years)	Precipitation (in)
0.5	1.79
2	2.80
5	3.75
10	4.35
25	5.10
50	5.65
100	6.15

Note: The 7-day, 100-year storm volume is 12 inches.

Table 6A.2. Interception Values for Various Land Covers.

Land Cover	Interception (inches)
Heavy Forest	0.15
Light Open Forest	0.12
Pasture and Shrubs	0.10
Lawn	0.05
Bare Ground	0.03
Pavement	0.02

Note: Values shown are about 1/2 of those for dry antecedent conditions found in references.

Table 6A.3. "n" and "k" Values Used in Time Calculations for Hydrographs.

"n" Sheet Flow Equation Manning's Values (for the initial 300 ft. of travel)	n_s[a]
Smooth surfaces (concrete, asphalt, gravel, or bare hand packed soil)	0.011
Fallow fields or loose soil surface (no residue)	0.05
Cultivated soil with residue cover (s≤ 0.20 ft/ft)	0.06
Cultivated soil with residue cover (s> 0.20 ft/ft)	0.17
Short prairie grass and lawns	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods or forest with light underbrush	0.40
Woods or forest with dense underbrush	0.80
Shallow Concentrated Flow (After the initial 300 ft. of sheet flow, R = 0.1)	k_s
1. Forest with heavy ground litter and meadows (n = 0.10)	3
2. Brushy ground with some trees (n = 0.060)	5
3. Fallow or minimum tillage cultivation (n = 0.040)	8
4. High grass (n = 0.035)	9
5. Short grass, pasture, and lawns (n = 0.030)	11
6. Nearly bare ground (n = 0.025)	13
7. Paved and gravel areas (n = 0.012)	27
Channel Flow (intermittent) (At the beginning of visible channels R = 0.2)	k_c
1. Forested swale with heavy ground litter (n = 0.10)	5
2. Forested drainage course/ravine with defined channel bed (n = 0.050)	10
3. Rock-lined waterway (n = 0.035)	15
4. Grassed waterway (n = 0.030)	17
5. Earth-lined waterway (n = 0.025)	20
6. CMP pipe (n = 0.024)	21
7. Concrete pipe (0.012)	42
8. Other waterways and pipe	0.508/n
Channel Flow (Continuous stream, R = 0.4)	k_c
9. Meandering stream with some pools (n = 0.040)	20
10. Rock-lined stream (n = 0.035)	23
11. Grass-lined stream (n = 0.030)	27
12. Other streams, man-made channels and pipe	0.807/n[b]

[a] Manning values for sheet flow only, from Overton and Meadows 1976 (See TR-55, 1986).
"k" Values Used in Travel Time/Time of Concentration Calculations.

[b] Determined from Table 6A.3

Source: Washington State Department of Ecology, *Stormwater Management Manual for the Puget Sound Basin*, February 1992.

Table 6A.4. Values of the Roughness Coefficient "n".

Type of Channel and Description	Manning's "n"
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	0.025
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as above, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1. Minor Streams (top width at flood stage <100 feet)	
a. Streams on plain	
1. Clean, straight, full stage no rifts or deep pools	0.030
2. Same as above, but more stones and weeds	0.035
3. Clean, winding, some pools and shoals	0.040
4. Same as above, but some weeds	0.040
5. Same as 4, but more stones	0.050
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2. Flood Plains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035

Table 6A.4 (continued). Values of the Roughness Coefficient "n".

Type of Channel and Description	Manning's "n"
B-2. Flood Plains (continued)	
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as above, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as above, but with flood stage reaching branches	0.120

Source: Washington State Department of Ecology, *Stormwater Management Manual for the Puget Sound Basin*, February 1992.

Table 6A.5. Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas.

Cover Type and Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
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
Open Space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[a]				
Fair condition (grass cover on 50% to 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[b] driveways, etc. (excluding right-of-way)	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
Permeable Pavement				
Porous Asphalt, Porous Concrete, or Grid/Lattice Systems (without underlying perforated drain pipes to collect stormwater) (use landscaped area CNs)	77	85	90	92
Paving Blocks (without underlying perforated drain pipes to collect stormwater) (use 50% landscaped area/50% impervious CNs)	87	91	94	96
All Permeable Pavement Types (with underlying perforated drain pipes to collect stormwater) (use impervious area CNs)	98	98	98	98

Table 6A.5 (continued). Post-Development Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas.

Single-Family Residential[c] (shall only be used for subdivisions >50 acres)		
Dwelling Unit/Gross Acre (DU/GA)	**Average Percent Impervious Area[c,d]**	**Curve Number**
1.0 DU/GA	15	Separate curve number shall be selected for pervious and impervious portions of the site or basin
1.5 DU/GA	20	
2.0 DU/GA	25	
2.5 DU/GA	30	
3.0 DU/GA	34	
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	
PUDs, condos, apartments, commercial businesses, industrial areas and 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 2 of the Natural Resources Conservation Service Technical Release No. 55 (210-VI-TR-55, Second Ed., June 1986).		

[a] Composite Curve Numbers may be computed for other combinations of open space cover type.

[b] Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Chapter 7, Section 7.4.10: Roof Downspout Controls, the average percent impervious area may be adjusted in accordance with the procedure described under “Modeling and Sizing.”

[c] Assumes roof and driveway runoff is directed into street/storm drain system.

[d] All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

Sources: Natural Resources Conservation Service, Technical Release No. 55, *Urban Hydrology for Small Watersheds*, June 1986; Washington State Department of Ecology, *Stormwater Management Manual for Western Washington*, 2019.

Table 6A.6. Hydrologic Soil Group (HSG) of Soils in Lacey and Vicinity.

Soil	HSG	SCS Map Symbol #	Soil	HSG	SCS Map Symbol #	Soil	HSG	SCS Map Symbol #
Alderwood*	C		Hydraquents	D		Puyallup	B	89
Baldhill	B	5–8	Indianola*	A	46–48	Rainier	C	
Baumgard	B		Jonas	B		Raught	B	
Bellingham*	D		Kapowsin*	C/D		Riverwash	variable	
Boistfort	B		Katula	C		Salkum	B	
Bunker	B		Lates	C		Scamman	D	
Cagey*	C	20	Mal	C		Schneider	B	
Cathcart	B		Mashel	B		Semiahmoo	D	
Centralia	B		Maytown	C		Shalcar	D	
Chehalis	B		McKenna*	D		Skipopa*	D	
Delphi	D		Melbourne	B		Spana*	D	
Dupont	D		Mukilteo*	C/D		Spanaway*	A/B	110–114
Dystric Xero. Xerochrepts	C		Newberg	B	71, 72	Sultan	C	115
Eld	B		Nisqually*	B	73, 74	Tacoma	D	
Everett*	A	32–35	Norma*	C/D		Tenino	C	117–119
Everson	D		Olympic	B		Tisch	D	
Galvin	D		Pheeney	C		Vailton	B	
Giles*	B		Pilchuck	C	84	Wilkeson	B	
Godfrey	D		Pits, gravel	N/A	85	Xerorthents	C	
Grove	C	42	Prather	C		Yelm*	C	
Hoogdal*	C		Puget	D				

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 to 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 to 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 to 0.05 in/hr.).

N/A = Not Applicable

Notes:

1. Soils with * are commonly found in the Lacey area.
2. Soils with SCS Map Symbol numbers are found in Category I Critical Aquifer Recharge Areas (per Section 14.36.070 LMC).
3. HSG classifications, as defined by the NRCS (formerly Soil Conservation Service).
4. Where field infiltration tests indicate a measured (initial) infiltration rate less than 0.30 in/hr, continuous simulation model users may model the site as a C soil if needed to meet Core Requirement #5 (LID Performance Standard).

Sources: Soil Conservation Service, *Soil Survey of Thurston County, Washington*, 1990; Natural Resources Conservation Service, Technical Release No. 55, *Urban Hydrology for Small Watersheds*, June 1986.

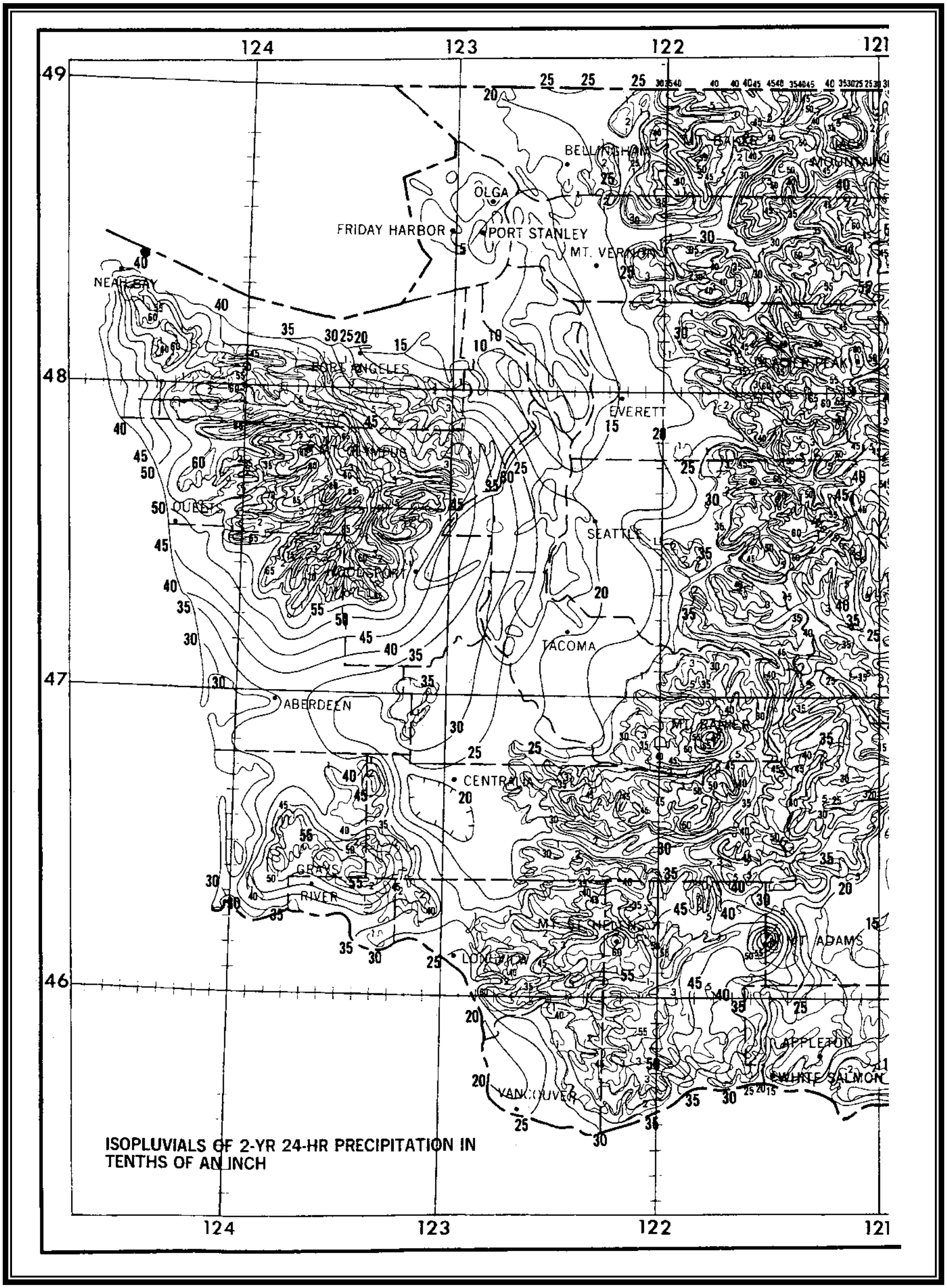


Figure 6A.1. Western Washington Isopluvial 2-Year, 24-Hour.

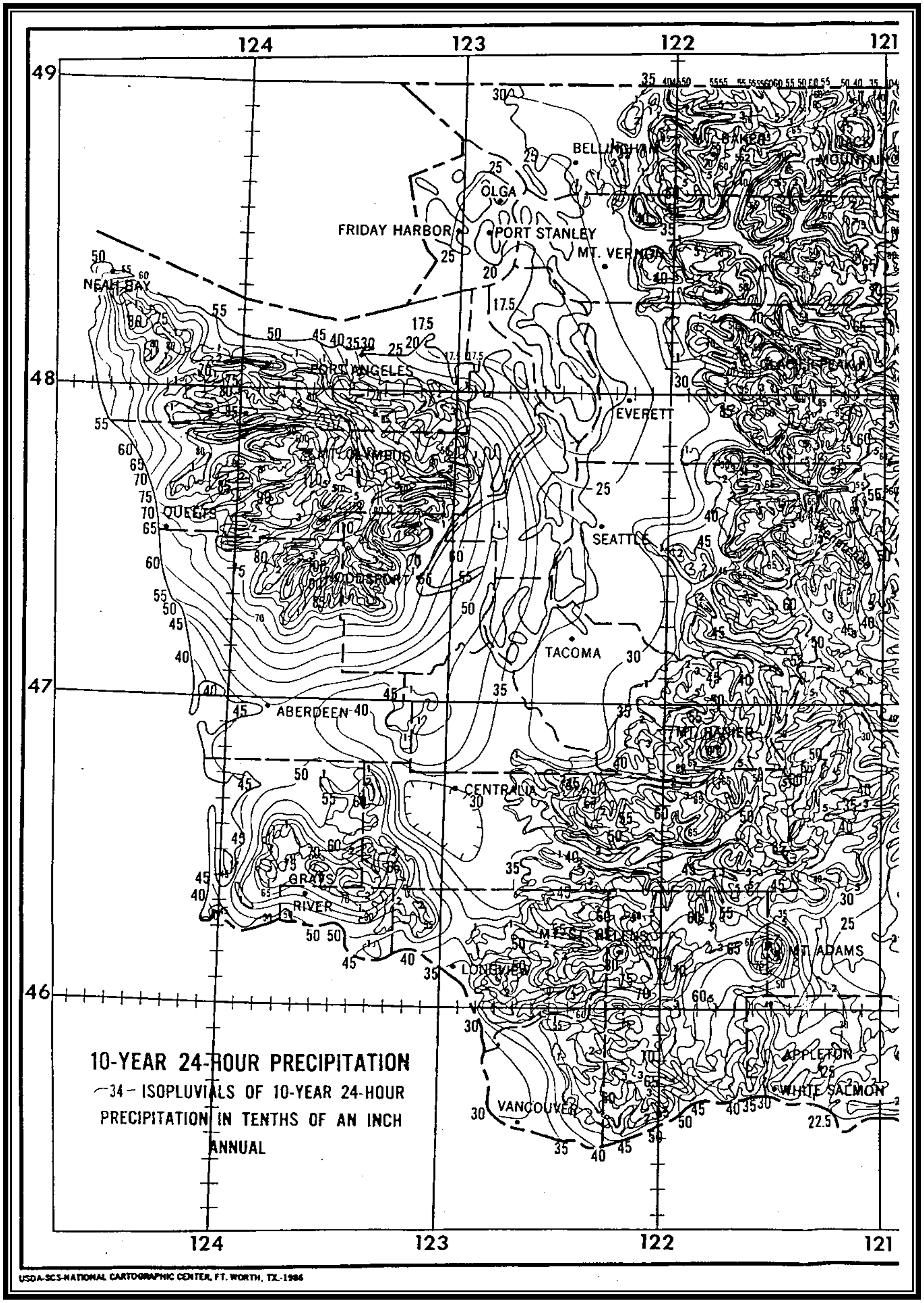


Figure 6A.2. Western Washington Isopluvial 10-Year, 24-Hour.

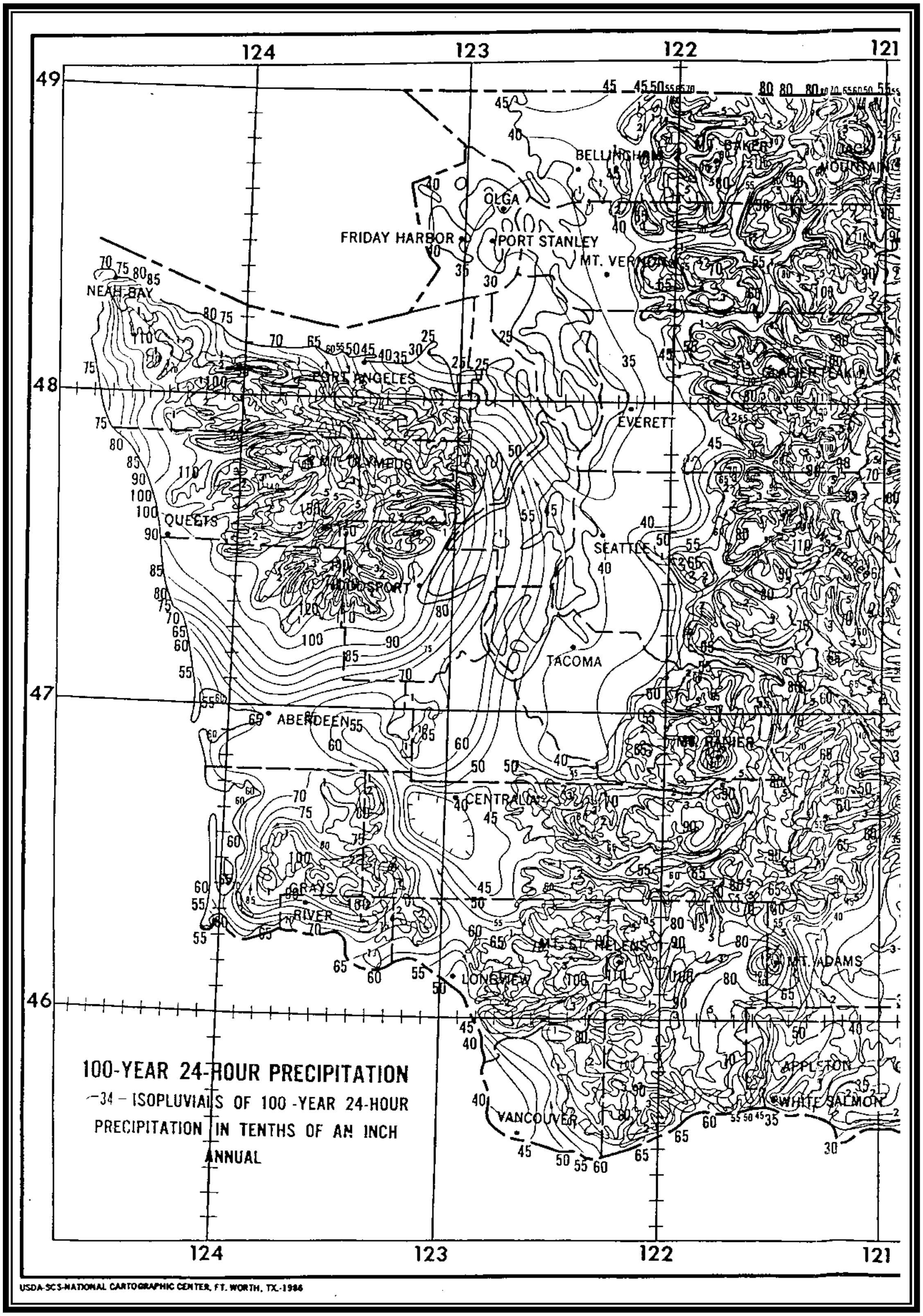


Figure 6A.3. Western Washington Isopluvial 100-Year, 24-Hour.

Appendix 6B – Nomographs for Various Culvert Sizing Needs

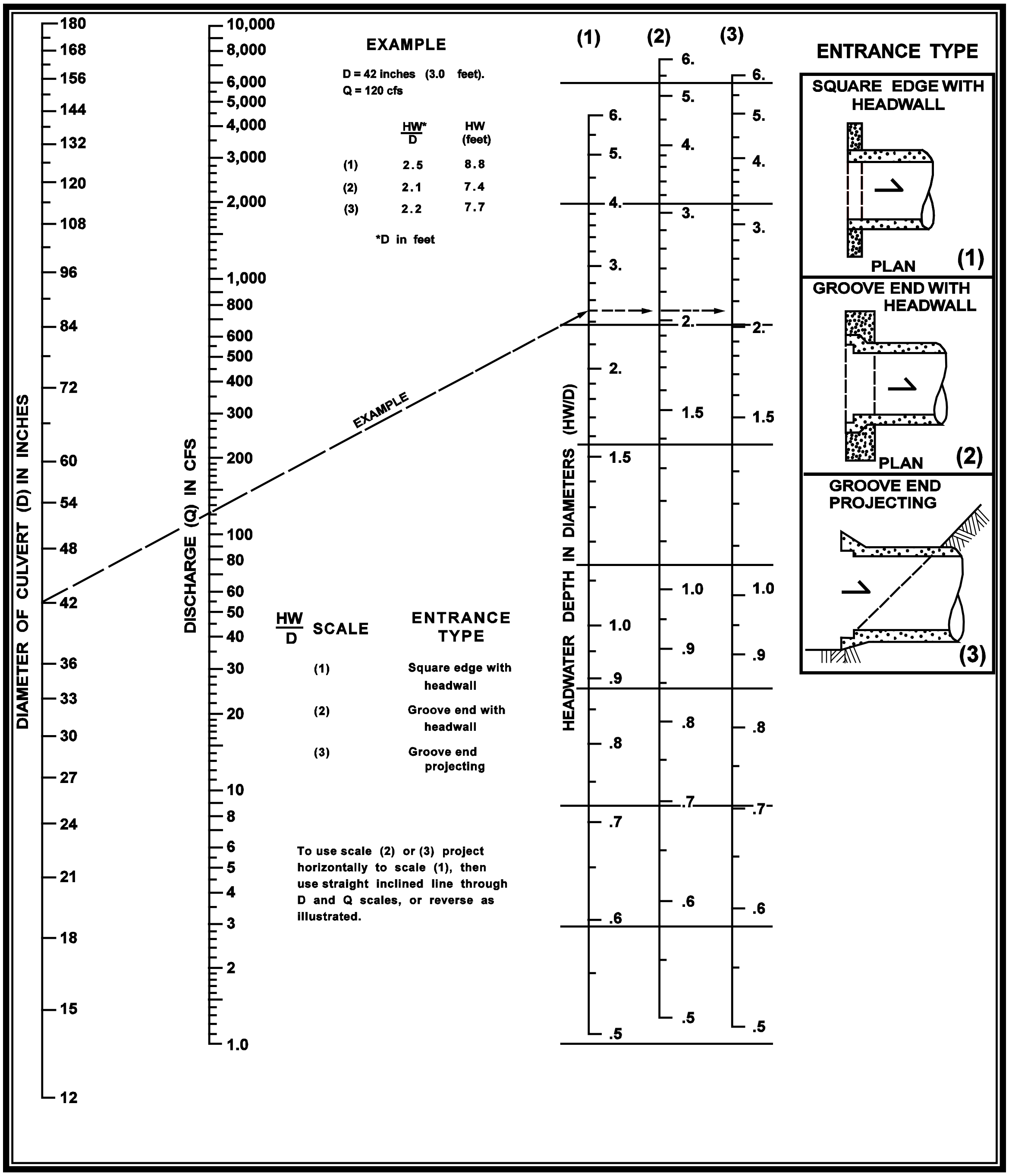


Figure 6B.1. Headwater Depth for Smooth Interior Pipe Culverts with Inlet Control.

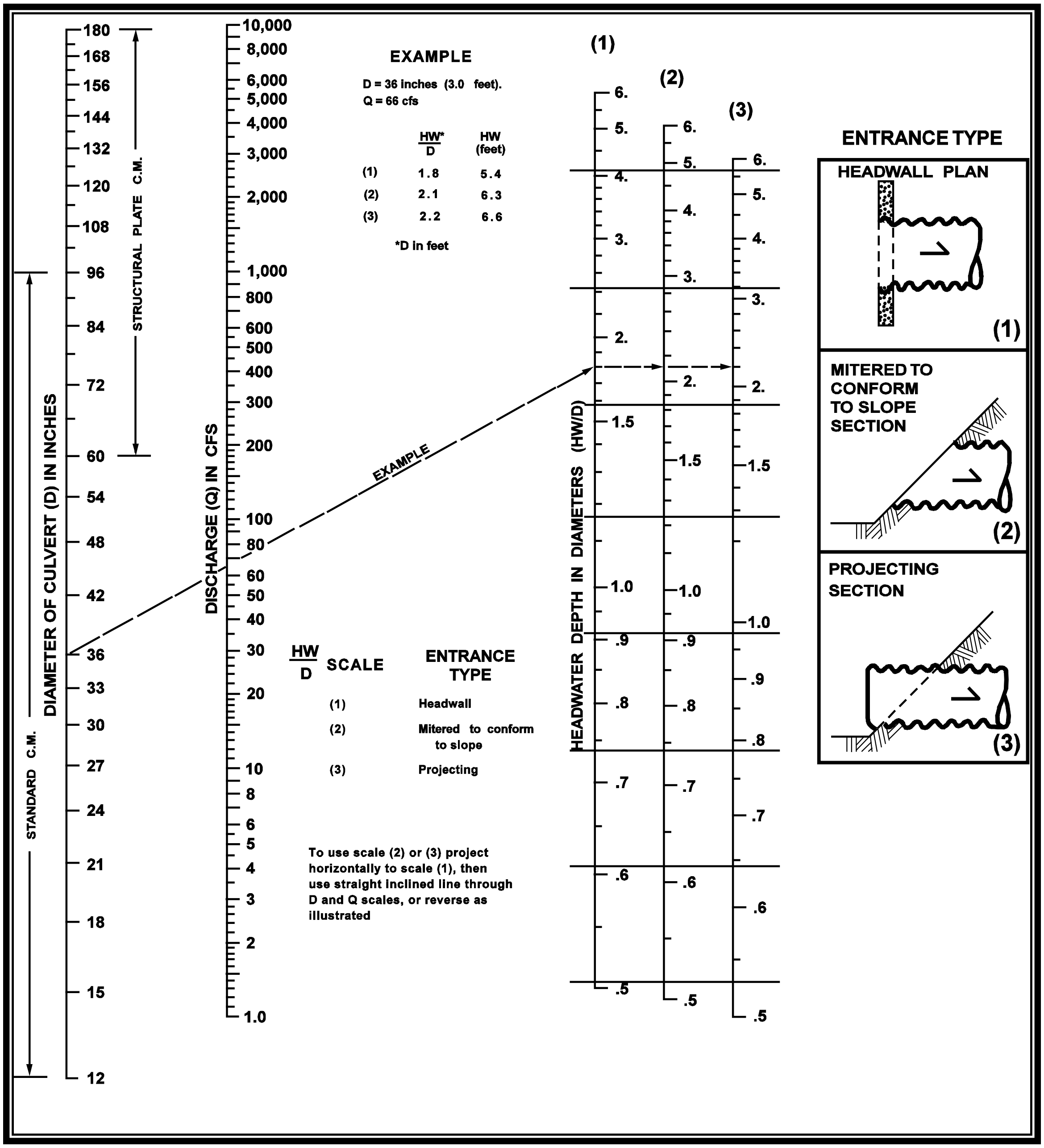
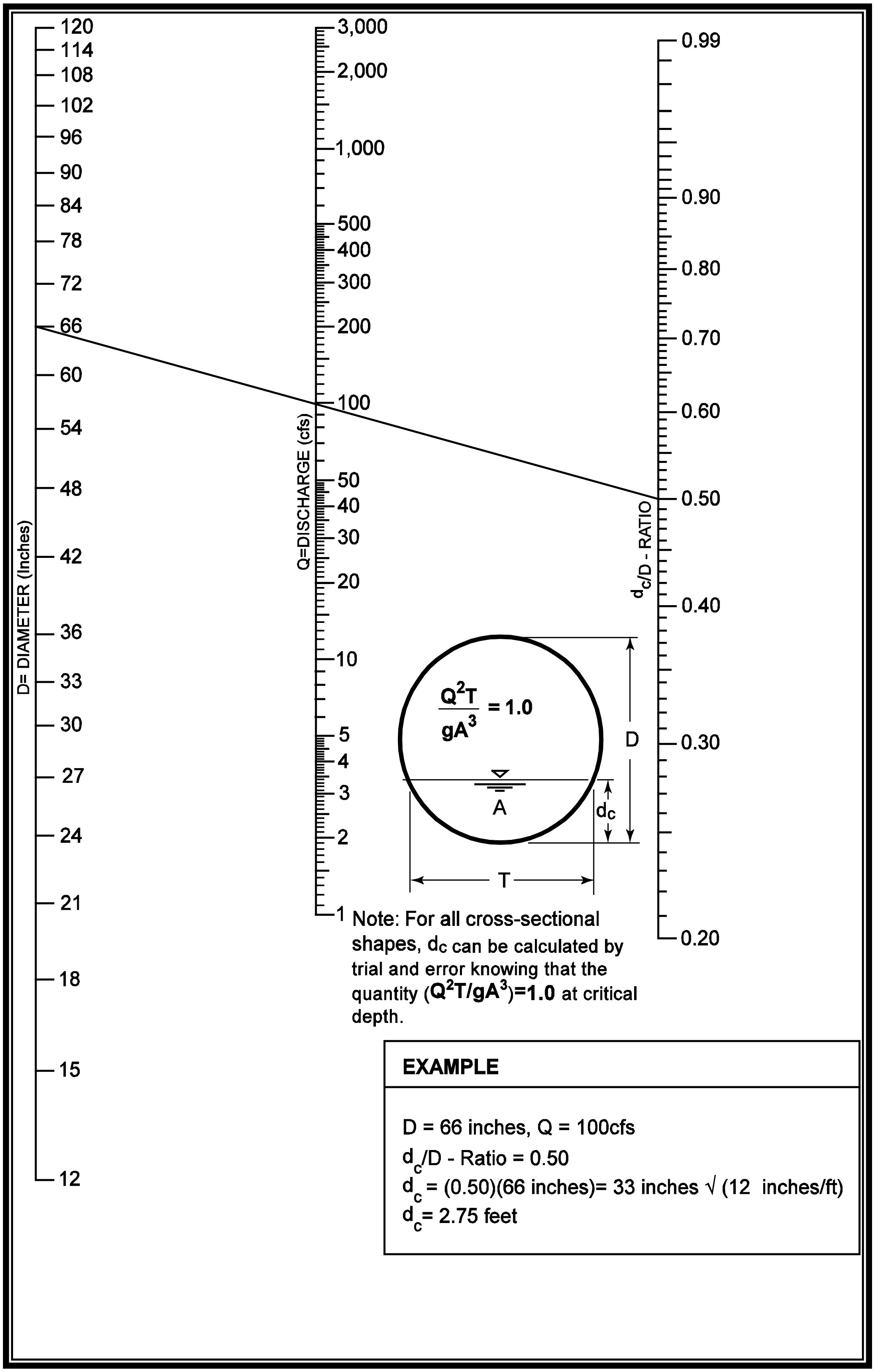


Figure 6B.2. Headwater Depth for Corrugated Pipe Culverts with Inlet Control.



Note: For all cross-sectional shapes, d_c can be calculated by trial and error knowing that the quantity (Q^2T/gA^3)=**1.0** at critical depth.

EXAMPLE
D = 66 inches, Q = 100cfs d_c/D - Ratio = 0.50 d_c = (0.50)(66 inches)= 33 inches √ (12 inches/ft) d_c= 2.75 feet

Figure 6B.3. Critical Depth of Flow for Circular Culverts.

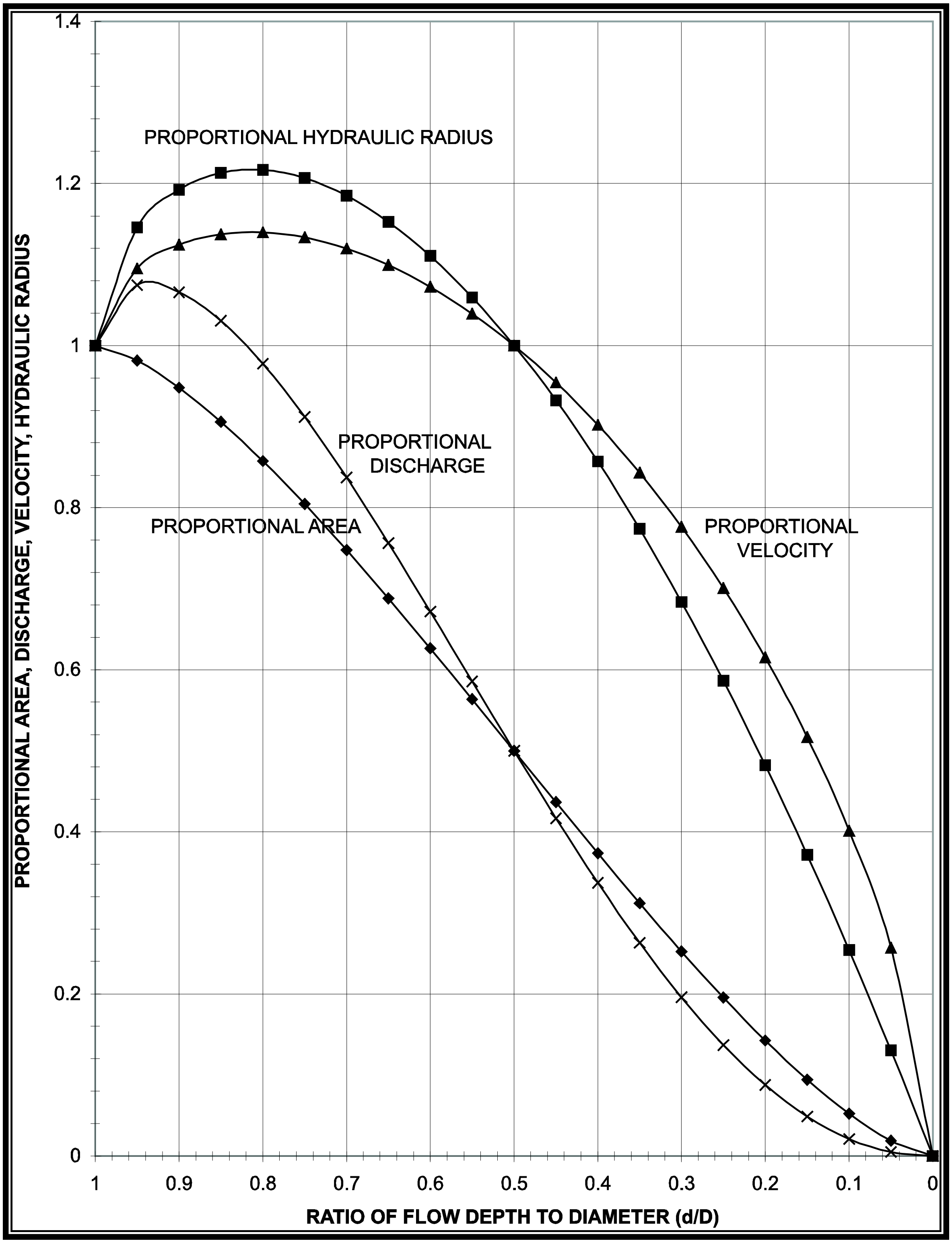


Figure 6B.4. Circular Channel Ratios.

Chapter 7 – Flow Control BMPs

Table of Contents

Tables

Figures

Chapter 7 – Flow Control BMPs

7.1 Purpose, Content, and Organization

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 Chapter 2 of this 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 treatment of runoff to remove sediment and other pollutants
- BMPs addressing prevention of pollution from potential sources.

This chapter focuses mainly on the first category. It presents techniques for hydrologic analysis and BMPs related to management of the amount and timing of stormwater flows from developed sites. The purpose of this chapter is to provide guidance on the estimation and control of stormwater runoff quantity. *BMPs for treating contaminated runoff and for preventing pollution of stormwater runoff are presented in Chapters 8 and 9, respectively.*

The BMPs described in this chapter are likely insufficient by themselves to prevent significant hydrologic disruptions and impacts to streams and their natural resources. Therefore, it is important to look for opportunities to minimize impervious surfaces and retain native vegetation in all development situations.

This chapter details the City of Lacey's (City) policies regarding flow control from developed or artificially altered sites. The scope of this chapter includes:

- Design criteria and specifications for the construction of flow control BMPs
- Approved methods for estimating peak flow rates, volume of runoff, required input data, and required storage volumes based on site conditions (see also Chapter 6)
- Approved materials for use in private and public stormwater BMPs (see also Chapter 6).

The intent of this chapter is to prescribe approved methods and requirements for flow control to prevent impacts to downstream properties or natural resources to the maximum extent practical. The City recognizes that it is not always possible to fully prevent any impacts downstream; in these extreme cases, the project applicant may be required to provide off-site mitigation as determined by the City.

These regulations and criteria are based on fundamental principles of drainage; hydraulics; hydrology; environmental considerations; and publications, manuals, and texts accepted by the professional engineering community. The engineer is responsible for being knowledgeable and proficient with the necessary design methodologies identified within the manual. A partial listing of publications which may be useful as reference documents follows:

- The Washington State Department of Ecology (Ecology) 2019 *Stormwater Management Manual for Western Washington*
- The *Low Impact Development Technical Guidance Manual for Puget Sound* by C. Hinman and B. Wulkan (Washington State University Extension and Puget Sound Partnership)
- *Applied Handbook of Hydrology* by V.T. Chow
- *Handbook of Hydraulics* by E.G. Brater and H.W. King
- The following references published by the Washington State Department of Transportation (WSDOT):
    - Hydraulics Manual
    - Highway Runoff Manual
    - *Standard Specifications for Road, Bridge, and Municipal Construction* (WSDOT Standard Specifications)
    - Standard Plans
- *Soil Survey of Thurston County, Washington* published by the United States Department of Agriculture (USDA) Soil Conservation Service (also refer to the Natural Resources Conservation Service [NRCS] Web Soil Survey at <http://websoilsurvey.sc.egov.usda.gov>).
- City of Lacey *Development Guidelines and Public Works Standards* (DG&PWS), most recent version
- Other information sources acceptable to the City and based on general use by the professional engineering community.

The most current edition of all publications shall be used.

This chapter contains five sections:

- **Section 7.1** serves as an introduction.
- **Section 7.2** discusses information and procedures specific to infiltration BMPs, including the steps required to evaluate the suitability of a site for infiltration BMPs.
- **Section 7.3** discusses underground injection control (UIC) information and requirements.
- **Section 7.4** describes flow control BMPs and provides design specifications for infiltration BMPs specific to flow control (additional water quality design considerations are addressed in Chapter 8).
- **Section 7.5** provides design specifications for detention and retention BMPs.

This chapter also includes three appendices:

- **Appendix 7A** details infiltration testing procedures.
- **Appendix 7B** summarizes the infeasibility criteria that can be used to justify not using various on-site stormwater management BMPs for consideration in the List #1 or List #2 option of Core Requirement #5.
- **Appendix 7C** provides information on underground injection control (UIC) requirements.

7.2 Soil and Infiltration Analysis

Unless otherwise specified within a specific subsection, **the information outlined in Section 7.2 applies to infiltration basins, trenches, and galleries**. Information and procedures specific to other infiltration BMPs (e.g., bioretention BMPs, permeable pavement surfaces, rain gardens, and downspout infiltration systems) are included as part of those specific BMP subsections within Section 7.4.

7.2.1 Purpose

The purpose of this section is to describe the steps required to evaluate the suitability of a site for infiltration BMPs, establish a design infiltration rate, and design BMPs for infiltration.

Infiltration is the percolation of surface water into the ground. While other flow control BMPs, such as detention ponds, reduce peak flow rates associated with developed areas, infiltration BMPs also reduce surface water runoff volumes. When properly sited and designed, infiltration BMPs can help to decrease runoff, recharge groundwater, and protect downstream receiving waters.

Infiltration for runoff treatment is permitted within the City. However, the requirements for infiltration for runoff treatment are substantially different from those for flow control and are outlined in Chapter 8, Section 8.6. To be used for runoff treatment, soils must include sufficient organic content and sorption capacity to remove pollutants. 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 pollution generating surfaces must be preceded by runoff treatment to protect groundwater quality (see Chapter 8). Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa.

Also note that although infiltration is one of the preferred methods for disposing of excess stormwater, infiltration is regulated by Ecology and the UIC program (WAC 173-218). Additional information and requirements for UIC and how it applies to infiltration and stormwater management is included in Section 7.3.

This section also highlights design criteria that are applicable to infiltration BMPs serving a runoff treatment function.

7.2.2 Procedures

The following procedures must be followed when considering and designing an infiltration basin, trench or gallery. Each step is outlined in more detail in the subsequent sections. All pertinent information must be reported in the Soils Report portion of the Drainage Control Plan (see Chapter 3, Section 3.3.3).

Step 1 – Conduct general site reconnaissance, and review survey and other information to identify existing drinking water wells, wellhead protection areas, or critical aquifer recharge areas; existing and proposed buildings; steep slopes; or septic systems in the vicinity of the proposed BMP.

Step 2 – Evaluate minimum requirements for infiltration BMPs to determine whether infiltration is feasible for the site.

Step 3 – Determine whether the simple or detailed method of analysis is required. Consultation with the City is required at this stage to obtain approval for the proposed method of analysis (simple or detailed).

Step 4 – Complete the simple analysis.

Step 5 – Complete detailed analysis, if necessary.

Step 1: General Site Characterization

The first step in designing an infiltration BMP is to select a location and assess the site suitability. The information to be reviewed as part of this initial site characterization will vary from site to site, but may include:

- Topography within 500 feet of the proposed BMP
- Anticipated site use (street/highway, residential, commercial, high-use site)
- Location of water supply wells within 500 feet of proposed BMP
- Location of wellhead protection areas or critical aquifer recharge areas (see area maps in Chapter 8, Appendix 8B as well as on the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/>)
- Locations of any steep slopes, erosion hazards, or landslide hazard areas
- Location of septic systems in the vicinity of the proposed BMP
- Location of soil or groundwater contamination in the vicinity of the site as identified through Ecology's "What's In My Neighborhood" website or an Environmental Data Report.
- A description of local site geology, including soil or rock units likely to be encountered, the groundwater regime, and geologic history of the site.

This information, along with additional geotechnical information necessary to design the BMP, shall be summarized in the Soils Report prepared under Step 4.

Step 2: Minimum Requirements for Infiltration BMPs

*Infiltration is not permissible unless all of the following criteria are met. Note: not all sites that meet the following criteria will be suitable for infiltration—these are **minimum** requirements only:*

- **Setbacks and Site Constraints:**
  - Refer to Setbacks in Section 7.2.3 for setbacks that apply to all infiltration ponds/basins, trenches, and galleries. Refer to Sections 7.4.7 through 7.4.9 for additional setbacks for these BMPs. Refer to other subsections in Section 7.4 for setbacks that apply to other infiltration BMPs (i.e., bioretention BMPs, permeable pavement surfaces, rain gardens, and downspout infiltration systems).
  - If the depth of the infiltration BMP being considered is greater than the largest surface dimension, it is considered an injection well and is subject to the requirements of the UIC Program, Chapter 173-218 WAC **and must be registered with Ecology.** See also Section 7.3.
- **Groundwater Protection Areas:** The applicant must check the maps provided in Chapter 8, Appendix 8B as well as on the City's website at <https://cityoflacey.org/resource_library/stormwater-utility/> to determine if the

project lies within a wellhead protection area or critical aquifer recharge area. A site is not suitable if the infiltration BMP will cause a violation of groundwater quality standards. At a minimum, projects proposing to infiltrate runoff from pollution generating areas must refer to the General Requirements in Chapter 8, Sections 8.2.1 and 8.3.4. Those requirements can affect the design and placement of BMPs on your site. In addition, all infiltration basins, trenches, or galleries located within the 1-year capture zone of any drinking water well must be preceded by an approved runoff treatment BMP (including for runoff from roofs and other non-pollution generating surfaces). Note that the setbacks referred to in the previous bullet item may also include setbacks related to groundwater resources for most infiltration BMPs. The project Soils Report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- **Depth to Bedrock, Water Table, or Impermeable Layer:** The base of all infiltration basins, trenches, or galleries shall be a minimum of 5 feet above seasonal high groundwater levels, bedrock, dense glacial till (“hardpan”), or other low permeability layer. A separation down to 3 feet may be considered if the groundwater 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 criteria specified in this section. Infiltration basins may not be constructed within a floodplain area. Refer to other subsections in Section 7.4 for depth to seasonal high groundwater levels, bedrock, dense glacial till (“hardpan”), or other low permeability layers that apply to other infiltration BMPs (i.e., bioretention BMPs, permeable pavement surfaces, rain gardens, and downspout infiltration systems).

- The maximum depth of an infiltration BMP is 20 feet below the surrounding finished (developed) ground elevation, in order to provide for long-term inspection and maintenance access to the BMP.

Step 3: Determine Method of Analysis

The City encourages consideration of infiltration BMPs for sites where conditions are appropriate. However, some sites may not be appropriate for infiltration due to soil characteristics, groundwater levels, steep slopes, or other constraints. All proposed infiltration basins, trenches, and galleries are required, at a minimum, to perform the simple analyses specified below. For those sites that present a risk of infiltration system failure, a more detailed method of analysis is required in addition to the simple analysis.

The sections below outline the criteria to be considered when determining whether a project is subject to the simplified or the detailed method of analysis. The chosen method of analysis must be submitted for approval by the City. Moreover, the City may require that the detailed method of analysis be conducted based on the results of the simple method. (See Section 7.4.4, Bioretention Cells, Swales, and Planter Boxes and Section 7.4.5, Rain Gardens for methods specific to bioretention and rain gardens. See Section 7.4.6, Permeable Pavement for methods specific to permeable pavement.)

Simple Method (Detailed in Step 4 Below)

Projects considering using the simplified method generally will have the following characteristics:

- Small BMPs serving short plats or commercial developments with less than 1 acre of contributing area
- High infiltration capacity soils (NRCS Hydrologic Soil Group A or B) with no restrictive layers within 15 feet of the ground surface
- Evidence of other infiltration BMPs performing successfully at nearby locations in similar soil conditions
- No septic systems, steep slopes, or other sensitive features within 500 feet
- Low risk of flooding and property damage in the event of clogging or other failure of the infiltration system.

Detailed Method (Detailed in Steps 4 and 5 Below)

Where there is not clear evidence that a site is well-suited to infiltration, a more detailed method of analysis will be required. The detailed method of analysis, described below, includes more intensive field testing and soils investigation and analyses than the simplified method. Site conditions that will likely require use of the detailed method may include:

- Low infiltration capacity soils (NRCS Hydrologic Soil Group C or D), including glacial till soils
- History of unsuccessful infiltration BMP performance, or no history of successful infiltration performance at nearby locations
- A large contributing drainage area
- High groundwater levels
- High risk of flooding in the event of clogging or other failure.

Step 4: Simple Analysis

The following analyses are required for all proposed infiltration basins, trenches, and galleries. Refer to other subsections in Section 7.4 for additional information on infiltration testing procedures that apply to other infiltration BMPs (i.e., bioretention BMPs, and permeable pavement surfaces). Project sites with infiltration rates lower than those identified in the infeasibility criteria for each BMP (refer to Appendix 7B) may be used for infiltration of stormwater only if the City approves the design.

Conduct Soils Testing

- **Timing:** Test hole or test pit explorations shall be conducted during the **mid to late "wet season" (December 1 through April 30)** to provide accurate soil saturation and groundwater information. Soil explorations conducted during other times of the year (e.g., summer or fall) may be subject to supplementary explorations and/or groundwater monitoring during the December 1 through April 30 period prior to design acceptance.

- **Sampling Depth:** Collect representative continuous samples from each soil type and/or unit to a depth below the base of the infiltration BMP of 2.5 times the maximum design ponded water depth, but not less than 10 feet.

  - 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.

- **Locations:** Soil test locations shall be within each proposed infiltration BMP footprint or in close proximity (typically within 10 feet), to be considered valid for the proposed BMP location.

  - For infiltration basins and galleries, there shall be one test pit or test hole per 5,000 square feet of BMP infiltrating surface with a minimum of two per BMP, regardless of BMP size.

  - For infiltration trenches, there shall be one test pit or test hole per 200 feet of trench length with a minimum of two required per trench, regardless of length.

- **Mapping:** Prepare a map showing the location of the test pits and/or test holes relative to both existing topography and proposed site plan layout including infiltration BMP locations.

- **Soil Logs:** Prepare detailed logs for each test pit or test hole. Logs must include the existing ground surface elevation, soil descriptions (including classifications) and depths, elevations of any restrictive layers (such as glacial till and/or water table), seasonal high groundwater elevation (and how it was determined), proposed BMP bottom elevation, and presence of any stratification or other factors that may impact the infiltration design.

  - If using the soil grain size analysis method for estimating infiltration rates, include laboratory testing as necessary to establish the soil gradation characteristics and other properties to complete the infiltration BMP design. At a minimum, conduct one grain size analysis per soil stratum in each test hole to a depth of 10 feet below the proposed base of the infiltration BMP. 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 BMP, requiring soil gradation/classification testing for layers deeper than indicated above.

- Determine design infiltration rate as described in detail in Appendix 7A. Note that the maximum allowable design infiltration rate is 20 inches per hour.

Prepare Soils Report

A report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington that summarizes site characteristics and demonstrates that sufficient permeable soil for infiltration exists at the proposed BMP location. Refer to Chapter 3, Section 3.3.3, for Drainage Control Plan Soils Report content requirements.

Estimate Volume of Stormwater

Estimate the volume of stormwater runoff using an approved continuous runoff model. The runoff file developed for the project site serves as input to the infiltration BMP.

For infiltration BMPs sized simply to meet runoff treatment requirements, the BMP must successfully infiltrate 91 percent of the runoff volume. The remaining 9 percent of the runoff volume can bypass the infiltration BMP. Note that infiltration BMPs used to provide runoff treatment must either have a treatment layer as part of the BMP (such as Section 7.4.4, Bioretention Cells, Swales, and Planter Boxes), or the native soils must meet the criteria for runoff treatment per Chapter 8, Section 8.6.3.

For infiltration BMPs sized to meet the LID Performance Standard (Chapter 2, Section 2.2.5) and/or the discharge requirements defined in Core Requirement #7 (Chapter 2, Section 2.2.7), the BMP must infiltrate either all of the runoff volume, or a sufficient amount of the runoff volume such that any overflow/bypass meets the standard.

Step 5: Detailed Analysis

In addition to the simple method requirements outlined above, projects subject to the detailed analysis method shall include infiltration receptor characterization, as outlined below.

Infiltration Receptor Characterization

Monitor Groundwater Levels

- A minimum of three groundwater monitoring wells shall be installed per infiltration BMP that will establish a three-dimensional relationship for the groundwater table unless the highest groundwater level is known to be at least 50 feet below the proposed base of the infiltration BMP.

- Seasonal groundwater levels must be monitored at the site during at least one mid to late "wet season" (December 1 through April 30).

- Normalize the single winter season observation to historical groundwater records in the region.

Characterize Infiltration Receptors in Soils Report

Address the following:

- Depth to groundwater and to bedrock/impermeable layers.
- Seasonal variation of groundwater table based on well water levels and observed mottling of soils.
- Existing groundwater flow direction and gradient.
- Volumetric water holding capacity of the infiltration receptor soils. The volumetric water holding capacity is the storage volume in the soil layer directly below the infiltration BMP and above the seasonal high groundwater mark, bedrock, hardpan, or other low permeability layer.
- Horizontal hydraulic conductivity of the saturated zone to assess the aquifer's ability to laterally transport the infiltrated water.
- Approximation of the lateral extent of infiltration receptor.
- Impact of the infiltration rate and proposed added volume from the project site on local groundwater mounding, flow direction, and water table determined by hydrogeologic methods.
- The City may require a groundwater mounding analysis on projects where an infiltration BMP has a drainage area exceeding 1 acre and has less than 10-foot depth to seasonal high groundwater (as measured from the bottom of the infiltration basin or trench) or other low permeability stratum. Groundwater mounding analysis methods are subject to City approval and may include an analytical groundwater model (such as MODRET) to investigate the effects of the local hydrologic conditions on BMP performance.
- State whether location is suitable for infiltration and recommend a design infiltration rate. Note that the maximum allowable design infiltration rate is 20 inches per hour.

Construct the BMP and Conduct Performance Testing

The project engineer or designee shall inspect all infiltration BMPs (e.g., basins, trenches, and galleries) before, during, and after construction as necessary to ensure BMPs are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place.

Before release of the maintenance bond, the project engineer shall perform a minimum of two performance tests of each infiltration BMP after construction to determine that the BMP will operate as designed. For trenches and galleries, the type of performance test will depend on specific BMP and site constraints, and therefore shall be determined by the project engineer on a case-by-case basis and must be submitted for approval by the City prior to testing. For infiltration basins, the project engineer shall perform a sufficient number of modified falling-head percolation tests (a minimum of two). The City must be notified of the scheduled infiltration testing at least two working days in advance of the test. See Appendix 7A for infiltration testing requirements. If the tests indicate the BMP will not function as designed, this information must be brought to the immediate attention of the City along with any reasons as to why not and how it can be remedied.

In addition, before release of the maintenance bond, the completed BMP must be monitored through a minimum of one winter "wet season," December 1 to April 30, to demonstrate that the BMP performs as designed. The monitoring must occur after permanent erosion control and site stabilization measures have been installed. If tests indicate that the BMP will not function as designed (as per the Maintenance and Source Control Manual developed for the project), this information must be brought to the immediate attention of the City along with reasons and potential remedies.

7.2.3 General Criteria for Infiltration Basins, Trenches, and Galleries

This section covers design, construction, and maintenance criteria that apply to infiltration basins, trenches, and galleries. Similar information for other infiltration BMPs (i.e., bioretention BMPs, permeable pavement surfaces, rain gardens, and downspout infiltration systems) is included under the detailed BMP descriptions within the individual BMP subsections in Section 7.4.

Design Criteria – Sizing BMPs

- The size of infiltration basins, trenches, and galleries can be determined by routing the influent runoff file generated by the continuous runoff model through the BMP. In general, an infiltration BMP would have two discharge modes. The primary mode of discharge from an infiltration BMP is infiltration into the ground. However, when the infiltration capacity of the BMP is reached, additional runoff to the BMP will cause the BMP to overflow. Overflows from an infiltration basin, trench, or gallery must comply with the Core Requirement #7.

- Infiltration BMPs used for runoff treatment must not overflow more than 9 percent of the runoff volume.

- In order to determine compliance with the LID performance standard and/or the flow control requirements, WWHM or an appropriately calibrated continuous simulation runoff model must be used. When using WWHM for simulating flow through an infiltrating BMP, represent the BMP by using the appropriate element within the software (e.g., pond, trench, permeable pavement, or bioretention) and entering the predetermined infiltration rates. Below are the procedures for sizing a basin to completely infiltrate 100 percent of runoff.

For 100 Percent Infiltration

- Input dimensions of your infiltration BMP.
- Input infiltration rate and safety (rate reduction) factor. See Appendix 7A for methods for determining infiltration rates.
- Input a riser height and diameter (any flow through the riser indicates that you have less than 100 percent infiltration and must increase your infiltration BMP dimensions).
- Run the continuous simulation for the developed mitigated scenario. (Evaluating runoff durations for the 100 percent infiltration is not necessary.)
- Evaluate the percentage infiltrated at the bottom right. If less than 100 percent infiltrated, increase BMP dimension until reaching 100 percent.

Pretreatment

A BMP to remove a portion of the influent suspended solids must precede infiltration basins, trenches, and galleries (unless the BMP is **only** managing runoff from rooftop areas). Use either an option under the basic treatment BMP menu (see Chapter 8, Section 8.3.6), or a pretreatment option from Chapter 8, Section 8.5. The lower the influent suspended solids loading to the infiltration BMP, the longer the infiltration BMP can infiltrate the desired amount of water or more, and the longer interval between maintenance activity.

Reduction in infiltration capability can have significant maintenance or replacement costs in infiltration basins, trenches, and galleries; therefore, selection of a reliable treatment device with high solids removal capability is preferred. In BMPs 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 8, Section 8.3.6. Though basic treatment options may be higher in initial cost and space demands, the infiltration BMP should have lower maintenance costs over time. Note that if designed as a pretreatment BMP and a runoff treatment BMP (in compliance with Core Requirement #6), the pretreatment BMP must be designed to treat runoff from the water quality design storm event, but must also safely convey or bypass the developed 100-year recurrence interval peak flow.

Runoff Treatment

To protect groundwater, projects must apply the appropriate level of runoff treatment whenever infiltration is proposed. The appropriate level of runoff treatment varies by land use and project type, and is determined by one of the following methods:

- If the project is required to meet Core Requirement #6, use the guidance in Chapter 8, Section 8.2.1 to determine the appropriate level of runoff treatment prior to infiltration.
- If the project is installing a UIC well as defined in Chapter 1, Section 1.7.13 Underground Injection Control – UIC Program, use the guidance in Appendix 7C: Underground Injection Control (UIC) Program Guidelines to determine the appropriate level of runoff treatment prior to infiltration.
- If the conditions below the infiltration BMP meet the criteria for runoff treatment per Chapter 8, Section 8.6.3, this will satisfy Core Requirement #6.
- If the project is proposing infiltration, but is not required to meet Core Requirement #6 or follow the guidance in Appendix 7C, the designer has the following options to determine the appropriate level of runoff treatment:
    - Follow the guidance in Chapter 8, Section 8.2.1
    - Follow the guidance in Appendix 7C
    - Provide another protective measure consistent with all applicable regulations. See Chapter 1, Section 1.7 for some of the regulations and standards that may apply to the project.
- Infiltration or dispersion BMPs that are only used to meet the List Approach in Core Requirement #5 do not require additional runoff treatment prior to infiltration.

Spill Control Device

In addition to requirements for pretreatment, all infiltration basins, trenches, and galleries must have a spill control device upstream of the BMP to capture oil or other floatable contaminants before they enter the infiltration BMP. If a T-section is used for spill control, the top of the spill control riser must be set above the BMP's 100-year overflow elevation to prevent oils from entering the infiltration BMP. Refer to Details 5-8 and 5-8.1 in the DG&PWS for storm manhole baffle details that may be used to meet this requirement.

100-Year Overflow Conveyance

An overflow route must be identified for stormwater flows that overtop the infiltration BMP when infiltration capacity is exceeded or the BMP becomes plugged and fails. The overflow route must be able to convey the 100-year recurrence interval developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

Access Road

Access roads are needed to 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 7.5.1.

Setbacks

All infiltration BMPs shall maintain minimum setback distances as follows. All setbacks shall be horizontal unless otherwise specified or modified with written approval by the City or Thurston County Public Health and Social Services Department:

- 1 foot positive vertical clearance from any open water maximum surface elevation to structures, crawl spaces, or below grade basement areas within 25 feet.
- 5 feet from septic tank, holding tank, containment vessel, pump chamber, and distribution box.
- 20 feet from open water maximum surface elevation or edge of infiltration BMP to property lines and on-site structures.
- 10 feet from open water maximum surface elevation or edge of infiltration BMP to building sewer.
- 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment and Soils Report must be prepared to address the potential impact of the BMP on the steep slopes, erosion hazard, or landslide hazard areas. See also Section 14.37.110 of the Lacey Municipal Code (LMC). The Soils Report may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.
- Setbacks from environmentally sensitive areas not listed here as required by LMC Chapter 16.54.
- 100 feet from retaining walls to prevent “short circuiting” of stormwater by free-draining rock behind the retaining walls unless the bottom of the infiltration BMP is greater than 2-feet below the lowest point on the retaining wall.
- 300 feet from an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.
- 200 feet from flowing artesian wells and springs used for public drinking water supplies.
- Stormwater infiltration BMPs, and unlined wetponds and detention ponds shall be located at least 100 feet from drinking water wells.

- Infiltration BMPs, unlined wetponds, and detention ponds with a maximum design flow less than 0.5 cfs must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210). Infiltration basins, trenches, and galleries with a maximum design flow of 0.5 cfs or greater must be at least 100 feet from the septic drainfield primary and reserve areas.

- Setbacks from environmentally sensitive areas not listed above in accordance with LMC Chapter 16.54 and the Shoreline Master Program.

Construction Criteria

During construction, it is critical that the subgrade soils be protected from clogging and compaction to maintain the soil properties identified during infiltration testing (e.g., infiltration capacity) and ensure BMP performance. Most of the construction requirements for small-scale infiltration BMPs included in Chapter 5, Section 5.3, apply to all infiltration BMPs. Any additional BMP specific construction requirements are included in the infiltration BMP “Construction Criteria” subsections of Section 7.4.

Operations and Maintenance Criteria

Adequate access for operation and maintenance must be included in the design of infiltration basins, trenches, and galleries. Provisions must be made for regular and perpetual maintenance of the infiltration BMP, including replacement and/or reconstruction of the any media that are relied upon for treatment purposes. A City approved Maintenance and Source Control Manual shall include information to ensure maintenance of the desired infiltration rate.

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

7.3 Underground Injection Control

The UIC program in the State of Washington is administered by Ecology. In 1984, Ecology adopted Chapter 173-218 WAC – UIC to implement the program. A UIC well is a manmade subsurface fluid distribution system designed to discharge fluids into the ground and consists of an assemblage of perforated pipes, drain tiles, or other similar mechanisms, or a dug hole that is deeper than the largest surface dimension (WAC 173-218-030).

UIC systems include drywells, pipe or French drains, drainfields, and other similar devices that are used to discharge stormwater directly into the ground. Infiltration trenches with perforated pipe used to disperse and inject flows (as opposed to collect and route to surface drainage, as in an underdrain) are considered to be UIC wells. This type of infiltration trench must be registered with Ecology.

The following are not UIC wells; therefore, this guidance does not apply to:

- Buried pipe and/or tile networks that serve to collect water and discharge that water to a conveyance system or to surface water
- Surface infiltration basins and flow dispersion stormwater infiltration BMPs, unless they contain additional infiltration structures at the bottom of the basin/system such as perforated pipe, or additional bored, drilled, or dug shafts meant to inject water further into the subsurface greater than 20 feet deeper than the bottom of the pond (or deeper than the largest surface dimension per above)
- Infiltration trenches designed without perforated pipe or a similar mechanism
- A system receiving roof runoff from a single family home.

The two basic requirements of the UIC Program are:

- Register UIC wells with Ecology unless the wells are located on tribal land (Those wells must be registered with the Environmental Protection Agency.).
- Make sure that current and future underground sources of groundwater are not endangered by pollutants in the discharge (non-endangerment standard).

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, a permit is not required. Rule authorization can be rescinded if a UIC well no longer meets the non-endangerment standard. Ecology can also require corrective action or closure of a UIC well that is not in compliance. Additional information on UIC systems can be found on Ecology's website and in Appendix 7C.< https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program >.

In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or other low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

7.4 LID and Infiltration BMPs

7.4.1 Postconstruction Soil Quality and Depth (Ecology BMP T5.13)

Most projects require that site soils meet minimum quality and depth requirements at project completion. Requirements may be achieved by either retaining and protecting undisturbed soil or restoring the soil (e.g., amending with compost) in disturbed areas.

Additional guidance for this BMP can be found in *Building Soil: Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13* (Stenn et al. 2018), which is available at: <www.buildingsoil.org>.

Naturally occurring (undisturbed) soil, soil organisms, and vegetation provide the following important stormwater management functions:

- Water infiltration
- Nutrient, sediment, and pollutant adsorption
- Sediment and pollutant biofiltration
- Water interflow storage and transmission
- Pollutant decomposition

These functions are largely lost when development strips away native soil and vegetation and replaces it with minimal soil and sod. Not only are these important stormwater management functions lost, but such landscapes themselves can become pollution-generating pervious surfaces due to compaction; increased use of pesticides, fertilizers, and other landscaping and household/industrial chemicals; the concentration of pet wastes; and pollutants that accompany roadside litter.

Postconstruction Soil Quality and Depth requirements help to regain greater stormwater functions in the post development landscape, provide increased treatment of pollutants and sediments that result from development and habitation, and minimize the need for some landscaping chemicals (thus reducing pollution through prevention).

Applications and Limitations

- Applies to all lawn and landscape areas of all residential and commercial projects subject to Core Requirement #5.
- When used in combination with other on-site stormwater management BMPs, soil preservation and amendment can help achieve compliance with the LID Performance Standard option of Core Requirement #5.
- On sites that are underlain by cemented till layers, which are nearly impermeable, the upper soil horizon (native topsoil) processes the majority of stormwater on the site. Ensure that the existing depth of the upper soil horizon is either left in place or removed and replaced (according to the requirements herein) during the grading process.
- On sites that are underlain by outwash soils, the existing topsoil is not usually as deep (as with till soils), but must still be preserved or replaced.
- Portions of the site composed of till soils with slopes greater than 33 percent need not implement this BMP.

Modeling and Sizing

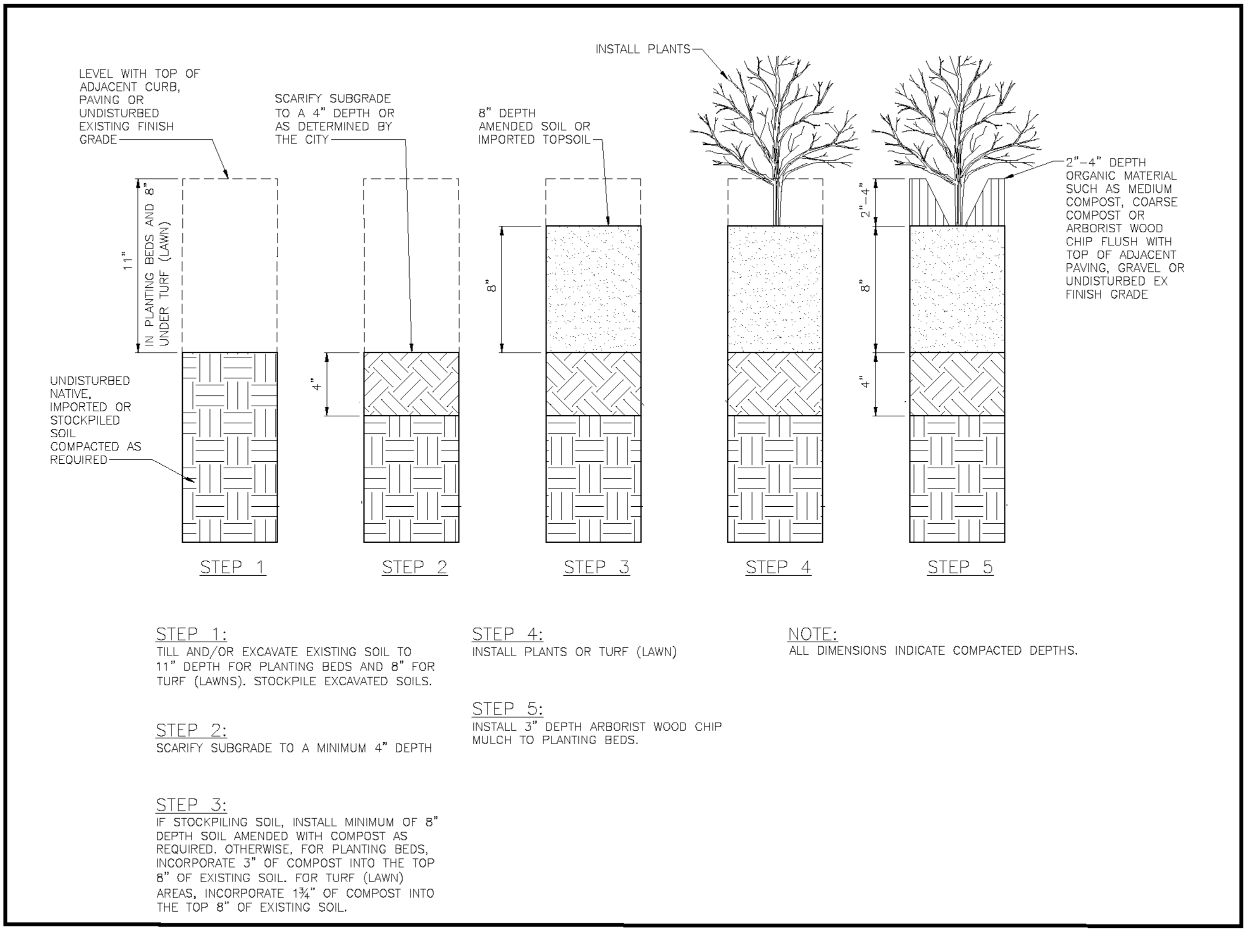
Lawn and landscaped areas that meet the requirements of this section may be modeled, using approved runoff models, as “pasture” rather than “lawn” surface over the underlying soil (till or outwash).

In addition, flow control credit is given in runoff modeling when Postconstruction Soil Quality and Depth BMP requirements are met and used as part of a dispersion design under the conditions described in Sections 7.4.2 and 7.4.10.

Postconstruction Soil Quality and Depth Design Criteria

This section describes the implementation options and design requirements for Postconstruction Soil Quality and Depth. Typical cross-sections of compost-amended soil in planting bed and turf applications are shown in Figure 7.1. Design criteria are provided in this section for the following elements:

- Implementation options
  - Retain and protect undisturbed soil
  - Amend soil
  - Stockpile soil
  - Import soil
- Soil Management Plan



Source: City of Seattle

Figure 7.1. Cross-section of Soil Amendment.

Implementation Options

The soil quality design requirements can be met by using one of the four options listed below. Additional details for each option are provided in the subsequent subsections. Refer to Details 5-13 and 5-13.1 in the DG&PWS to include on plans, as applicable.

1. Retain and Protect Undisturbed Soil

   - Leave undisturbed vegetation and soil and protect from compaction by fencing and keeping materials storage and equipment off these areas during construction.

   - For all areas where soil or vegetation is disturbed, use option 2, 3, or 4.

2. Amend Soil

   - Soil amendments shall be applied to all areas which are being set aside as non-buildable areas (open space or natural resource protection areas) and are in need of rehabilitation because of past land use disturbances such as clearing and intrusion of invasive species. The purpose is to enhance and accelerate the rehabilitation of the soil structure. The application will be non-destructive to the existing vegetation that is retained by taking care to taper depths of soil amendment near the surface roots.

- Amend existing site topsoil or subsoil either at default “preapproved” rates, or at custom calculated rates to meet the soil quality guidelines based on engineering tests of the soil and amendment. (Refer to the *Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org> for custom calculation methods.)

3. Stockpile Soil

- Stockpile existing topsoil during grading and replace it prior to planting. Amend stockpiled topsoil if needed to meet the organic matter or depth requirements either at the default “preapproved” rate or at a custom calculated rate (refer to the *Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org> for custom calculation method). Scarify subsoil and mulch planting beds, as described under the Soil Amendment heading below.

4. Import Soil

- Import topsoil mix of sufficient organic content and depth to meet the requirements. Imported soils must not contain excessive clay or silt fines (more than 5 percent passing the U.S. #200 sieve) because that could restrict stormwater infiltration. Use imported topsoil that meets default “preapproved” rates.

- Scarify subsoil and mulch planting beds, as described under the Soil Amendment heading below.

Note: more than one method may be used on different portions of the same site.

Soil Retention

In buildable areas where minimal excavation foundation systems may be applied, existing topsoils shall be left in place to the greatest extent feasible and shaped or feathered only with tracked grading equipment not exceeding 650 pounds per square foot machine loads. Where some re-grading is required, re-compaction of placed materials, which may include topsoils free of vegetated matter, shall be limited to the minimum densities required by the foundation system engineering.

Soil Amendment

If soil retention and protection is not feasible, disturbed soil must be amended. Soil organic matter is often missing from disturbed soils. Replenish organic matter by amending with compost. It is important that the materials used to meet the Postconstruction Soil Quality and Depth BMP are 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 or silt fines.

Amend existing site topsoil or subsoil either at default “preapproved” soil amendment rates or at custom calculated rates to meet the soil quality guidelines based on engineering tests of the soil and amendment. Both options are described in further detail below.

All areas subject to clearing and grading that have not been covered by impervious surface, incorporated into a drainage BMP, or engineered as structural fill or slope must, at project completion, demonstrate the following:

- A topsoil layer meeting these requirements:
  - Turf areas: Place 1.75 inches of compost and till-in to an 8-inch depth. Achieve an organic matter content, as measured by the loss-on-ignition test, of a minimum 4 percent (target 5 percent) organic matter content[1].
  - Planting beds: Place 3 inches of compost and till-in to an 8-inch depth. Achieve an organic matter content, as measured by the loss-on-ignition test, of a minimum 8 percent (target 10 percent) dry weight[1].
  - A pH from 6.0 to 8.0 or matching the pH of the original undisturbed soil.
  - A minimum depth of 8 inches.
- Root zones where tree roots limit the depth of incorporation of amendments are exempted from this requirement. Fence and protect these root zones from stripping of soil, grading, or compaction to the maximum extent practical.
- Scarify (loosen) subsoils below the topsoil layer at least 4 inches for a finished minimum depth of 12 inches of uncompacted soil. Incorporate some of the upper material to avoid stratified layers, where feasible.
- For turf installations: Water or roll to compact to 85 percent of maximum dry density, rake to level, and remove surface woody debris and rocks larger than 1-inch diameter (*Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org>).

[1] Acceptable test methods for determining loss-on-ignition soil organic matter include the most current version of ASTM D2974 “Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils” and TMECC 05.07-A “Loss-On-Ignition Organic Matter Method”

- After planting: Mulch planting beds with 2 to 4 inches of organic material such as arborist wood chips, bark, shredded leaves, compost, etc. Do not use fine bark because it can seal the soil surface.

- Use compost and other materials that meet the following organic content requirements:

  - The organic content for "preapproved" amendment rates can only be met using compost meeting the compost specification for bioretention (see Section 7.4.4), with the exception that the compost may have up to 35 percent biosolids or manure. The compost must have an organic matter content of 40 percent to 65 percent, 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 (*Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org>).

  - Within the 1-year capture zone of any drinking water well or wellhead protection area, compost used within the site shall not include biosolids or animal manure components, as these can result in large concentrations of nitrates leaching into groundwater aquifers and are consequently prohibited within the wellhead protection area.

  - Calculated amendment rates may be met through use of composted materials as defined above, or other organic materials amended to meet the carbon to nitrogen ratio requirements, and not exceeding the contaminant limits identified in Table 220-B, Testing Parameters, in WAC 173-350-220 (*Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org>).

Ensure that the resulting soil is conducive to the type of vegetation to be established.

Soil Stockpiling

In any areas requiring grading, remove and stockpile the duff layer and topsoil on site in a designated, controlled area, which is not adjacent to public resources and critical areas. Reapply to other portions of the site where feasible.

- In buildable areas of the site, where conventional grading is required, the areas requiring cuts shall have the upper native topsoil removed and stockpiled for replacement for areas of the development utilized for stormwater and/or vegetation management (yards, bioretention BMPs, interflow pathways, vegetated channels, or degraded natural resource protection areas).

- The depth of upper native topsoil required to be stockpiled and replaced shall be the entire depth of the native topsoil horizon up to a maximum of 3 feet.

- Over-excavation of cut sections may be necessary if the cut is in a location that will be utilized for stormwater management. Cut to a depth that will allow replacement of stockpiled native topsoil to the entire depth that was on the site postdevelopment up to a maximum of 3 feet.

- Cut sections where native topsoil replacement is required shall require ripping of any cemented till layers to a depth of 6 inches. Subsequently the replacement of stockpiled topsoil shall be thoroughly mixed into the ripped till to provide a gradual transition between the cemented till layer and the topsoil.

- Stockpiled topsoil shall be replaced in lifts no greater than 1-foot deep and compacted by rolling to a density that matches existing conditions.

- Amend stockpiled topsoil if needed to meet the organic matter or depth requirements either at the default "preapproved" rate or at a custom calculated rate (refer to the *Building Soil* manual [Stenn et al. 2018] or website <www.buildingsoil.org> for custom calculation method).

Importing Soil

The default preapproved rates for imported topsoils are:

- For planting beds: Use a mix by volume of 35 percent compost with 65 percent mineral soil to achieve the requirement of a minimum 8 percent (target 10 percent) organic matter by loss-on-ignition test

- For turf areas: Use a mix by volume of 20 percent compost with 80 percent mineral soil to achieve the requirement of a minimum 4 percent (target 5 percent) organic matter by loss-on-ignition test.

Soil Management Plan

A Soil Management Plan must be included in the project submittal, i.e., the Construction Stormwater Pollution Prevention Plan (SWPPP), and Drainage Control Plan or Abbreviated Drainage Plan. Refer to Chapter 3, Section 3.3, for Soil Management Plan requirements.

Construction Criteria

Most of the construction requirements for small-scale infiltration and dispersion BMPs included in Chapter 5, Section 5.3, also apply to postconstruction soil quality and depth. Minimum construction requirements for disturbed areas include the following:

- Install soil to meet Postconstruction Soil Quality and Depth BMP requirements toward the end of construction, and once established, protect from compaction and erosion

- Plant soil with appropriate vegetation and mulch planting beds installation.

Operations and Maintenance Criteria

The most important maintenance issue is to replenish the soil organic matter by leaving leaf litter and grass clippings on site (or by adding compost and mulch regularly). This BMP is designed to reduce the need for irrigation, fertilizers, herbicides, and pesticides.

7.4.2 Dispersion BMPs

General Dispersion BMP Design Criteria

General Site Considerations

The following are key considerations in determining the feasibility of dispersion BMPs for a particular site:

- Dispersion flow path area: Dispersion BMPs generally require large areas of vegetated ground cover to meet flow path requirements and are not feasible in many urban settings, and some rural settings.
- Erosion or flooding potential: Dispersion is not allowed in settings where the dispersed flows might cause erosion or flooding problems, either on site or on adjacent properties.
- Site topography: Dispersion flow paths are prohibited in and near certain sloped areas (refer to detailed flow path requirements below).

General Design Criteria

Flow path design requirements common to all dispersion BMPs are listed below. Additional requirements that are specific to the individual dispersion BMP types are provided in each subsequent BMP section.

- Natural resource protection areas and critical area buffers may count towards flow path lengths. This does not include steep slopes. However, the natural resource protection area must be permanently protected from modification through a covenant or easement, or a tract dedicated by the proposed project.
- Dispersion BMPs shall be placed no closer than 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high, and a vegetated flow path must be maintained between the outlet of the BMP and the slope. A geotechnical assessment and Soils Report must be prepared addressing the potential impact of the BMP on the slope. The geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope. For sites unable to meet the above setbacks, a geotechnical assessment recommending dispersion on a slope may be allowed. Approval will be at the discretion of the City.
- The discharge point for the dispersion BMP is not permitted within 300 feet of an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless the slope stability impacts of such systems have been analyzed and

mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

- For sites with on-site or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210). In addition, the entire flow path must be oriented so as to not intersect with the primary or reserve areas. Additional site-specific considerations may be required for septic systems serving commercial or light industrial land use to protect environmentally sensitive areas. These requirements may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that a shorter setback is feasible.

- The vegetated flow path must consist of either undisturbed native landscape, or well-established lawn, landscape, groundcover over soil that meets the Postconstruction Soil Quality and Depth BMP requirements outlined in Section 7.4.1. The groundcover must be dense to help disperse and infiltrate flows and prevent erosion.

- The dispersion flow path is not permitted over contaminated sites or abandoned landfills.

Full Dispersion (Ecology BMP T5.30)

This BMP allows for “fully dispersing” runoff from impervious surfaces and cleared areas of Project Sites into areas preserved as forest, native vegetation, or cleared area.

The City accepts Full Dispersion as meeting Core Requirement #5, Core Requirement #6, and Core Requirement #7. Sites that can fully disperse are not required to provide additional runoff treatment or flow control BMPs. Hard surfaces that are not fully dispersed should be partially dispersed to the maximum extent practicable.

Applicability and Limitations

The site (or area of the site) that is applying full dispersion per this BMP must be laid out to allow the runoff from the impervious (or cleared) surface to fully disperse into the preserved dispersion area. (i.e., have full access to and not be intercepted by pipe(s), ditch(es), stream(s), river(s), pond(s), lake(s), or wetland(s)).

Projects that successfully apply this BMP on all or a portion of their site will decrease effective impervious surfaces and may avoid triggering the TDA thresholds in Core Requirement #7.

A site (or an area of a site) that applies full dispersion per this BMP consists of the following elements:

- **An impervious (or cleared) area.** The impervious (or cleared) area is the area that the design is mitigating for by using this BMP.

- **A flow spreader.** Runoff from the impervious (or cleared) area may need to be routed through a flow spreader (see Chapter 6, Section 6.3.5), depending on the site layout and type of impervious surface, as further described below.
- **A dispersion area.** This area defines the limits of the Full Dispersion BMP. The impervious (or cleared) area must disperse into the preserved dispersion area.
    - The dispersion area must be forest, native vegetation, or a cleared area depending on the site type. Details are provided below for what amount of vegetation the dispersion area must contain based on site type.
    - If the dispersion area must be preserved as forest or native vegetation, it may be a previously cleared area that has been replanted in accordance with Native Vegetation Landscape Specifications and Restoring Site Vegetation in Chapter 4, Section 4.3.1.
    - The dispersion 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 as part of the dispersion area), and to buffer stream corridors.
    - The dispersed area should be placed in a separate tract or protected through recorded easements for individual lots.
    - The dispersion area should be shown on all property maps and should be clearly marked during clearing and construction on the site.
    - All trees within the dispersion area at the time of permit application shall be retained, aside from:
        - Approved timber harvest activities regulated under WAC Title 222. Class IV General Forest Practices that are conversions from timberland to other uses are not acceptable for the preserved area.
        - Dangerous or diseased trees. Removal of dangerous or diseased trees will require approval by the City and may require an arborist to make a written assessment of the trees' condition.
    - The dispersion area may be used for passive recreation and related BMPs, including pedestrian and bicycle trails, nature viewing areas, fishing, and camping areas, and other similar activities that do not require permanent structures. Cleared areas and areas of compacted soil associated with these areas and BMPs must not exceed 8 percent of the dispersion area.
    - The dispersion area may contain utilities and utility easements, but not septic systems. For the purpose of this BMP, utilities are defined as potable and wastewater underground piping, underground wiring, and power and telephone poles.

  - The dispersion area is not allowed in critical area buffers or within 300 feet of an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless slope stability impacts of such systems have been analyzed and mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.
  - For sites with on-site or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246 272A 0210). In addition, the entire flow path must be oriented so as to not intersect with the primary or reserve areas. These requirements may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that a shorter setback is feasible.

- **A flow path through the dispersion area.** The length of the flow path from the impervious (or cleared) area through the dispersion area varies based on the site layout and type of impervious surface, as further described below. Regardless of the site layout and type of impervious surface, the flow path must meet the following criteria:
  - The slope of the flow path must be no steeper than 15 percent for any 20-foot reach of the flow path. Slopes up to 20 percent are allowed where flow spreaders are located upstream of the dispersion area and at sites where vegetation can be established.
  - The flow paths from adjacent flow spreaders must be sufficiently spaced to prevent overlap of flows in the flow path areas.

The dispersion of runoff must not create flooding or erosion impacts.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for full dispersion. If one or more infeasibility criteria apply, then full dispersion is not required for consideration in the List #1 or List #2 option of Core Requirement #5. If a project proponent wishes to use full dispersion—though is not required to because of these infeasibility criteria—they may propose a functional design to the City. In addition, other design criteria and site limitations that make full dispersion infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Minimum Design Requirements for Residential, Commercial, and Industrial Projects

Rural single family residential developments and commercial and industrial developments should use this BMP wherever possible to minimize effective impervious surfaces.

Full Dispersion from Impervious Surfaces

Impervious surfaces may be "fully dispersed" if they are within a TDA that is less than 10 percent impervious. If the TDA has more than 10 percent impervious area, the design may still fully disperse up to 10 percent of the TDA's area. The impervious areas that are beyond the 10 percent cannot drain to the dispersion area and are subject to the thresholds in Core Requirement #6 and Core Requirement #7.

The lawn and landscaping areas associated with the impervious areas may be dispersed into the dispersion area. The lawn and landscaped area must comply with Section 7.4.1. The guidance in the Building Soil Manual (Stenn et al. 2018) can be used, or an approved equivalent soil quality and depth specification approved by Ecology.

The dispersion area must be preserved as forest or native vegetation.

The dispersion area shall have a minimum area 6.5 times the area of the impervious surface draining to it.

The flow path from the impervious surface through the area preserved as forest or native vegetation must be at least 100 feet in length, or 25 feet for sheet flow from lawn and landscaping areas associated with the impervious area being mitigated.

The following additional guidelines must be followed for the following types of impervious surfaces within residential projects:

- **Full dispersion from roof surfaces:** Runoff from roof surfaces must either:
  - Provide dispersion BMPs as described in Downspout Dispersion Systems (Ecology BMP T5.10B) prior to the runoff entering the dispersion area. The dispersion area and flow path must meet the criteria described in this BMP.

    or

  - Combine the roof runoff with the road runoff and follow the guidance for full dispersion from roadway surfaces (below).
- **Full dispersion from driveway surfaces:** Runoff from driveway surfaces must either:
  - Provide dispersion BMPs as described in Concentrated Flow Dispersion (Ecology BMP T5.11) and Sheet Flow Dispersion (Ecology BMP T5.12) prior to the runoff entering the dispersion area. The dispersion area and flow path must meet the criteria described in this BMP.

    or

  - Combine the roof runoff with the road runoff and follow the guidance for full dispersion from roadway surfaces (below).

- **Full Dispersion from Roadway Surfaces:** Runoff from roadway surfaces comply with all of the following requirements:
    - 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.
    - 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 from any single discharge location 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.
    - 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 into the dispersion area. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use dispersion trenches to disperse flows into the dispersion area. See Chapter 6, Section 6.3.5 for details on outfalls including rock pads and dispersion trenches.
        - Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flow path, and shall have a minimum 2 feet by 2 feet cross section, 50 feet in length, filled with 0.75-inch to 1.5-inch washed rock, and provided with a level notched grade board. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to four trenches. Dispersion trenches shall have a minimum spacing of 50 feet between centerlines.
    - Where the City determines there is a potential for significant adverse impacts downstream (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of runoff from roadway surfaces may not be allowed, or other measures may be required.

Full Dispersion from Cleared Areas

The runoff from cleared areas that are comprised of bare soil, non-native landscaping, lawn, and/or pasture is “fully dispersed” if it meets the following criteria:

- Cleared areas must comply with Section 7.4.1 (Ecology BMP T5.13).
- The dispersion area must be preserved as forest or native vegetation.

- The flow path through the cleared area (and leading to the dispersion area) must not be greater than 25 feet.
- If the cleared area has a width of up to 25 feet:
    - The minimum flow path length from the cleared area through the dispersion area must be at least 25 feet.
- If the cleared area has a width of 25 to 250 feet:
    - The minimum flow path length from the cleared area through the dispersion area must be 25 feet, plus an additional 1 foot for every 3 feet of width of the cleared area (beyond 25 feet) up to a maximum width of 250 feet.
- The topography of the cleared area must be such that runoff will not concentrate prior to dis-charge to the dispersion area.
- The width of the dispersion area must equal the width of the cleared area.

Minimum Design Requirements for Road Projects

These criteria apply to the construction of roads not within the context of residential, commercial, or industrial site development. Full dispersion can be applied to public road projects that meet the following requirements:

- The dispersion area must be in legally protected areas (e.g., easements, conservation tracts, public parks).
- An agreement with the property owner(s) is advised for any dispersion areas that represent a continuation of past practice. If not a continuation of past practice, an agreement should be reached with the property owner.

Note that most roadways in the City will not have the required space to fully meet the design requirements for full dispersion (e.g., dispersion area widths, and legal protection of the dispersion area). In addition, the City may still require runoff treatment for pollution generating areas that are routed to dispersion BMPs (e.g., for groundwater protection).

Full Dispersion by Sheet Flow from Uncollected, Unconcentrated Runoff into the Dispersion Area

The runoff from road projects that sheet flow into the dispersion area is "fully dispersed" if it meets all of the following criteria:

- The dispersion area must be preserved as forest or native vegetation.
- Depth to the average annual maximum ground water elevation should be at least 3 feet.

- The flow path through any impervious area leading to the dispersion area must not be greater than 75 feet.

- The flow path through any pervious area leading to the dispersion area must not be greater than 150 feet. Pervious flow paths include up-gradient road side slopes that run onto the road and down-gradient road side slopes that precede the dispersion area.

- The width of the dispersion area should be equivalent to the width of impervious surface sheet flowing into it.

- Flow path length through the dispersion area:

  - *For outwash soils:* The following criteria apply to sites (or areas of sites) with outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands). The outwash soils mush 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 (PIT), or Soil Grain Size Analysis method identified in Appendix 7A.

    - If the impervious area has a flow path length of up to 20 feet, the flow path length through the dispersion area must be at least 10 feet.

    - If the impervious area has a flow path length greater than 20 feet, the flow path length through the dispersion area must be 10 feet, plus an additional 0.25 feet for every 1 foot of impervious flow path beyond the initial 20 feet.

  - *For other soils*: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion described in the bullet above)

    - For every 1 foot of flow path length across the impervious surface, the flow path length through the dispersion area must be 6.5 feet.

    - The minimum flow path length through the dispersion area is 100 feet.

- The lateral slope of the impervious area should be less than 8 percent.

- Road side slopes must be less than 25 percent. Road side slopes do not count as part of the dispersion area unless native vegetation is re-established, and slopes are less than 15 percent. Road shoulders that are paved or graveled to withstand occasional vehicle loading count as impervious surface.

- The longitudinal slope of road must be less than 5 percent.

- The average longitudinal (parallel to road) slope of the dispersion area should be less than or equal to 15 percent.
- The average lateral slope of the dispersion area must be less than or equal to 15 percent.

Full Dispersion of Channelized (Collected and Re-dispersed) Stormwater into the Dispersion Area

The runoff from road projects that is collected and re-dispersed is "fully dispersed" if it meets all of the following criteria:

- The dispersion must be preserved as forest or native vegetation.
- Depth to the average annual maximum groundwater elevation should be at least 3 feet.
- Channelized flow must be re-dispersed to produce the longest possible flow path.
- Flows must be evenly dispersed across the dispersion area.
- 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 into the dispersion area. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use dispersion trenches to disperse flows into the dispersion area. See Chapter 6, Section 6.3.5 details on outfalls including rock pads and dispersion trenches.
    - Dispersion trenches shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flow path, and shall have a minimum 2 feet by 2 feet cross section, 50 feet in length, filled with 0.75 inch to 1.5 inch washed rock, and provided with a level notched grade board. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to four trenches. Dispersion trenches shall have a minimum spacing of 50 feet between centerlines.
- Approved energy dissipation techniques may be used.
- This option is limited to on-site (associated with the road) flows.
- The width of dispersion area should be equivalent to length of the road from which runoff is collected.
- The average longitudinal and lateral slopes of the dispersion area should be less than 8 percent.

- The slope of any flow path segment must be no steeper than 15 percent for any 20-foot reach of the flow path segment.
- Flow path length through the dispersion area:
  - *For outwash soils:* The following criteria apply to sites (or areas of sites) with outwash soils (Type A – sands and sandy gravels, possibly some Type B – loamy sands). The outwash soils must 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 Appendix 7A.
    - The dispersion area should be at least 1/2 of the impervious drainage area.
  - *For other soils*: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion described in the bullet above)
    - For every 1 foot of flow path length across the impervious surface, the flow path length through the dispersion area must be 6.5 feet.
    - The minimum flow path length through the dispersion area is 100 feet.

Full Dispersion by Engineered Dispersion

The runoff from road projects is "fully dispersed" if it meets all of the following criteria:

- Stormwater can be dispersed via sheet flow or via collection and re-dispersion in accordance with the techniques for Full Dispersion of Channelized (Collected and Re-dispersed) Stormwater into the Dispersion Area (above).
- The dispersion area should be planted with native trees and shrubs.
- *For Outwash Soils:* The following criteria apply to sites (or areas of sites) with 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 Appendix 7A.
  - The dispersion area must be compost amended in accordance with Section 7.4.1.
  - If the impervious area has a flow path length of up to 20 feet, flow path length through the dispersion area must be at least 10 feet.
  - If the impervious area has a flow path length greater than 20 feet, the flow path length through the dispersion area must be 10 feet, plus an additional

0.25 feet or every 1 foot of impervious flow path length beyond the initial 20 feet.

- *For other soils*: The following criteria apply to sites (or areas of sites) with soils other than those described in the bullet above (Types C and D and some Type B not meeting the criterion in the bullet above).
  - The dispersion area must be compost-amended in accordance with Section 7.4.1.
  - The dispersion area must be 6.5 times the area of the surface(s) draining to it.
- The average longitudinal (parallel to road) slope of dispersion area should be less than or equal to 15 percent.
- The average lateral slope of dispersion area should be less than or equal to 15 percent.
- The depth to the average annual maximum ground water elevation should be at least three feet.

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) 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 2 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.

5. 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 3 tree species, 3 species of shrubs, and 2 or 3 species of groundcover.

6. 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.*

7. Plantings must be watered consistently once per week during the dry season for the first two years.

8. The plantings must be well established on at least 90 percent of the converted area. A minimum of 90 percent 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 4-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 on-center (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.

Model Representation

Areas that are fully dispersed do not have to use approved continuous simulation models to demonstrate compliance. They are presumed to fully meet the runoff treatment and flow control requirements in Core Requirement #6 and Core Requirement #7.

Sheet Flow Dispersion (Ecology BMP T5.12)

Description

Sheet flow dispersion is the simplest method of flow 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

- Use for flat or moderately sloping (less than 15 percent slope) surfaces such as driveways, sport courts, patios, roofs without gutters, lawns, pastures; or any situation where concentration of flows can be avoided.
- Where the contributing surface is flat to moderately sloped and cross-sloped at a minimum of 2 percent (to convey runoff across the contributing surface), a transition zone may be used to route runoff to a vegetated buffer.
- Where the contributing surface is of variable slope, berms and dispersion trenches may be used to route runoff to the vegetated buffer.
- Modeling credits for sheet flow dispersion (see Modeling and Sizing below) can be applied to help meet the flow control standards of Core Requirement #7, as well as to help achieve compliance with the LID Performance Standard option of Core Requirement #5.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for sheet flow dispersion. If one or more infeasibility criteria apply, then sheet flow dispersion is not required for consideration in the List #1 or List #2 option of Core Requirement #5. If a project proponent wishes to use sheet flow dispersion—though is not required to because of these infeasibility criteria—they may propose a functional design to the City. In addition, other design criteria and site limitations that make sheet flow dispersion infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

Where sheet flow dispersion is used to disperse runoff into an undisturbed native landscape area or an area that meets the requirements of Section 7.4.1, the impervious area may be modeled as grass/lawn area.

Sheet Flow Dispersion Design Criteria

Refer to the general dispersion design criteria above. This section provides additional design criteria specific to sheet flow dispersion:

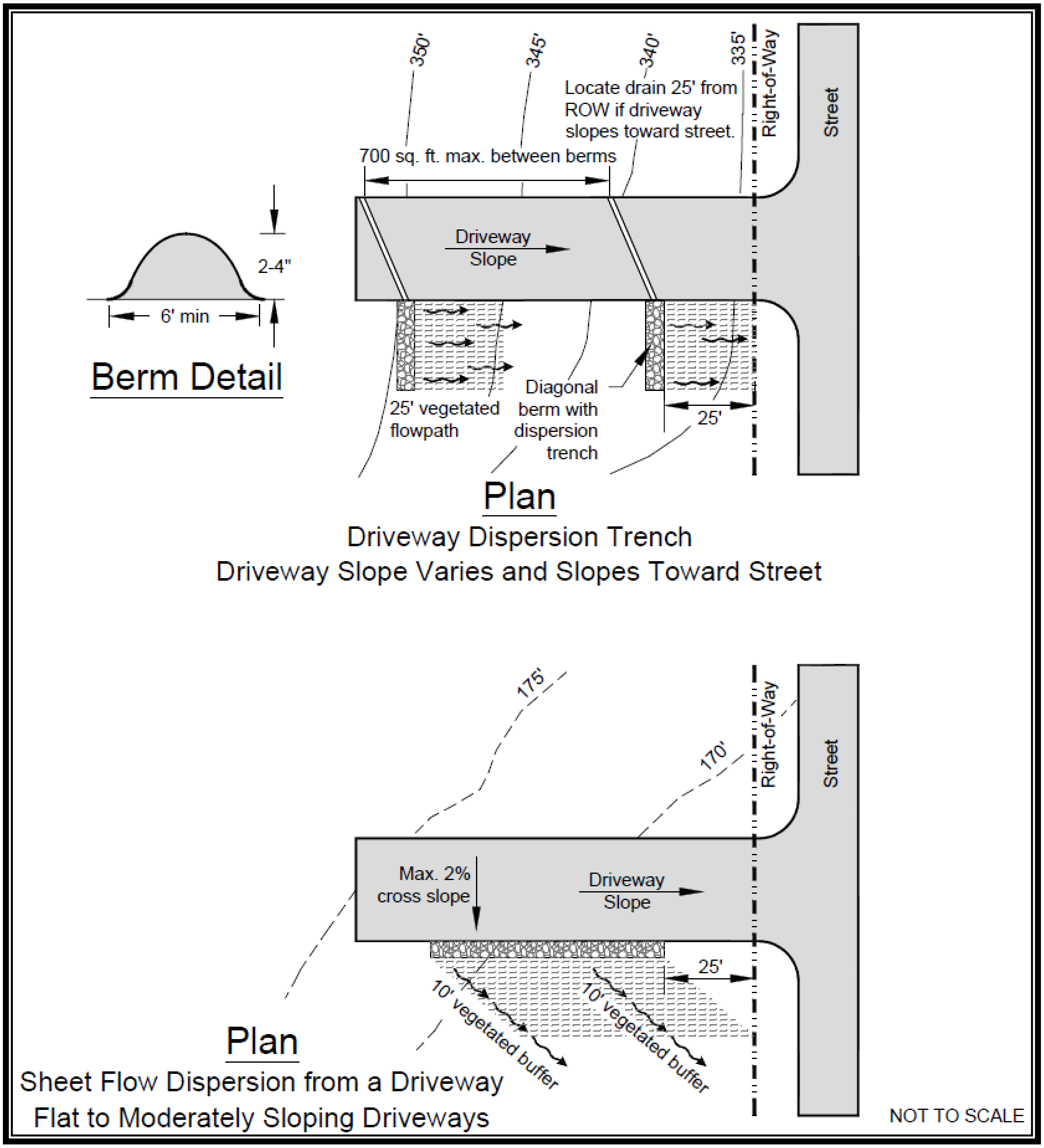
- See Figure 7.2 for required setbacks and flow path lengths. Figure 7.2 is applicable for non-driveway surfaces.
- Transition Zones:
    - A 2-foot-wide transition zone to discourage channeling must be provided between the edge of the contributing surface (or building eaves) and the downslope vegetation. This transition zone may consist of subgrade material (crushed rock), modular pavement, drain rock, or other material approved by the City.
    - Provide a 10-foot-wide vegetated buffer for up to 20 feet of width of contributing surface. Provide an additional 10 feet of width for each additional 20 feet of contributing area width or fraction thereof. (For example, if a driveway is 30 feet wide and 60 feet long, provide a 15-foot-wide by 60-foot long vegetated buffer, with a 2-foot by 60-foot transition zone).
- Berms:
    - Berms must be diagonal to surface flow to intercept and convey runoff to dispersion trenches.
    - Dispersion trenches must be designed in accordance with Section 7.4.10.
    - Provide a 25-foot vegetated flow path between the discharge point of the dispersion trench and any property line, structure, steep slope (greater than 20 percent), stream, lake, wetland, or other impervious surface.

Construction Criteria

Protect the dispersion flow path from sedimentation and compaction during construction. If the flow path area is disturbed during construction, restore the area to meet the postconstruction soil quality and depth requirements in Section 7.4.1 and establish a dense cover of lawn, landscape, or groundcover. See Chapter 5, Section 5.3, for additional dispersion BMP construction requirements.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.



Source: Ecology

Figure 7.2. Sheet Flow Dispersion for Driveways.

Concentrated Flow Dispersion (Ecology BMP T5.11)

Description

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 runoff treatment. See Figure 7.3.

Applications and Limitations

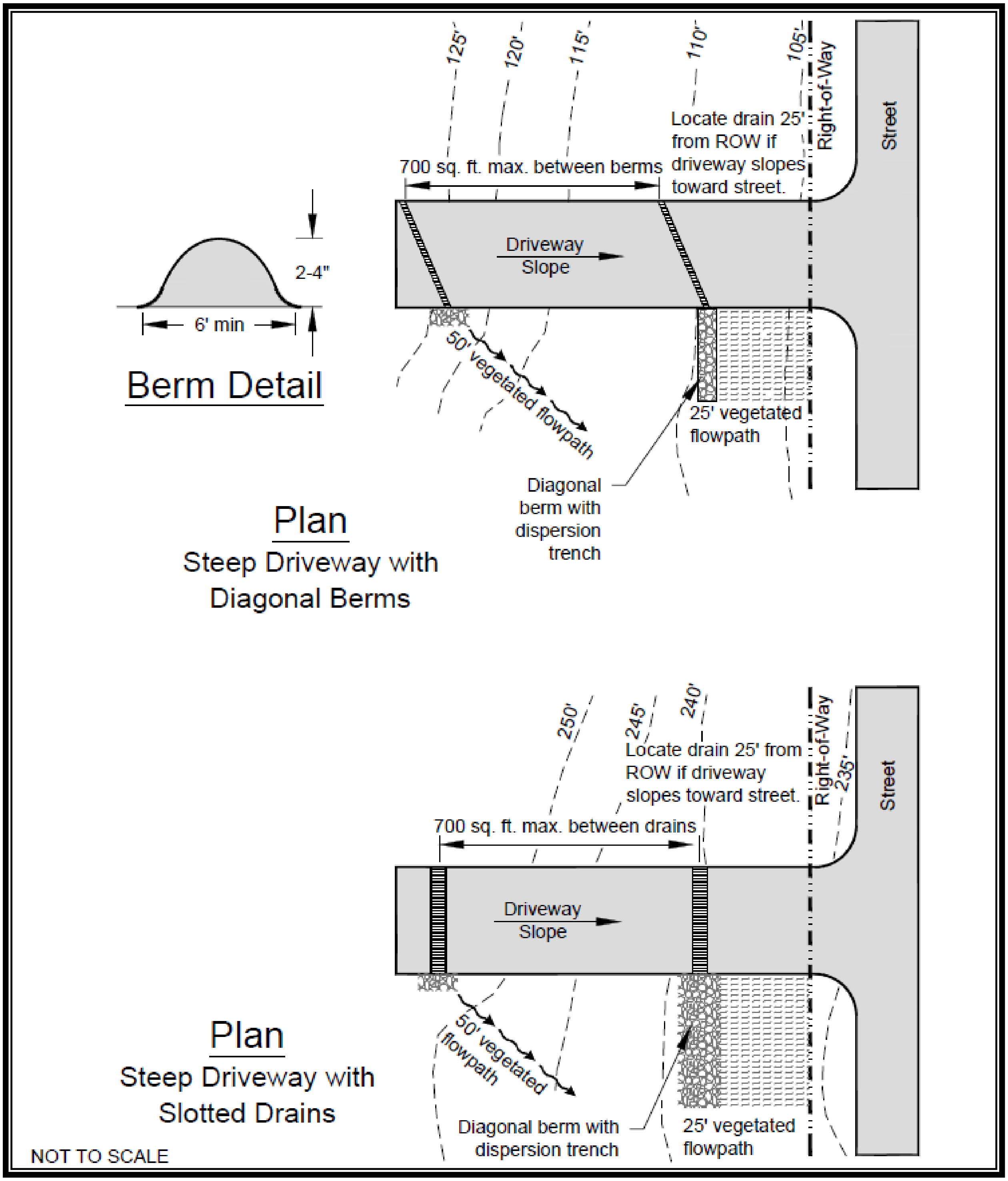
- Concentrated flow dispersion can be used in any situation where concentrated flow can be dispersed through vegetation.
- Modeling credits for concentrated flow dispersion (see below) can be applied to help meet the flow control standards of Core Requirement #7, as well as to help achieve compliance with the LID Performance Standard option of Core Requirement #5.
- 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 7.3 shows two possible ways of spreading flows from steep driveways.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for concentrated flow dispersion. If one or more infeasibility criteria apply, then concentrated flow dispersion is not required for consideration in the List #1 or List #2 option of Core Requirement #5. If a project proponent wishes to use concentrated flow dispersion—though is not required to because of these infeasibility criteria—they may propose a functional design to the City. In addition, other design criteria and site limitations that make concentrated flow dispersion infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

Where concentrated flow dispersion is used to disperse runoff into an undisturbed native landscape area or an area that meets the requirements of Section 7.4.1, and the vegetated flow path is at least 50 feet, the impervious area may be modeled as grass/lawn area. If the available vegetated flow path is 25 to 50 feet, use of a dispersion trench allows modeling the impervious area as 50 percent impervious and 50 percent landscape.



Source: Ecology

Figure 7.3. Typical Concentrated Flow Dispersion for Steep Driveways.

Concentrated Flow Dispersion Design Criteria

Refer to general dispersion design criteria above. This section provides additional design criteria specific to concentrated flow dispersion:

- Maintain a vegetated flow path of at least 50 feet (if using rock pads) or 25 feet (if using dispersion trenches) between the discharge point and any property line, structure, slopes steeper than 20 percent, stream, lake, wetland, or other impervious surface. The flow path length is measured perpendicular to site contours.

- A slotted drain, diagonal berm, or similar measure must be provided to direct flow to the rock pad or dispersion trench.

- A maximum of 700 square feet of impervious area may drain to each concentrated flow dispersion device.

- Provide a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) or dispersion trench (per Section 7.4.10) at each discharge point.

- No erosion or flooding of downstream properties may result.

- Each dispersion device must have a separate flow path. For the purpose of maintaining adequate separation of flows discharged from adjacent dispersion devices, vegetated flow paths must be at least 20 feet apart at the upslope end and must not overlap with other flow paths at any point along the minimum required flow path lengths.

Construction Criteria

Protect the dispersion flow path from sedimentation and compaction during construction. If the flow path area is disturbed during construction, restore the area to meet the postconstruction soil quality and depth BMP requirements in Section 7.4.1 and establish a dense cover of lawn, landscape, or groundcover. See Chapter 5, Section 5.3, for additional dispersion BMP construction requirements.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

7.4.3 Tree Retention and Tree Planting (Ecology BMP T5.16)

Description

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.

Applications and Limitations

- When used in combination with other low impact development techniques, retained and newly planted trees can help achieve compliance with the Core Requirement #5.
- When implemented in accordance with the criteria outlined below, retained and newly planted trees receive credits toward meeting the flow control standards of Core Requirement #7. The degree of flow control provided by a tree depends on the tree type (i.e., evergreen or deciduous), canopy area, and proximity to hard surfaces. Flow control credits may be applied to project sites of all sizes.
- Site considerations specific to retained and newly planted trees are provided below.

Retained Trees

Setbacks of proposed infrastructure from existing trees are critical considerations. Tree protection requirements limit grading and other disturbances in proximity to the tree.

Newly Planted Trees

Mature tree height, size, and rooting depth must be considered to ensure that new tree planting locations are appropriate given adjacent above- and below-ground infrastructure. Although setbacks will vary by species, some general recommendations include:

- Minimum 5-foot setback from structures.
- Minimum 2-foot setback from edge of any paved surface.

Modeling and Sizing

Retained Trees

Flow control credits for retained trees are provided in Table 7.1 by tree type. These credits can be applied to reduce the 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 7.1. Flow Control Credits for Retained Trees.	
Tree Type	**Credit**
Evergreen	20% of canopy area (minimum of 100 sq. ft./tree)
Deciduous	10% of canopy area (minimum of 50 sq. ft./tree)

Impervious/Hard Surface Area Mitigated = (Σ Evergreen Canopy Area x 0.2) + (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 the hard surface requiring mitigation.

Newly Planted Trees

Flow control credits for newly planted trees are provided in Table 7.2 by tree type. These credits can be applied to reduce the hard surface area requiring flow control. Credits range from 20 to 50 square feet per tree.

Table 7.2. Flow Control Credits for Newly Planted Trees.	
Tree Type	**Credit**
Evergreen	50 sq. ft. per tree
Deciduous	20 sq. ft. per tree

Impervious/Hard Surface Area Mitigated = Σ Number of Trees x Credit (square feet).

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 the hard surface requiring mitigation.

Tree Planting and Tree Retention Design Criteria

Retained Trees

The following design criteria are specific to projects proposing to retain on-site trees for flow control credits:

Tree Species and Condition

- 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-inch 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 as presented below.

Tree Canopy Area

- 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 (see also Figure 7.4). If trees are clustered, overlapping canopies are not double counted.

Tree Location

- Flow control credit for retained trees depends upon proximity to ground level 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 hard surfaces (e.g., driveway or patio) on the development site. Distance from hard surfaces is measured from the tree trunk center.

- Minimize the installation of any impervious surfaces in critical root zone areas. An arborist report is 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 (see also Figure 7.4). 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 tree flow control credit may still be approved.

- Where road or sidewalk surfaces are needed under a tree canopy, unmortared permeable pavers or flagstone (rather than concrete or asphalt) or bridging techniques should be used (see Figure 7.5).

Newly Planted Trees

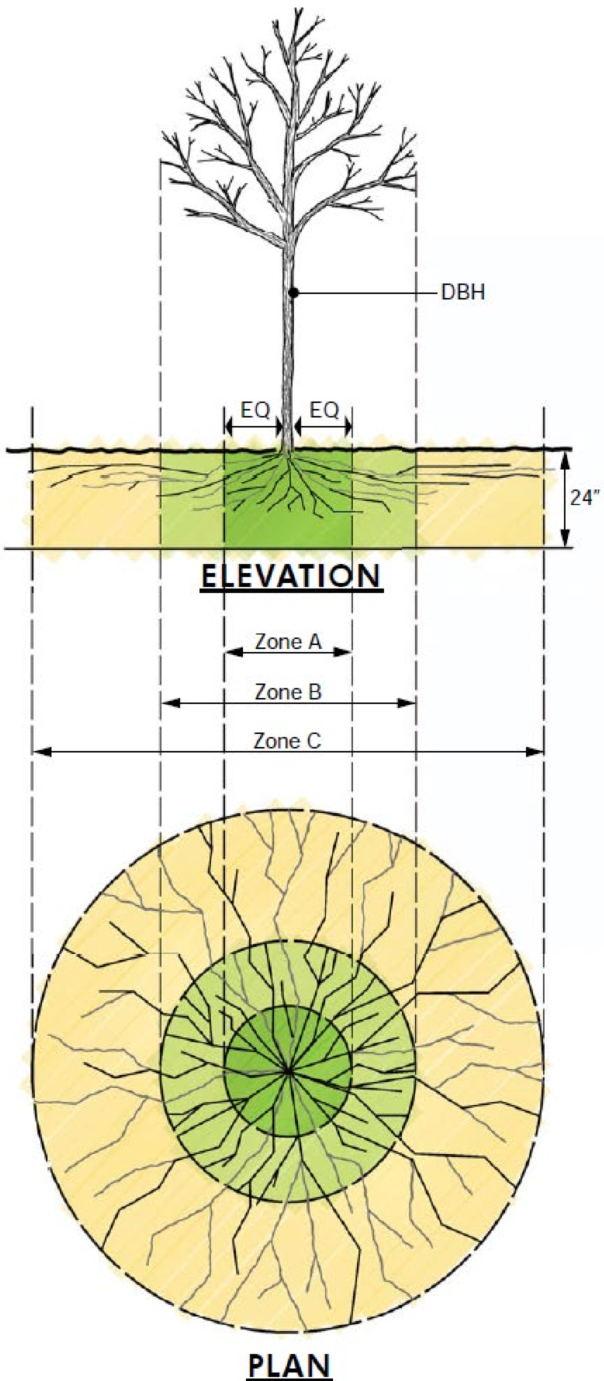
The following design criteria are specific to projects proposing to plant new on-site trees for flow control credits.

Tree Species

It is recommended that a landscape architect or other trained professional guide plant selection for each unique location and/or application. An approved list of tree species is provided in the City of Lacey Urban Forest Management Plan.

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 PROTECTION ZONES:

Zone A - *Critical Root Zone*
The area under a tree whose diameter at breast height (DBH) measures 1 foot per 1 inch of DBH from the trunk outwards and twenty-four inches in depth. See table below for examples:

Tree Diameter	CRZ radius	CRZ diameter (including tree trunk)
2 inches	2 feet	4.5 feet
6 inches	6 feet	13 feet
20 inches	20 feet	42 feet
50 inches	50 feet	105 feet

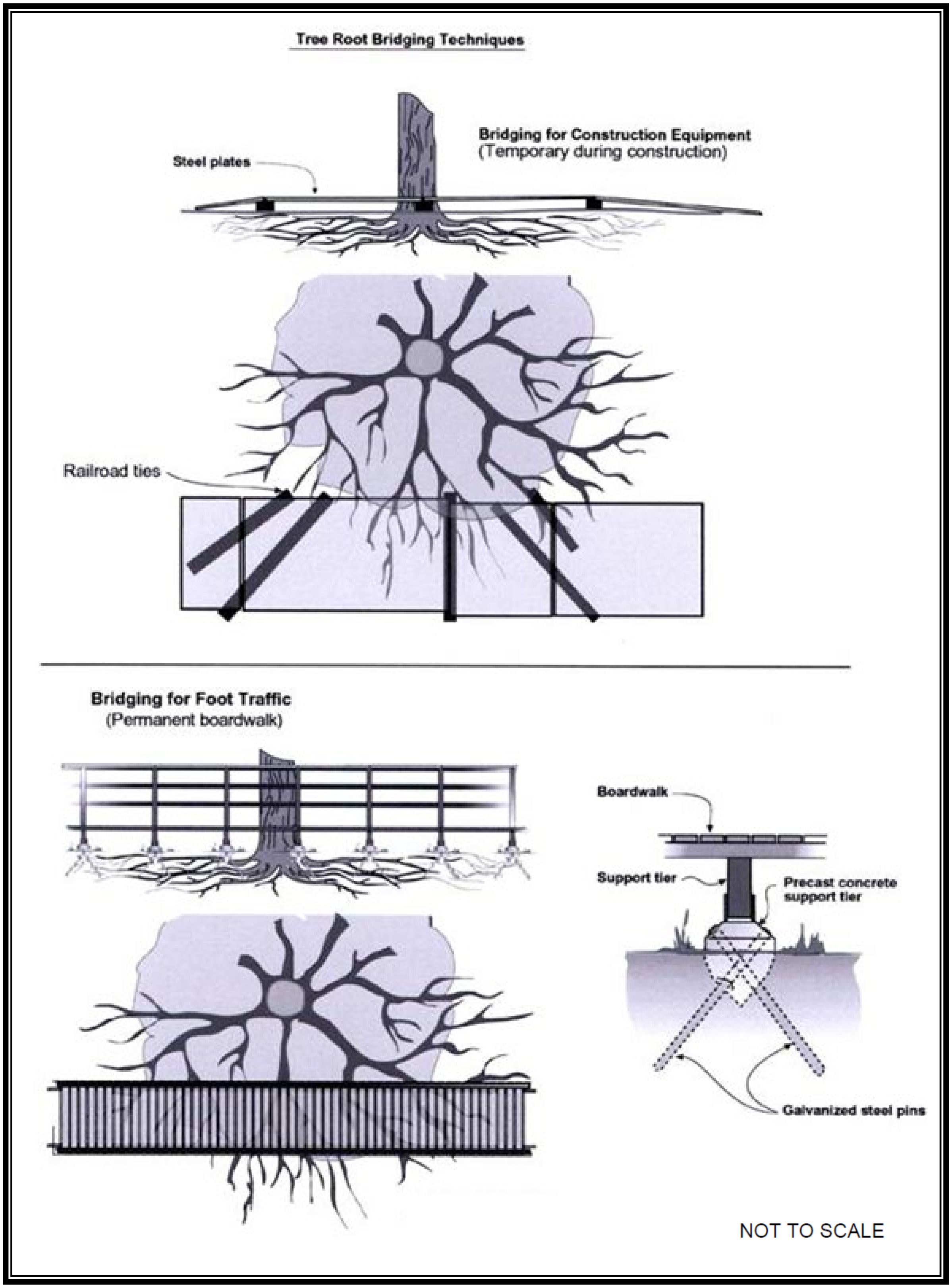
Zone B - *Drip Line*
The area on the ground below the tree in which the boundary is designed by the edge of the tree's crown. For young trees, Zone A and B may be one and the same.

Zone C - *Feeder Root Zone*
The area under a tree whose diameter measures 2 feet per one inch of DBH from the trunk outwards and 24 inches in depth. For example, for a 10 inch DBH tree, the Feeder Root Zone is at least 20 feet in diameter and 24 inches deep.

Tree Protection Zone (TPZ)
"Tree Protection Zone" is an arborist defined area surrounding the trunk intended to protect the roots and soil to ensure future tree health and stability. A TPZ consists of a minimum Zone A or B, whichever is greater, or other area as defined by a project arborist or urban forester.

Source: Hinman and Wulkan 2012

Figure 7.4. Critical Root Zone (CRZ).



Source: Hinman and Wulkan 2012

Figure 7.5. Root Bridge.

Tree Location

- Similar to retained trees, flow control credit for newly planted trees depends upon proximity to ground level hard surfaces. To receive a credit, the tree must meet tree location requirements listed in retained tree design criteria above. Distance from hard surfaces is measured from the edge of the surface to the center of the tree at ground level.

- 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.

- To help ensure tree survival and canopy coverage, the minimum tree spacing for newly planted trees shall accommodate mature tree spread. On-site stormwater management and/or flow control credit shall not be given for new trees with on-center spacing less than 10 feet.

Plant Material and Planting Specifications

- Standard practices for planting materials and methods are provided in the City of Lacey Urban Forest Management Plan.

Construction Criteria

Protect trees and tree root systems utilizing the following methods:

- The existing tree roots, trunk, and canopy shall be fenced and protected during construction activities.

- 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).

- Reduce soil compaction during the construction phase by protecting critical tree root zones that usually extend beyond the trees canopy or drip line. The critical tree root zone should be factored using the tree’s diameter breast height (see Figure 7.4).

- Prohibit any excavation within the critical root zone of the tree.

- Prohibit the stockpiling or disposal of excavated or construction materials in tree planting areas to prevent contaminants from damaging vegetation and soils.

- Avoid excavation or changing the grade near trees that have been designated for protection. If the grade level around a tree is to be raised, a dry rock wall or rock well shall be constructed around the tree. The diameter of this wall or well should be at least equal to the diameter of the tree canopy plus 5 feet.

- Prevent wounds to tree trunks and limbs during the construction phase.
- Tree root systems tend to overlap and fuse among adjacent trees. Trees or woody vegetation that will be removed and that are next to preserved trees must be cut rather than pushed over with equipment. Where construction operations unavoidably require temporary access over tree root zones or other soil protection areas, provide protection as follows:
  - For foot access or similar light surface impacts, apply a 6-inch layer of arborist wood chip mulch and water regularly to maintain moisture, control erosion and protect surface roots.
  - For any vehicle or equipment access, apply a minimum 1-inch steel plate or 4-inch-thick timber planking over 2 to 3 inches of arborist wood chip mulch, or a minimum 0.75-inch plywood over 6 to 8 inches of arborist wood chip mulch to protect roots and root zone soil from disturbance or compaction.
- Prep tree conservation areas to better withstand the stresses of the construction phase by pruning and applying a 1-inch layer of compost covered with a 2-inch layer of mulch around them well in advance of construction activities.

Operations and Maintenance Criteria

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. Replace trees that are removed or die with like species during the next appropriate planting season (typically in the fall).

Prune, when necessary for compatibility with other infrastructure and/or to preserve the health and longevity of trees. Meet industry standards for pruning (ANSI A300 standards).

For newly planted trees, provide supplemental irrigation during the first 5 growing seasons after installation to help ensure tree survival. Replenish mulch annually to retain soil moisture.

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

7.4.4 Bioretention Cells, Swales, and Planter Boxes (Ecology BMPs T5.14B and T7.30)

Description

Bioretention BMPs are shallow stormwater systems with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Bioretention BMPs are designed to mimic a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. Bioretention BMPs also provide runoff treatment through sedimentation, filtration, adsorption, and phytoremediation.

Bioretention BMPs function by storing stormwater as surface ponding before it filters through the underlying amended soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil.

The terms “bioretention” and “rain garden” are sometimes used interchangeably. Bioretention BMPs and rain gardens are applications of the same LID concept and can be highly effective for reducing surface runoff and removing pollutants. However, in the City (in accordance with Ecology’s distinction), the term “bioretention” is used to describe an engineered BMP that includes designed soil mixes and perhaps underdrains and control structures. The term “rain garden” is used to describe a shallow landscaped depression on small project sites that only trigger Core Requirements #1 through #5. Rain gardens have less restrictive design criteria for the soil mix and do not include underdrains or other control structures. See Section 7.4.5 for more information on rain garden design.

The term bioretention is used to describe various designs using soil and plant complexes to manage stormwater. The following bioretention-related terminology is used in this manual:

- **Bioretention cells** are 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 underdrain and are not designed as a conveyance system. Bioretention cells can be configured as depressed landscape islands, larger basins, planters, or vegetated curb extensions.

- **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.

- **Bioretention planters and planter boxes** incorporate 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 underdrain). Planters have an open bottom and allow infiltration to the subgrade. These designs are often used in ultra-urban settings.

Note: Ecology has approved use of certain patented treatment systems that use specific, high flow rate media for treatment. These systems may be similar to bioretention BMPs, but unless specifically approved by Ecology are not considered on-site stormwater management BMPs and are not options for meeting the requirements of Core Requirement #5. The Ecology approval (General Use Level Designations only) is meant to be used to meet Core Requirement #6, where appropriate.

Figure 7.6 provides an example illustration of a bioretention BMP. See Figure 7.7 for an example of a bioretention planter. Refer to the DG&PWS for standard detail drawings.

Applications and Limitations

Bioretention provides effective removal of many stormwater pollutants by passing stormwater through a soil profile that meets specified characteristics. Bioretention BMPs that infiltrate stormwater into the ground can also serve a significant flow reduction function.

- Bioretention BMPs are an on-site stormwater management BMP option for:

  1) Projects that only have to comply with Core Requirements #1 through #5, and

  2) Projects that trigger Core Requirements #1 through #9.

- Bioretention can achieve the LID Performance Standard option or can be applied from the List #1 or List #2 option of Core Requirement #5.

- Bioretention BMPs may meet the Core Requirement #6 requirements for basic and enhanced treatment (see Chapter 2 and Chapter 8) when the bioretention soil meets the requirements described under the Bioretention Soil Mix subsection below.

- Bioretention can be designed to fully meet the flow control duration standard of Core Requirement #7. However, because they typically do not have an orifice restricting overflow or underflow discharge rates, most designs typically don’t fully meet Core Requirement #7. Nonetheless, their performance contributes to meeting the standard, and that can result in much smaller flow control BMPs on the project site.

- Bioretention BMPs are particularly effective at flow control in locations where the underlying soil has a high infiltration rate. Where the native soils have low infiltration rates, underdrain systems can be installed and the BMP used to filter pollutants and detain flows that exceed infiltration capacity of the surrounding soil. However, designs utilizing underdrains provide less flow control benefits.

- Bioretention constructed with imported composted material should not be used within one-quarter mile of phosphorus-sensitive waterbodies if the underlying native soil does not meet the requirements for treatment soil provided in Chapter 8, Section 8.6.3.

- Bioretention constructed with imported composted material and underdrains are not allowed when the underdrain is upstream of a phosphorus-sensitive receiving water because preliminary monitoring indicates that bioretention BMPs constructed with imported composted material can add phosphorus to stormwater.

  - Phosphorus-sensitive waterbodies include:

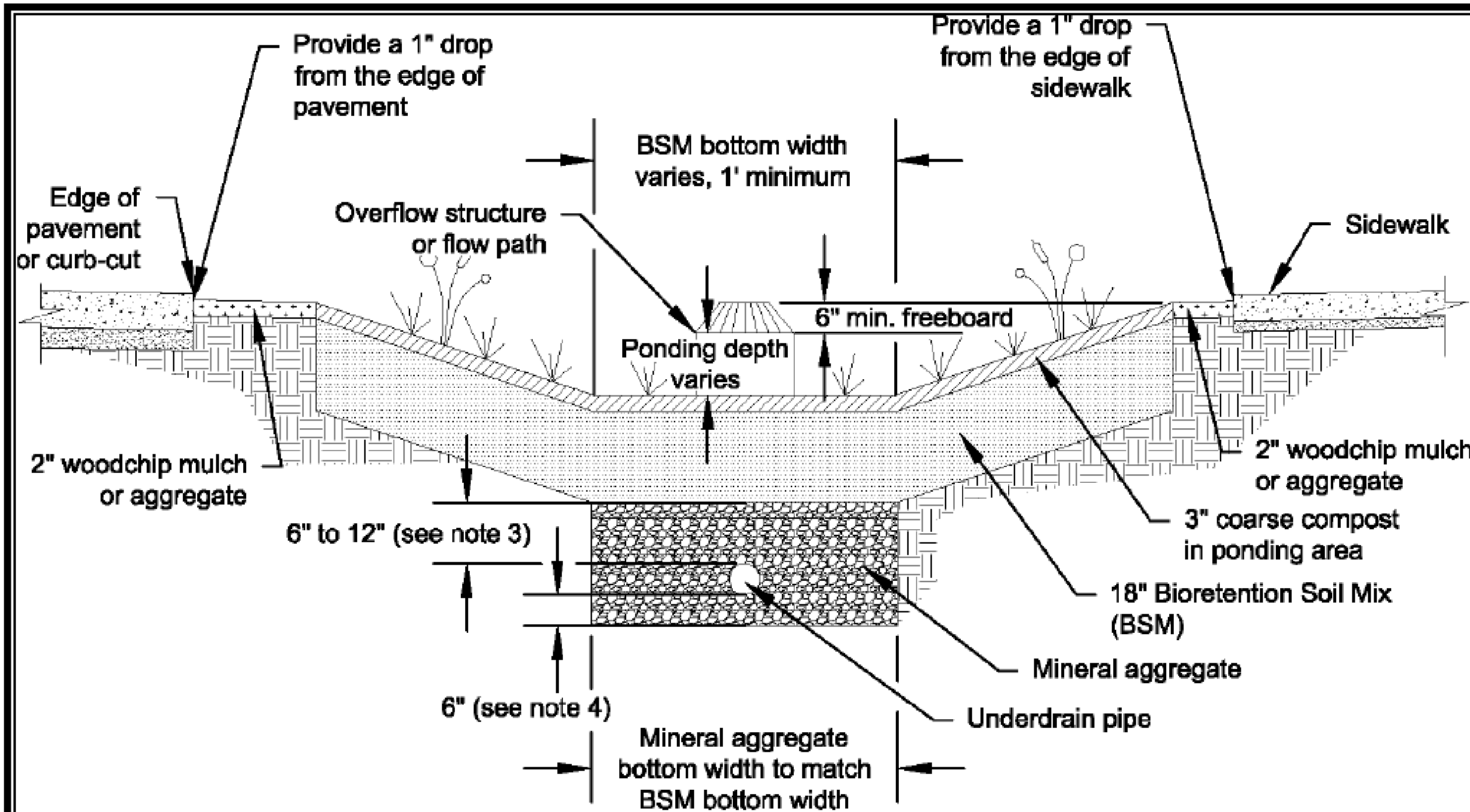
    - All lakes and ponds

    - Waterbodies listed in lake management plans, water quality improvement plans, or salmon recovery plans that recommend reducing sources of phosphorus in order to control aquatic plant growth

    - Surface waters listed on the state (303)d list for dissolved oxygen or pH due partly, or entirely, to elevated nutrient concentrations

  - High-performance bioretention soil mixes may be used in locations near phosphorus-sensitive waterbodies. Refer to the latest guidance on using high-performance mixes, available on Ecology’s website at: <https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html>

- Because bioretention BMPs use an imported soil mix that has a moderate design infiltration rate, they are best applied for small drainage areas, 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.



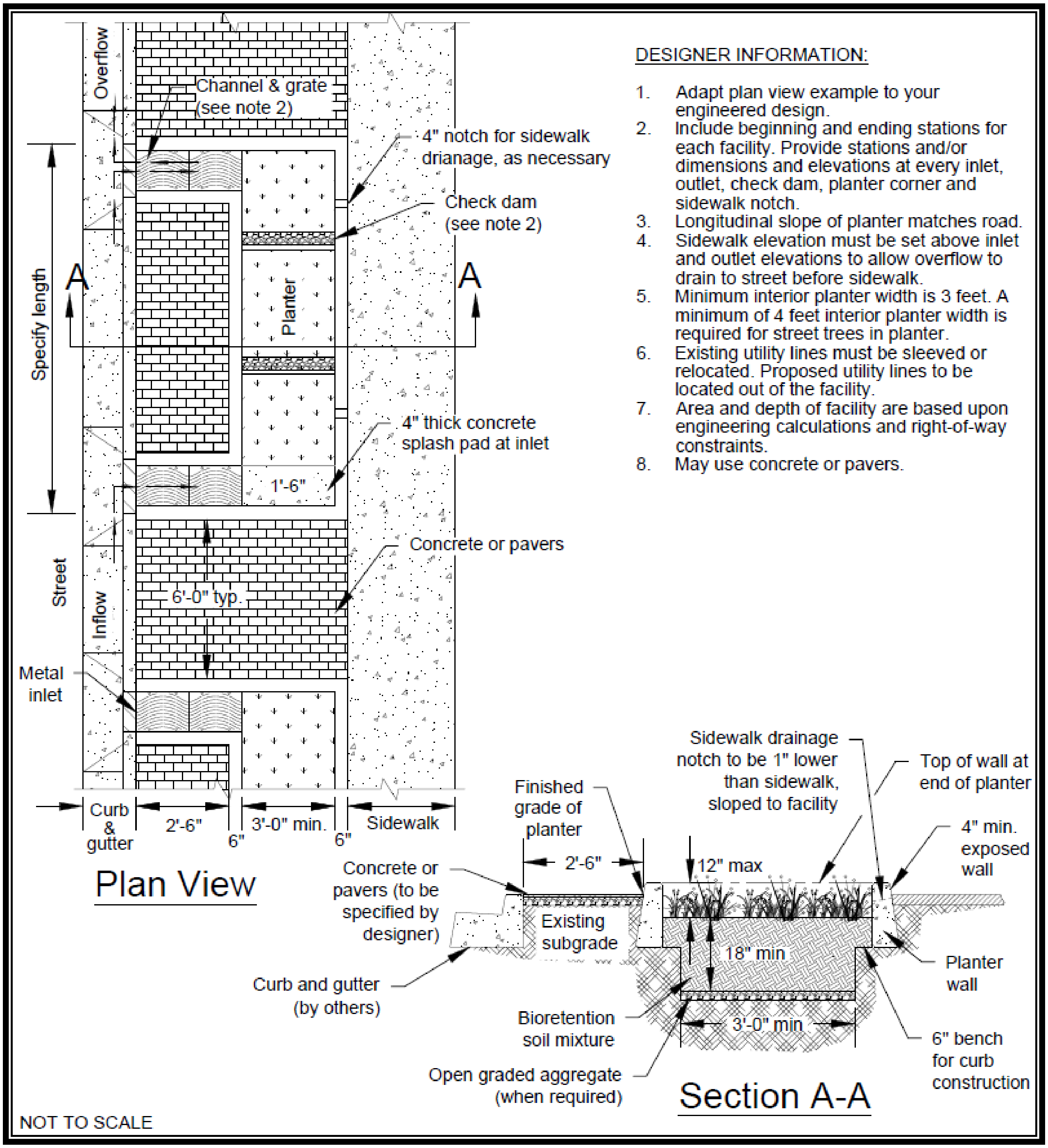
Notes:

1. Scarify subgrade 3" min. before BSM installation
2. Compact BSM to 85% per ASTM 1577
3. Minimum 6" to discourage fines from entering the underdrain from the BSM. Maximum 12" to prevent unnecessary BMP depth from encroaching into the seasonal high ground water.
4. If depth to the seasonal high ground water allows, this distance may be larger.
5. When an underdrain is used, the design must ensure that the seasonal high ground water does not encroach into the BMP (including the mineral aggregate layer surrounding the underdrain pipe).

NOT TO SCALE

Source: Ecology

Figure 7.6. Bioretention (shown with optional underdrain).



Source: Ecology

Figure 7.7. Example of a Bioretention Planter.

- Bioretention BMPs are applicable to new development, redevelopment and retrofit projects. Typical applications with or without underdrains include:
  - Individual lots for managing rooftop, driveway, and other on-lot impervious surfaces.
  - Shared BMPs located in common areas for individual lots.
  - Areas within loop roads or cul-de-sacs.
  - Landscaped parking lot islands, where bioretention can be situated lower than the height of the parking lot surface so that stormwater runoff is directed as sheet flow into the bioretention BMP. This application, in concert with permeable surfaces in the parking lot, can greatly attenuate stormwater runoff.
  - Within rights-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

See Appendix 7B for infeasibility criteria for bioretention. If one or more infeasibility criteria apply, bioretention is not required for consideration in the List #1 or List #2 option of Core Requirement #5. In addition, other bioretention design criteria and site limitations that make bioretention BMPs infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City. If a project proponent wishes to use a bioretention BMP, though is not required to because of these infeasibility criteria, they may propose a functional design to the City.

Other Site Suitability Factors

- **Utility conflicts:** Consult City requirements for horizontal and vertical separation required for publicly-owned utilities, such as sewer lines. Consult the appropriate franchise utility owners for separation requirements from their utilities, which may include communications, water, power, 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 the City’s 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 BMP in the development. For example, locate bioretention BMPs 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 BMPs can be used to buffer structures from roads, enhance privacy among residences, and as 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 to 3 years of irrigation for establishment. Invasive species control will be required as typical with all planted landscape areas.

Modeling and Sizing

Bioretention BMPs receiving runoff from roads or a combination of roads and other impervious/pervious surfaces will be larger than rain gardens. For bioretention BMPs designed to meet Core Requirement #5, the bioretention BMP shall have a horizontally projected surface area below the overflow which is at least 5 percent of the total impervious surface area draining to it. If pervious areas will also be draining to the bioretention BMP, the horizontally projected surface area below the overflow shall be increased by 2 percent of the pervious area. For bioretention BMPs designed to meet Core Requirement #6 or #7, the bioretention BMP must be sized using an approved continuous simulation model.

Ecology's approval status for continuous simulation models is provided in the "Additional Resources" section of the 2019 Ecology Manual: <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm>

When using continuous modeling to size bioretention BMPs, the assumptions listed in Table 7.3 shall be applied. It is recommended that bioretention cells be modeled as a layer of soil (with specified infiltration rate) with infiltration to underlying soil, ponding, and overflow. The bioretention soil is designed in accordance with the treatment soil requirements outlined in the design criteria below.

To meet Core Requirement #6, at least 91 percent of the influent runoff file produced using a continuous simulation model must be infiltrated. Applicable water quality design storm volume drawdown requirements must also be met (see Chapter 8).

If 91 percent of the influent runoff file cannot be infiltrated, the percent infiltrated may be subtracted from the 91 percent volume that must be treated, and downstream treatment BMPs may be significantly smaller as a result.

Table 7.3. Continuous Modeling Assumptions for Bioretention Cells.

Variable	Assumption
Computational Time Step	15 minutes
Inflows to BMP	Surface flow and interflow from drainage area routed to BMP
Precipitation and Evaporation Applied to BMP	Yes. If model does not apply precipitation and evaporation to BMP, include the BMP area in the basin area (note that this will underestimate the evaporation of ponded water).
Bioretention Soil Mix Measured Infiltration Rate	For imported soil, rate is 12 inch per hour before applying the correction factor.
Bioretention Soil Porosity	30 percent
Bioretention Soil Depth	Minimum of 18 inches
Native Soil Infiltration Rate	Measured infiltration rate, including applicable safety factors (see Appendix 7A)
Infiltration Across Wetted Surface Area	Only if side slopes are 3:1 or flatter
Underdrain (optional)	If an underdrain is placed at bottom extent of the bioretention soil layer, all water that filters through the bioretention soil must be routed through the underdrain (i.e., no losses to infiltration). If there is no liner or impermeable layer and the underdrain is elevated above the bottom extent of the bioretention soil or aggregate layer, water stored in the bioretention soil or aggregate below the underdrain invert may be allowed to infiltrate.
Overflow	Overflow elevation set at maximum ponding elevation (excluding freeboard). May be modeled as weir flow over riser edge or riser notch. Note that the total BMP depth (including freeboard) must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

To meet Core Requirement #7, the tributary areas, cell bottom area, and ponding depth must be iteratively sized until the duration curves and/or peak values meet the applicable flow control requirements (see Chapter 2).

Infiltration rates of the native soil (i.e., the undisturbed soil below the imported and/or amended BMP soil) and bioretention soil mix infiltration rate must be used when sizing and modeling bioretention BMPs. The native infiltration rate shall be determined using the methods outlined above. The method for determining infiltration rate of bioretention soil mix is described in the Bioretention Soil Mix subsection below.

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. This section includes infiltration testing requirements and application of appropriate safety factors specific to bioretention BMPs.

Refer to Appendix 7A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix 7A may not apply to bioretention (additional details provided below).

If the bioretention BMP includes a liner and does not infiltrate into the underlying soils, they are not considered infiltration BMPs and are not subject to the infiltration procedures or the setbacks provided in this section. Adhere to setbacks and site constraints for detention vaults included in Section 7.5.3 for these BMPs.

Determining Design Infiltration Rate

Determining the infiltration rate of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on site. Infiltration rates are also necessary to estimate bioretention performance using an approved continuous simulation model.

Determining Initial Soil Infiltration Rate

Initial (measured) infiltration rates are determined through soil infiltration tests. Infiltration tests must be run at the anticipated elevation of the top of the native soil beneath the bioretention BMP. Test hole or test pit explorations shall be conducted during mid to late in the “wet season” (December 1 through April 30) to provide accurate soil saturation and groundwater-level information. The following provides required test procedures for analysis of the soils underlying bioretention BMPs:

- Projects subject to Core Requirements #1 through #5:
  - One small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed at each potential bioretention site. Tests at more than one site could reveal the advantages of one location over another.

    Note that to demonstrate infeasibility of bioretention BMPs for Core Requirement #5, a small-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
  - Confirm that the site has the required 1-foot minimum clearance to the seasonal high groundwater or other impermeable layer (refer to Setbacks and Site Constraints below).

- Projects subject to Core Requirements #1 through #9:

    - For small bioretention cells (bioretention BMPs receiving water from one or two individual lots or <0.25 acre of pavement or other impervious surface), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed at each potential bioretention site. Tests at more than one site could reveal the advantages of one location over another.

    - For large bioretention cells (bioretention BMPs receiving water from several lots or 0.25 acre or more of pavement or other impervious surface), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A, shall be performed every 5,000 square feet. The more test pits/borings used, and the more evidence of consistency in the soils, the less of a safety factor may be used. If soil characteristics across the site are consistent, a geotechnical professional may recommend a reduction in the number of tests.

      If using the PIT method, multiple small-scale or one large-scale PIT can be used. If using the small-scale test, measurements shall be taken at several locations within the area of interest.

    - For bioretention swales or long, narrow bioretention BMPs (i.e., one following the road right-of-way), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed every 200 linear feet and within each length of road with varying subsurface characteristics (i.e., groundwater elevation, soils type, infiltration rates). However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high groundwater conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

      Note that to demonstrate infeasibility of bioretention BMPs for Core Requirement #5, a small-scale PIT or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).

    - Confirm that the site has the required 1- or 3-foot minimum clearance to the seasonal high groundwater or other impermeable layer (refer to Setbacks and Site Constraints below).

    - If a single bioretention BMP serves a drainage area exceeding 1 acre, infiltration receptor analysis and performance testing may be necessary. See Section 7.2.2, Step 5, for specific requirements for infiltration receptor characterization.

- If the general site assessment cannot confirm that the seasonal high groundwater or hydraulic restricting layer will be greater than 1 or 3 feet below the bottom of the bioretention, monitoring wells or excavated pits should be placed strategically to assess depth to groundwater.

Assignment of Appropriate Safety Factor

- If deemed necessary by a qualified professional engineer, a safety factor may be applied to the measured K_{sat} of the subgrade soils to estimate its design (long-term) infiltration rate. Depending on the size of the BMP, the variability of the underlying soils, and the number of infiltration tests performed, a safety factor may be advisable. (Note: This is a separate design issue from the assignment of a safety factor to the overlying, designed bioretention soil mix. See the Bioretention Soil Mix subsection below).

- The overlying bioretention soil mix provides excellent protection for the underlying native soil from sedimentation. Accordingly, a safety factor for the native soil (i.e., $F_{plugging}$ used in Appendix 7A) does not have to take into consideration the extent of influent control and clogging over time.

Prepare Soils Report

For projects subject to Core Requirements #1 through #5, a Soils Report must be 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. Refer to Chapter 3, Section 3.3.2, for Abbreviated Drainage Plan Soils Report requirements.

For projects subject to Core Requirements #1 through #9, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington. Refer to Chapter 3, Section 3.3.3, for Drainage Control Plan Soils Report requirements.

Estimate Volume of Stormwater

If required, use an approved continuous simulation model to generate an influent file that will be used to size the bioretention BMP. The BMP must infiltrate either all of the flow volume as specified by the influent file, or a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Core Requirement #7. In addition, the overflow/bypass must meet the LID Performance Standard if it is the option chosen to meet Core Requirement #5, or if it is required of the project.

Bioretention Design Criteria

The following provides descriptions, recommendations, and requirements related to the components of bioretention. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for BMP review must include documentation of the following elements, discussed in detail below:

- Setbacks and site constraints
- Flow entrance/presettling
- Ponding area
- Bottom area and side slopes
- Overflow
- Bioretention soil mix
- Underdrain (if included)
- Check dams and weirs
- Planting
- Mulch layer
- Hydraulic restriction layer.

Setbacks and Site Constraints

For setbacks and site constraints for non-infiltrating bioretention (i.e., lined bioretention cells or planter boxes), refer to the setbacks for detention vaults in Section 7.5.3. Infeasibility criteria documented in Appendix 7B include setbacks and site constraints used to evaluate the bioretention option of List #1 and List #2 (Core Requirement #5). The following minimum setbacks and site constraints apply to all infiltrating bioretention BMPs (i.e., bioretention without a liner or planter box):

- All bioretention BMPs shall have a minimum of 1-foot positive vertical clearance from any open water maximum surface elevation to structures within 25 feet.

- All bioretention BMPs shall be a minimum of 10 feet away from any structure or property line. This setback may be reduced by the City for BMPs within or adjacent to the right-of-way.

- All bioretention BMPs shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A reduced setback may be allowed if a geotechnical assessment and Soils Report is prepared that addresses the potential impact of the BMP on the slope and recommends a reduced setback. In no case shall the setback be less than the vertical height of the slope.

- All bioretention BMPs shall be a minimum of 5 feet from septic tanks and distribution boxes.

- For sites with on-site or adjacent septic systems, the edge of the design water surface must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210). Additional site-specific considerations may be required for septic systems serving commercial or light industrial land use to protect environmentally sensitive areas. This requirement may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.

- Bioretention is prohibited within 300 feet of an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

- In no case shall bioretention BMPs be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.

    - Where water supply wells exist nearby, it is the responsibility of the applicant's engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration BMP on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the BMP design, or relocation of the BMP should be considered.

    - Bioretention BMPs upgradient of drinking water supplies and within 1-, 5-, and 10-year time of travel zones must comply with the DG&PWS, Chapter 6.025 Wellhead Protection Areas, which includes the following:

        - Requires directing all stormwater away from source wells

        - Prohibits introducing stormwater directly into the same aquifer of a drinking water supply well within the well's 1-year WHPA

        - May require more stringent requirements, if needed to protect drinking water sources with higher susceptibility to contamination.

    - Infiltration systems that qualify as Underground Injection Control Wells must comply with Chapter 173-218 WAC. Refer to Appendix 7C for additional requirements and guidance related to UIC wells.

    - The Soils Report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- All bioretention BMPs shall be a minimum of 3 feet from 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 BMP meets or exceeds any of the following thresholds:

- 5,000 square feet of PGIS
- 10,000 square feet of impervious area
- 0.75 acres of lawn and landscape.

- For bioretention systems with a contributing area less than the above thresholds, a minimum of 1 foot of clearance from seasonal high groundwater or other impermeable layer is acceptable.
- In the event that the downstream pathway of infiltration, interflow, and/or the infiltration capacity is insufficient to handle the contributing area flows (e.g., a BMP enclosed in a loop roadway system or a landscape island within a parking lot), an underdrain system can be incorporated into the bioretention BMP. The underdrain system can then be conveyed to a nearby vegetated channel, another stormwater BMP or dispersed into a natural protection area. See the underdrain section below for additional information.

Flow Entrance/Presettling

The design of flow entrance to a bioretention BMP will depend upon topography, flow velocities, flow volume, and site constraints. Flows entering a BMP should have a velocity of less than 1 foot per second to minimize erosion potential. Vegetated buffer strips are the preferred entrance type because they slow incoming flows and provide initial settling of particulates.

Minimum requirements associated with the flow entrance/presettling design include the following:

- If concentrated flows are entering the BMP, engineered flow dissipation (e.g., rock pad or flow dispersion weir) must be incorporated. Avoid the use of angular rock or quarry spalls at the flow entrance and instead use round (river) rock if needed. Removing sediment from angular rock is difficult.
- A minimum 2-inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance, or 5 percent slope from the outer curb face extending to a minimum of 12 inches beyond the back of curb, is required.
- If the catchment area contains unvegetated exposed soils or steep slopes, a presettling system (e.g., a filter strip, presettling basin, or vault) is required.

Four primary types of flow entrances can be used for bioretention:

1. Dispersed, low velocity flow across a grass or landscape area—this is the preferred method of delivering flows to the BMP and can provide initial settling

of particulates. Dispersed flow may not be possible given space limitations or if the BMP is controlling roadway or parking lot flows where curbs are mandatory.

2. Dispersed flow across pavement or gravel and past wheel stops for parking areas.

   - Parking lots that incorporate bioretention into landscaped areas should use concrete curb blocks as wheel stops to protect the bioretention BMP from traffic intrusion while also allowing the parking lot runoff to flow somewhat unobstructed to the bioretention BMP.

   - A 1-inch drop should be provided from the edge of pavement to the top of the bioretention BMP.

3. Drainage curb cuts for roadside, driveway, or parking lot areas—curb cuts shall include rock or other erosion protection material in the channel entrance to dissipate energy.

   - The minimum 12-inch drainage curb cut results in a 12-inch opening measured at the curb flow line and will require a 3-foot cut in an existing curb. An 18-inch curb cut is recommended for most applications.

   - 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 BMPs 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 inches from gutter line into the bioretention BMP and provide an area for settling and periodic removal of debris.

     - Plan for 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.

   - A 1-inch drop should be provided from the edge of the curb-cut to the top of the bioretention BMP.

- Refer to the Bioretention Curb Cut Standard Detail (Drawing 5-12) in the DG&PWS.

4. Pipe flow entrance—piped entrances shall include rock or other erosion protection material in the BMP entrance to dissipate energy and/or provide flow dispersion.

    - 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 BMP 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 should not be placed directly in the entrance flow path as they can restrict or concentrate flows and can be damaged by erosion around the root ball.

Ponding Area

Bioretention ponding area may be an earthen depression (for bioretention cells and swales), or a planter box (for bioretention planters or planter boxes). The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the BMP. Ponding depth and draw-down rate requirements are 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 1) restore hydraulic capacity of system, 2) maintain infiltration rates, 3) maintain adequate soil oxygen levels for healthy soil biota and vegetation, 4) provide proper soil conditions for biodegradation and retention of pollutants, and 5) prevent conditions supportive of mosquito breeding.

Minimum requirements associated with the bioretention ponding area design include the following:

- The ponding depth shall be a maximum of 12 inches.

- The surface pool drawdown time (surface ponding volume) shall be a maximum of 24 hours (drain time is calculated as a function of ponding depth and native soil design infiltration rate or bioretention soil mix infiltration rate, whichever is less).

The minimum freeboard measured from the invert of the overflow pipe or earthen channel to BMP overtopping elevation shall be 2 inches for drainage areas less than 1,000 square feet and 6 inches for drainage areas 1,000 square feet or greater. There should be a 1-inch drop from the edge of pavement or curb cut to the maximum freeboard elevation.

If berming is used to achieve the minimum top elevation needed to meet ponding depth and freeboard needs, the maximum slope on the berm shall be 3H:1V, and minimum top width of the design berm shall be 1 foot. Soil used for berming shall be imported bioretention soil or amended native soil and compacted to a minimum of 90 percent dry density.

Bottom Area and Side Slopes

Bioretention BMPs 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:

- The maximum planted side slope should be 3H:1V. If steeper side slopes are necessary rockeries, concrete walls, or soil wraps may be effective design options.

- The bottom width should be no less than 2 feet.

Bioretention BMPs should have a minimum shoulder of 12 inches between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should be 90 percent proctor.

Overflow

An overflow route must be identified for stormwater flows that overtop the bioretention BMP when infiltration capacity is exceeded or the BMP becomes plugged and fails. The overflow route must be able to convey the 100-year recurrence interval developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

Overflow designs shall be tailored to site conditions. Options include, but are not limited to: an emergency overflow spillway (minimum length of 3 feet), a vertical drain pipe installed at the designed maximum ponding elevation (12 inches) and connected to a downstream BMP or an approved discharge point, or a curb cut at the downgradient end of the bioretention BMP to direct overflows back to the street.

Bioretention Soil Mix

Unlike infiltration basins and trenches, the native soil underlying bioretention BMPs is not subject to the soil infiltration treatment requirements discussed in Chapter 8 (i.e., soil suitability criteria #1 and soil suitability criteria #2). Bioretention BMPs meet the requirements for basic and enhanced treatment, when the bioretention soil mix meets the requirements of the bioretention soil mix design criteria (see bioretention soil mix criteria below).

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.

The minimum requirements associated with the bioretention soil mix include the following:

- Minimum depth of treatment soil must be 18 inches
- Projects can either use a default bioretention soil mix or can create a custom bioretention soil mix.
    - Projects which use the default bioretention soil mix do not have to test bioretention soil mix infiltration rate. They may assume the rates specified in the next subsection.
    - Projects which create a custom bioretention soil mix rather than using the default requirements must demonstrate compliance with the specific design criteria and must test the bioretention soil mix infiltration rate as described in the Custom Bioretention Soil Mix subsection below.

Default Bioretention Soil Mix

Bioretention soil shall be a well-blended mixture of mineral aggregate and composted material measured on a volume basis. Bioretention soil shall consist of two parts fine compost (approximately 35 to 40 percent) by volume and three parts mineral aggregate (approximately 60 to 65 percent), by volume. The mixture shall be well blended to produce a homogeneous mix.

Mineral Aggregate

- Percent Fines: A range of 2 to 4 percent passing the U.S. #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to American Society for Testing and Materials (ASTM) D422.

Mineral Aggregate Gradation

- Mineral Aggregate shall be free of wood, waste, coating, or any other deleterious material. The aggregate portion of the bioretention soil mix shall be well graded. According to ASTM D2487-98 (Classification of Soils for Engineering Purposes [Unified Soil Classification System]), well-graded sand should have the following gradation coefficients:
    - Coefficient of Uniformity (Cu = D60/D10) equal to or greater than 4, and
    - Coefficient of Curve (Cc = (D30)2/D60 x D10) greater than or equal to 1 and less than or equal to 3.

Aggregate shall be analyzed by an accredited lab using the U.S. sieve numbers and gradation noted in Table 7.4.

Table 7.4. Aggregate for Bioretention Soil.	
U.S. Sieve Number	**Percent Passing**
0.375 inch	100
4	95–100
10	75–90
40	24–40
100	4–10
200	2–5

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 to 65 percent mineral aggregate, 35 to 40 percent compost.
- Organic matter content: 5 to 8 percent by weight.
- Cation Exchange Capacity (CEC) must be greater than 5 milliequivalents (meq) per 100 grams of dry soil. Note: Soil mixes meeting the above specifications do not have to be tested for CEC. They will readily meet the minimum CEC.

Composted Material

To ensure that the bioretention soil mix 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:

- Material must meet the definition of "composted material" in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Material must be produced at a composting facility that is permitted by a jurisdictional health authority. Permitted compost facilities in Washington are included on a list available at <https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost>.
- The compost product must originate a minimum of 65 percent by volume from recycled plant waste comprising "yard debris," "crop residues," and "bulking agents" as those terms are defined in WAC 173-350-100. A maximum of 35 percent by volume of "postconsumer food waste" as defined in WAC 173-350-100, but not including biosolids, may be substituted for recycled plant waste.
- Moisture content must be such that there is no visible free water or dust produced when handling the material.

- The material shall be tested in accordance with the U.S. Composting Council "Test Method for the Examination of Compost and Composting" (TMECC), as established in the Composting Council's "Seal of Testing Assurance" (STA) program. Most Washington compost BMPs now use these tests.

- Composted material shall meet the size gradations established in the U.S. Composting Council's Seal of Testing Assurance (STA) program, as follows: Fine Compost shall meet the following gradation by dry weight:

	Min.	**Max.**
Percent passing 2″	100	
Percent passing 1″	99	100
Percent passing 0.625″	90	100
Percent passing 0.25″	75	100

- The pH shall be between 6.0 and 8.5 (TMECC 04.11-A).

- "Physical contaminants" (as defined in WAC 173-350-100) content shall be less than 1 percent by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.

- Minimum organic matter content shall be 40 percent by dry weight basis as determined by TMECC 05.07-A, "Loss-On-Ignition Organic Matter Method."

- Soluble salt contents shall be less than 4.0 dS/mm (mmhos/cm) tested in accordance with TMECC 04.10-A, "1:5 Slurry Method, Mass Basis."

- Maturity indicators from a cucumber bioassay shall be greater than 80 percent for both emergence and vigor, in accordance with TMECC 05.05-A, "Germination and Vigor".

- The material must be stable (low oxygen use and CO2 generation) and mature (capable of supporting plant growth). This is critical to plant success in a bioretention soil mixes. Stability shall be 7 mg CO_2-C/g OM/day or below in accordance with TMECC 05.08-B, "Carbon Dioxide Evolution Rate."

- Fine Compost shall have a carbon to nitrogen ratio of less than 25:1 as determined using TMECC 05.02A "Carbon to Nitrogen Ratio" which uses the TMECC 04.01 "Organic Carbon" and TMECC 04.02-D "Total Nitrogen by Oxidation." The Engineer may specify a Carbon:Nitrogen ratio up to 35:1 for projects where the plants selected are entirely 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).

Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall be immediately removed from the project and replaced.

If using the bioretention soil mix included herein, a default infiltration rate of 12 inches per hour shall be used. Refer to the Determining Design Bioretention Soil Mix Infiltration Rate section below.

High Performance Bioretention Soil Mix

High-performance bioretention soil mixes may be used in locations near phosphorus-sensitive waterbodies. Refer to the latest guidance on using high-performance soil mixes, available on Ecology’s website at: <https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html>.

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 $\geq$ 5 milliequivalents/100 grams of dry soil; U.S. EPA 9081.
- pH between 5.5 and 7.0.
- 5 to 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 to 5 percent fines passing the U.S. #200 sieve; TMECC 04.11-A.
- If compost is used in creating the custom mix, it must meet all of the specifications listed above for compost, except for the gradation specification. An alternative gradation specification must indicate the minimum percent passing for a range of similar particle sizes.
- Measured (initial) saturated hydraulic conductivity of less than 12 inches per hour; ASTM D2434 (Standard Test Method for Permeability of Granular Soils [Constant Head]) at 85 percent compaction per ASTM D1557 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use Appendix 7A, Recommended Modifications to ASTM D2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes.
- Design (long-term) saturated hydraulic conductivity greater than 1 inch per hour. Refer to the Determining Design Bioretention Soil Mix Infiltration Rate section below.

Determining Design Bioretention Soil Mix Infiltration Rate

A long-term infiltration rate correction factor of 4 shall be used for the bioretention soil if the area tributary to the BMP meets or exceeds any of the below thresholds:

- 10,000 square feet of impervious area
- 5,000 square feet of PGIS
- 0.75 acres of lawn and landscape.

For bioretention BMPs with a contributing area less than the above thresholds, a long-term infiltration rate correction factor of 2 for the bioretention soil mix is acceptable.

Underdrain (Optional)

Where the underlying native soils have an estimated initial infiltration rate between 0.3 and 0.6 inches per hour, bioretention BMPs without an underdrain, or with an elevated underdrain directed to a surface outlet, may be used to satisfy List #2 of Core Requirement #5. Underdrained bioretention BMPs must meet the following criteria if they are used to satisfy List #2 of Core Requirement #5:

- The invert of the underdrain must be at least 6 inches above the bottom of the aggregate bedding layer. A larger distance between the underdrain and bottom of the bedding layer is desirable, but cannot be used to trigger infeasibility due to inadequate vertical separation to the seasonal high water table, bedrock, or other impermeable layer.
- The distance between the bottom of the bioretention soil mix and the crown of the underdrain pipe must be not less than 6 or more than 12 inches.
- The aggregate bedding layer must run the full length and the full width of the bottom of the bioretention BMP.
- The BMP must not be underlain by a low permeability liner that prevents infiltration into the native soil.

Underdrain systems should be installed only if the bioretention BMP is located where infiltration is not permitted and a liner is used, or where subgrade soils have infiltration rates that do not meet the maximum pool drawdown time. In these cases, underdrain systems can be installed and the BMP can be used to filter pollutants and detain flows. However, designs utilizing underdrains provide less infiltration and flow control benefits.

The volume above an underdrain pipe in a bioretention BMP provides pollutant filtering and some flow attenuation; however, only the void volume of the aggregate below the underdrain invert and above the bottom of the bioretention BMP (subgrade) can be used in an approved continuous simulation model for dead storage volume that provides flow control benefit. Assume a 40 percent void volume for the filter material aggregate specified below.

The minimum requirements associated with the underdrain design include:

- Slotted, thick-walled plastic pipe must be used:

  - Minimum pipe diameter: 6 inches (pipe diameter will depend on hydraulic capacity required). Changes in pipe diameter shall be made using a junction box or other approved structure. Within the public right-of-way any underdrain shall have a minimum diameter of 8 inches (pipe diameter will depend on hydraulic capacity required).

  - Slotted subsurface drain PVC per DG&PWS and WSDOT Standard Specifications.

- 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 one-half of the circumference of the pipe. Underdrain pipe slope must be no less than 0.5 percent.

- Pipe must be placed in filter material and have a minimum cover depth of 4 inches.

- Filter material shall meet the requirements of WSDOT Standard Specifications Section 9-03.12(4) (gravel backfill for drains).

- A 6-inch non-perforated cleanout must be connected to the underdrain every 300 feet minimum.

- The underdrain can be connected to a downstream BMP such as another bioretention/rain garden BMP as part of a connected system, or to an approved discharge point. A geotextile fabric (specifications in Chapter 8, Appendix 8A) must be used between the soil layer and underdrain.

Check Dams and Weirs

For sloped bioretention BMPs, check dams are necessary to provide ponding, reduce flow velocities, and reduce the potential for erosion. Typical check dam 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 rights-of-way, and aesthetics. Optimum spacing is determined by flow control benefit (modeling) in relation to cost considerations. See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for typical designs.

UIC Discharge

Where bioretention facilities discharge to UICs, Underground Injection Control (UIC) regulations are applicable and must be followed (Chapter 173-218 WAC). See Appendix 7C.

Planting

In general, the predominant plant material utilized in bioretention BMPs are species adapted to stresses associated with wet and dry conditions. Soil moisture conditions will vary within the BMP 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 BMP or on mounded areas.

The minimum requirements associated with the vegetation design include the following:

- The design plans must specify that vegetation coverage of selected plants will achieve 90 percent coverage within 2 years or additional plantings will be provided until this coverage requirement is met

- For BMPs receiving runoff from 5,000 square feet or more impervious surface, plant spacing and plant size must be designed to achieve specified coverage by a certified landscape architect

- The plants must be sited according to sun, soil, wind, and moisture requirements

- The side slopes for the bioretention BMP (vertical or sloped) can affect the plant selection and must be considered.

- At a minimum, provisions must be made for supplemental irrigation during the first 2 growing seasons following installation and in subsequent periods of drought.

- If a bioretention BMP will be located in a full shade area (i.e., receiving less than 3 hours of direct sunlight per day), then a licensed landscape architect shall provide input on the plant selection and layout. If a licensed landscape architect determines that plants will not survive in the fully shaded location, 3 inches of washed sandy gravel backfill (see DG&PWS) or mulch may be used as a top dressing in lieu of plants.

Additionally, trees can be planted along the side slopes or bottom of bioretention cells that are unlined.

Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional planting guidance, including:

- Guidance and recommendations for plant selection and increasing survival rates

- Planting zone descriptions

- Optimum planting times

- Plant selection for planting zones based on sun exposure

Mulch Layer

Bioretention BMPs shall be designed with a mulch layer or a dense groundcover. Properly selected mulch material also reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to soil. Mulch shall be:

- Medium compost in the bottom of the BMP (compost is less likely to float during cell inundation). Compost shall not include biosolids of manures.
- Wood chip mulch composed of shredded or chipped hardwood or softwood on cell 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 trunk or branch wood and bark.
- A minimum of 2 and a maximum of 3 inches thick (thicker applications can inhibit proper oxygen and carbon dioxide cycling between the soil and atmosphere).

Mulch shall not include weed seeds, soil, roots, and other material that are not from the above ground components of a tree, grass clippings (decomposing grass clippings are a source of nitrogen and are not recommended for mulch in bioretention BMPs), or pure bark (bark is essentially sterile and inhibits plant establishment).

In bioretention BMPs 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 1.5-inch gravel (rounded) decorative rock is typical. The area covered with aggregate mulch must not exceed one-third of the BMP bottom area.

As an alternative to mulch, a dense groundcover may be used. Mulch is required in conjunction with the groundcover until groundcover is established.

Hydraulic Restriction Layer

For infiltrating bioretention BMPs adjacent to roads, foundations, or other sensitive infrastructure, it may be necessary to restrict lateral infiltration pathways to prevent excessive hydrologic loading using a restricting layer (for the sides of the bioretention BMP only). Geomembrane liners are a type of restricting layer that can be incorporated into bioretention designs. Geomembrane liners completely block infiltration. The liner shall have a minimum thickness of 30 mils and be ultraviolet (UV) resistant.

Note: only the infiltrating bottom area (i.e., unlined) shall be used in sizing calculations or hydrologic modeling.

If it is necessary to prevent infiltration to underlying soils (e.g., contaminated soils or steep slope areas), the BMP must include a hydraulic restriction layer across the entire BMP. The BMP may be composed of a low permeability (e.g., concrete) container with a closed bottom, or may be lined with a low permeability material (e.g., geomembrane liner) to prevent infiltration. In these cases, underdrains are required.

Signage

The City recommends that bioretention installations used to meet Core Requirement #5, #6, and/or #7 include informational signage upon completion of the installation to help identify the vegetated area as a stormwater BMP and to inform maintenance crews and the general public about protecting the BMP's function.

Construction Criteria

See Chapter 5, Section 5.3, for infiltration BMP construction requirements. The minimum requirements associated with bioretention BMP construction include the following:

- Bioretention BMPs that infiltrate into the underlying soil (i.e., do not include a liner) rely on water movement through the surface soils as infiltration and interflow to underlying soils. Therefore, it is important to always consider the pathway of interflow and ensure that the pathway is maintained in an unobstructed and uncompacted state. This is true during the construction phase as well as postconstruction.

- During construction, it is critical to prevent clogging and over-compaction of the subgrade and bioretention soils.

- Place bioretention soil per the requirements of bioretention soil mix requirements specified in this section.

Acceptance Testing

The project engineer or designee shall inspect bioretention BMPS before, during, and after construction to ensure BMPs are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. Prior to placement of the bioretention soil mix, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate.

Before release of the maintenance bond, the project engineer shall perform a minimum of two acceptance tests after construction to determine if the BMP will operate as designed. The type of test will depend on specific BMP and site constraints, and therefore shall be determined by the project engineer on a case-by-case basis, and must be submitted for approval by the City prior to testing. The City must be notified of the scheduled infiltration testing at least 2 working days in advance of the test. See Appendix 7A for infiltration testing requirements. If the tests indicate the BMP will not function as designed, this information must be brought to the immediate attention of the City along with any reasons as to why not and how it can be remedied.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

7.4.5 Rain Gardens (Ecology BMP T5.14A)

Description

Rain gardens are shallow stormwater systems with compost amended soil or imported bioretention soil and plants adapted to the local climate and soil moisture conditions. Like bioretention, rain gardens are designed to mimic the hydrology of a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. Rain gardens also provide runoff treatment through sedimentation, filtration, adsorption, and phytoremediation.

Rain gardens function by storing stormwater as surface ponding before it filters through the underlying amended soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil.

The terms bioretention and rain garden are sometimes used interchangeably. However, in the City (in accordance with Ecology's distinction), the term bioretention is used to describe an engineered BMP that includes designed soil mixes and perhaps underdrains and control structures. The term rain garden is used to describe a landscape feature that serves to capture stormwater on small project sites that only trigger Core Requirements #1 through #5.

Rain gardens are similar to bioretention BMPs (refer to Section 7.4.4) with the following exceptions:

- Rain gardens may only be used to meet on-site stormwater management requirements (List #1) and must not be used on projects that trigger runoff treatment or flow control requirements (i.e., they are applicable for projects that only trigger Core Requirements #1 through #5).
- Rain gardens may not have a liner or underdrain.
- The maximum ponding depth is 6 inches.
- A certified landscape architect is not required for vegetation design.
- Rain gardens must not receive runoff from a public roadway.

Applications and Limitations

Bioretention BMPs and rain gardens are applications of the same LID concept and can be highly effective for reducing surface runoff and removing pollutants.

- Rain gardens are an on-site stormwater management BMP option for projects that have to comply with Core Requirements #1 through #5, but not Core Requirements #1 through #9.
- Rain gardens may be utilized as on-lot stormwater system, even in areas where underlying soils may not be conducive to rapid infiltration (such as underlying glacial till), but where the area does have a surface soil cover that allows the migration of stormwater through the upper soil horizon as interflow.
- Underdrains shall not be used for rain gardens. For sites with poorly draining soils (e.g., 0.3 to 0.6 inches per hour), applicants are encouraged to contact an engineer for other recommended options (e.g., designing a bioretention BMP for the site).
- Rain gardens shall not accept runoff from a public roadway.
- 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.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for rain gardens. If one or more infeasibility criteria apply, then rain gardens are not required for consideration in the List #1 option of Core Requirement #5. Infeasibility criteria for rain gardens are the same as for bioretention. In addition, other rain garden design criteria and site limitations that make rain gardens infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

For design on projects subject to Core Requirement #5, and choosing to use List #1 of that requirement, rain gardens shall have a horizontally projected surface area below the overflow that is at least 5 percent of the total impervious surface area draining to it. If lawn/landscape area will also be draining to the rain garden, the rain garden's horizontally projected surface area below the overflow shall be increased by 2 percent of the lawn/landscape area.

It is recommended that the rain garden bottom not be oversized because the vegetation in oversized rain gardens may not receive sufficient stormwater runoff for irrigation, increasing operation and maintenance requirements. Stormwater flows from other areas (beyond the area for which the rain garden is sized) should be bypassed around the rain garden in order to reduce sediment loading and the potential for clogging.

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. This section includes infiltration testing requirements and application of appropriate safety factors specific to rain gardens.

Refer to Appendix 7A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix 7A may not apply to rain gardens (additional details provided below).

Determining Design Infiltration Rate

Infiltration rates are determined through soil infiltration tests. Infiltration tests shall be run at the anticipated elevation of the top of the native soil beneath the rain garden area. A small-scale PIT or soil grain size analysis (for sites underlain by Type A soils only) outlined in Appendix 7A, shall be performed at each potential rain garden site. Test hole or test pit explorations shall be conducted during mid to late in the winter season (December 1 through April 30) to provide accurate groundwater saturation and groundwater information. Note that to demonstrate infeasibility for Core Requirement #5, the small-scale PIT must be used (i.e., measured infiltration rate of less than 0.3 inches per hour). Also confirm that the site has the required 1-foot minimum clearance to the seasonal high groundwater or other impermeable layer (e.g., through over excavation of the pit, or using a soil log or monitoring well). Note that when using the field testing procedures outlined in Appendix 7A, a safety factor is not required for rain gardens.

Prepare Soils Report

A Soils Report must be 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. Refer to Chapter 3, Section 3.3.2, for Abbreviated Drainage Plan Soils Report requirements.

Rain Garden Design Criteria

The following provides descriptions, recommendations, and requirements related to the components of a rain garden. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for rain garden review must include documentation of the elements discussed below.

Setbacks and Site Constraints

Setbacks and site constraints for rain gardens are the same as those for infiltrating bioretention BMPs (see Section 7.4.4).

Flow Entrance

Flow entrances should be sized to capture flow from the catchment area and designed to both reduce the potential for clogging at the inlet and prevent inflow from causing erosion in the rain garden. See the *Rain Garden Handbook for Western Washington* (Ecology 2013) for additional details and information (see References for website).

Cell Ponding Area

Cell ponding area design criteria for rain gardens are the same as those specified in the *Rain Garden Handbook for Western Washington* (Ecology 2013), except for the following:

- The ponding depth for rain gardens shall be a maximum of 6 inches.
- The minimum freeboard measured from the invert of the overflow pipe or earthen channel to BMP overtopping elevation shall be 6 inches.
- If berming is used to achieve the minimum top elevation needed to meet ponding depth and freeboard needs, the maximum slope on berm shall be 3H:1V, and the minimum top width of design berm shall be 1 foot. Soil used for berming shall be imported bioretention soil or amended native soil.

Bottom Area and Side Slopes

Rain gardens are highly adaptable and can fit various rural and urban settings by adjusting bottom area and side slope configuration. Recommended maximum and minimum dimensions include:

- The planted side slope should be no steeper than 3H:1V. If steeper side slopes are necessary, rockeries, concrete walls, or soil wraps may be effective design options.
- The bottom width should be no less than 2 feet.

Overflow

An overflow route must be identified for stormwater flows that overtop the rain garden area when infiltration capacity is exceeded or the BMP becomes plugged and fails. The overflow route must flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

Rain garden overflow can be provided by a drain pipe installed at the designed maximum ponding elevation and connected to a downstream BMP or an approved discharge point.

See the *Rain Garden Handbook for Western Washington* (Ecology 2013) for additional details and information.

Rain Garden Soil Mix

See the *Rain Garden Handbook for Western Washington* (Ecology 2013) for soil mix information. For amending the native soil within the rain garden, the City recommends use of compost that meets the compost specification for bioretention (see Section 7.4.4). Compost that includes biosolids or manure shall not be used.

Planting

Refer to the *Rain Garden Handbook for Western Washington* (Ecology 2013) for guidance on plant selection and recommendations for increasing survival rates. The minimum requirements associated with the vegetation design include the following:

- The design plans must specify that vegetation coverage of selected plants will achieve 90 percent coverage within 2 years or additional plantings will be provided until this coverage requirement is met
- Plant spacing and plant size must be designed to achieve specified coverage
- The plants must be sited according to sun, soil, wind, and moisture requirements
- At a minimum, provisions must be made for supplemental irrigation during the first two growing seasons following installation and in subsequent periods of drought.

Mulch Layer

Refer to the *Rain Garden Handbook for Western Washington* (Ecology 2013) for mulch layer requirements. Properly selected mulch material reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to soil. Mulch should consist of compost in the bottom of the BMPs (compost is less likely to float than wood chip mulch and is a better source for organic materials).

Signage

The City recommends that rain gardens used to meet Core Requirement #5, #6, and/or #7 include informational signage upon completion of the installation to help identify the vegetated area as a stormwater BMP and to inform maintenance crews and the general public about protecting the BMP’s function.

Rain Garden Construction Criteria

During construction, it is critical to prevent clogging and over-compaction of the native soil, bioretention soil, or amended soil. Additionally, excavation, soil placement, or soil amendment is not allowed during wet or saturated conditions.

Refer to Chapter 5, Section 5.3, LID BMP Protection During Construction, for additional infiltration BMP and bioretention BMP construction requirements that also apply to rain gardens.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

7.4.6 Permeable Pavements (Ecology BMP T5.15)

Description

Stormwater runoff 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. Permeable pavement is designed to accommodate pedestrian, bicycle, and auto traffic while allowing infiltration and storage of stormwater.

Permeable pavement includes porous asphalt; pervious concrete; permeable pavers and aggregate pavers; and grid systems.

- **Porous hot or warm-mix asphalt pavement** 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** 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.

- **Permeable interlocking concrete pavers (PICP) and aggregate pavers:** 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.

- **Grid systems** include those made of concrete or plastic. Concrete units are precast in a manufacturing BMP, 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 pavement is an on-site stormwater management BMP option for:

  1) Projects that only have to comply with Core Requirements #1 through #5, and

  2) Projects that trigger Core Requirements #1 through #9.

- Permeable pavement can achieve compliance with the LID Performance Standard option or can be applied from the List #1 or List #2 option of Core Requirement #5.

- Permeable pavement can meet runoff treatment requirements of Core Requirement #6 when the underlying soil meets the treatment soil requirements outlined in Chapter 8, Section 8.6, or a runoff treatment course is included.

- Permeable pavement installations can sometimes meet the flow control duration standard of Core Requirement #7. The flow control performance is typically a function of the infiltration rate of the underlying subgrade soil and the depth of the aggregate storage reservoir that stores stormwater until it is infiltrated.

- Typical applications for permeable pavement include parking lots, low volume roads, alleys, residential access roads, emergency and facility maintenance roads, sidewalks, pedestrian and bike trails, driveways, and patios.

- Refer to Chapter 4 of the DG&PWS for additional design requirements and allowable applications of different permeable pavement installations.

- Permeable pavement works well in concert with other on-site stormwater management BMPs such as permeable pavement parking stalls adjacent to bioretention BMPs, and permeable roadway surfaces bordered by vegetated biofiltration swales.

- Permeable pavement is not recommended under the following conditions:

  - Excessive sediment contamination is likely on the pavement surface (e.g., construction areas, landscaping material yards) due to potential for clogging.

  - It is infeasible to prevent stormwater run-on to the permeable pavement from unstabilized erodible areas without presettling, due to potential for clogging.

  - Sites where the risk of concentrated pollutant spills are more likely (e.g., gas stations, truck stops, car washes, vehicle maintenance areas, industrial chemical storage sites) since permeable pavement allows spills to infiltrate.

- To reduce the potential of clogging, runoff generated from unstabilized pervious surfaces shall not be directed onto a permeable pavement surface. Absolutely no point discharges shall be directed onto permeable pavement. If runoff comes from minor or incidental pervious areas (including lawns), those areas must be fully stabilized.

- ADA compliance should be requested from the manufacturer and is a consideration in determining where to use permeable pavement.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for permeable pavement. If one or more infeasibility criteria apply, then permeable pavement is not required for consideration in the List #1 or List #2 option of Core Requirement #5. If a project proponent wishes to use permeable pavement—though is not required to because of these infeasibility criteria—they may propose a functional design to the City. These criteria also apply to impervious pavements that would employ stormwater collection from the surface of impervious pavement with redistribution below the pavement. In addition, other permeable pavement design criteria and site limitations that make permeable pavement infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

Refer to the Runoff Model Representation subsection within the Permeable Pavements (Ecology BMP T5.15) section in Volume V of the 2019 Ecology Manual. This guidance is to show compliance of permeable pavement BMPs with the LID Performance Standard in Core Requirement #5 or the standards in Core Requirements 6 through 8.

Note that if the project is using permeable pavement to only meet the List Approach within Core Requirement #5, there is no need to model the permeable pavement in a continuous simulation model.

Ecology's approval status for continuous simulation models is provided in the "Additional Resources" section in the 2019 Ecology Manual: <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm>.

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. This section includes infiltration testing requirements and application of appropriate safety factors specific to permeable pavement surfaces.

Refer to Appendix 7A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix 7A may not apply to permeable pavement. All test hole or test pit explorations outlined below shall be conducted during mid to late in the winter season (December 1 through April 30) to provide accurate groundwater saturation and groundwater information.

Determining Design Infiltration Rate

Determining the infiltration rate of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on site. Infiltration rates are also necessary to estimate permeable pavement performance using an approved continuous simulation model.

Determining Initial Subgrade Infiltration Rates

Perform infiltration testing in the soil profile at the estimated bottom elevation of base materials for the permeable pavement. If no base materials will be used (e.g., a pervious concrete sidewalk), perform the testing at the estimated bottom elevation of the pavement.

- Projects subject to Core Requirements #1 through #5:
    - A small-scale PIT or soil grain size analysis (for sites underlain by Type A soils only) outlined in Appendix 7A, shall be performed for every 5,000 square feet of permeable pavement, but not less than one test per site.

      Note that to demonstrate infeasibility of permeable pavement for Core Requirement #5, a small-scale PIT or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
    - Confirm that the site has the required 1-foot minimum clearance from the lowest gravel base course to the seasonal high groundwater or other impermeable layer (e.g., through over excavation of the pit, or using a soil log or monitoring well). Refer to Setbacks and Site Constraints below.

- Projects subject to Core Requirements #1 through #9:
  - On commercial property: a small-scale PIT, or other method outlined in Appendix 7A, shall be performed for every 5,000 square feet of permeable pavement, but not less than one test per site.
  - On residential developments: a small-scale PIT, or other method outlined in Appendix 7A, shall 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 groundwater conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

    Note that to demonstrate infeasibility of permeable pavement for Core Requirement #5, a small-scale PIT or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
  - Confirm that the site has the required 1-foot minimum clearance from the lowest gravel base course to the seasonal high groundwater or other impermeable layer (refer to Setbacks and Site Constraints below).
- If the general site assessment cannot confirm that the seasonal high groundwater or hydraulic restricting layer will be greater than 1 foot below the bottom of the lowest gravel base course of permeable pavement (subgrade surface), monitoring wells or excavated pits should be placed strategically to assess depth to groundwater.

Assignment of Appropriate Safety/Correction Factors

- If deemed necessary by a qualified professional engineer, a safety factor may be applied to the measured K_{sat} of the subgrade soils to estimate its design (long-term) infiltration rate. Depending on the size of the BMP, the variability of the underlying soils, and the number of infiltration tests performed, a safety factor may be advisable.
- A safety factor for the subgrade (i.e., $F_{plugging}$ used in Appendix 7A) does not have to take into consideration the extent of influent control and clogging over time, unless deemed necessary by a professional engineer.
- The quality of pavement aggregate base material may be compromised if the aggregate base is not clean and washed material and has more than 1 percent fines passing the U.S. #200 sieve. In these cases, a correction factor ($F_{aggregate}$) may be necessary. $F_{aggregate}$ ranges from 0.9 (not clean or washed aggregate, greater than

1 percent fines passing the U.S. #200 sieve) to 1 (aggregate base meets specifications).

Soil Suitability Criteria Confirmation

- Where permeable pavements are used for pollution-generating hard surfaces (primarily roads, shared accesses, driveways, and parking lots), there must be a determination whether the soil suitability criteria of Chapter 8, Section 8.6, are met. This requirement does not apply to projects that trigger only Core Requirement #1 through #5.
- Sites not meeting these criteria are considered infeasible for permeable pavements for pollution-generating hard surfaces unless a treatment layer is provided.
- The information to make this determination may be obtained from various sources: historical site information, estimated qualities of a general soil type, laboratory analysis of field samples.

Prepare Soils Report

For projects subject to Core Requirements #1 through #5, a Soils Report must be 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. Refer to Chapter 3, Section 3.3.2, for Abbreviated Drainage Plan Soils Report requirements.

For projects subject to Core Requirements #1 through #9, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington. Refer to Chapter 3, Section 3.3.3, for Drainage Control Plan Soils Report requirements.

Estimate Volume of Stormwater

Use an approved continuous simulation model to generate an influent file that will be used to size the permeable pavement BMP. The BMP must infiltrate either all of the flow volume as specified by the influent file, or a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Core Requirement #7. In addition, the overflow/bypass must meet the LID Performance Standard if it is the option chosen to meet Core Requirement #5, or if it is required of the project.

Paving Surface Design Criteria

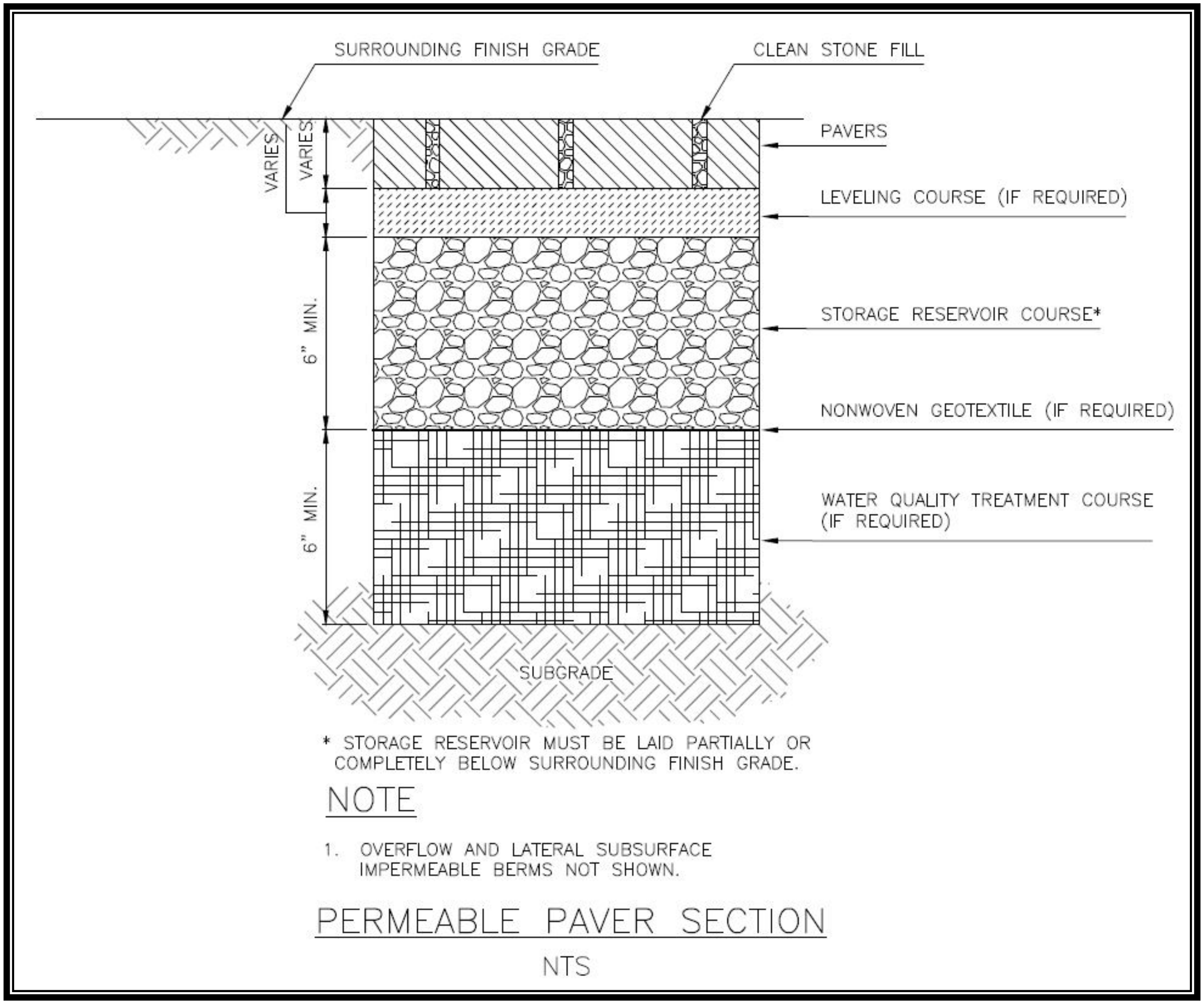
The following provides a description, recommendations, and requirements for the components of permeable pavement. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for BMP review must include documentation of the following elements, discussed in detail below:

- Setbacks and site constraints
- Permeable wearing course
- Drainage conveyance
- Leveling course
- Aggregate storage reservoir
- Lateral subsurface impermeable barriers
- Nonwoven geotextile (optional)
- Subgrade
- Permeable pavement as runoff treatment
- Signage

Typical cross-sections of permeable pavement consist of a top layer (pervious wearing course) underlain by a leveling course (if required), aggregate storage reservoir, geotextile fabric (optional), treatment layer (if required), and subgrade. See Figures 7.8 and 7.9 for example permeable surface cross-sections.

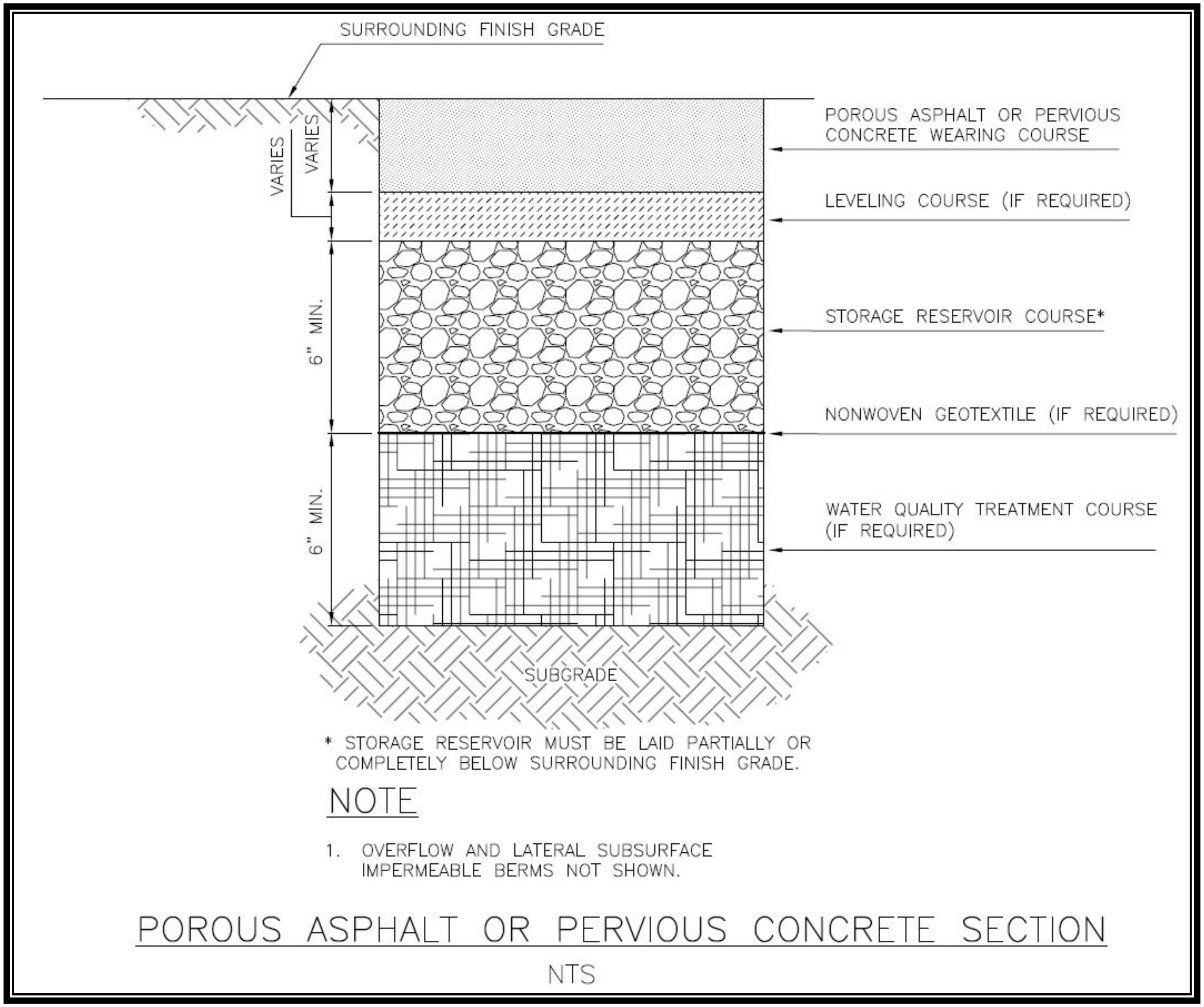
Manufacturer's recommendations on design, installation, and maintenance shall be followed for each application.

See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional guidance, but note that the research and application of permeable pavement is a rapidly changing field and more recent guidance may be available.



Source: Pierce County

Figure 7.8. Permeable Paver Section.



Source: Pierce County

Figure 7.9. Porous Asphalt or Pervious Concrete Section.

Setbacks and Site Constraints

See Infeasibility Criteria above for setbacks and site constraints used to evaluate the permeable pavement option of List #1 and List #2 (Core Requirement #5). (See also Appendix 7B for a summary of infeasibility criteria for all BMPs.) The following minimum setbacks and site constraints apply to all permeable pavement areas:

- Permeable pavement shall not be located where seasonal high groundwater, or an underlying impermeable/low permeable layer would create saturated conditions within 1 foot of the bottom of the lowest gravel base course or treatment later.
- The base of the lowest gravel course or treatment layer shall be a minimum of 1-foot positive vertical clearance to structures within 25 feet.
- All permeable pavement surfaces shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment and Soils Report must be prepared addressing the potential impact of the BMP on the slope. The geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.
- For sites with on-site or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210. This requirement may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.
- In no case shall permeable pavement surfaces be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.
  - Where water supply wells exist nearby, it is the responsibility of the applicant’s engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration BMP on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the BMP design, or relocation of the BMP should be considered.
  - Permeable pavement surfaces upgradient of drinking water supplies and within 1-, 5-, and 10-year time of travel zones must comply with Washington State Wellhead Protection Program Guidance Document (WSDOH, 2010). Infiltration systems that qualify as Underground Injection Control Wells must comply with Chapter 173-218 WAC and Appendix 7C.

  - The Soils Report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- Permeable pavement surfaces are prohibited within 300 feet of an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

Permeable Wearing Course

The wearing course or surface layer of the permeable pavement surface may consist of porous asphalt, pervious concrete, interlocking concrete pavers, or open-celled paving grid with vegetation or gravel.

- Recommended maximum wearing course slope for permeable pavement surfaces is 6 percent.

- Manufacturer's recommendations on design, installation, and maintenance shall be followed for each application.

- For all surface types, a minimum initial infiltration rate of 20 inches per hour is required. 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 and must meet performance grade (PG) 70-22. A void space within the range of 16 to 25 percent is typical.

  - *Pervious Concrete:* Products must have adequate void spaces through which water can infiltrate and must meet the most current version of American Concrete Institute (ACI) 522. A void space within the range of 15 to 35 percent is typical.

  - *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. Fill media for grid systems with grass vary per manufacturer from coarse sand to topsoil. Consult manufacturer to confirm that the fill media will provide adequate infiltration capacity and, at that rate, support healthy plant growth.

  - *Permeable Interlocking Concrete Pavement and Aggregate Pavers:* Pavement joints should be filled with No. 8, 89 or 9 stone. Consult with paver manufacturer specifications to determine the appropriate material type and size.

- Permeable pavement systems that utilize pavers need to be confined with a rigid edge system to prevent gradual movement of the paving stones.

- Both gravel and soil with vegetation can be used to fill the openings in paver and rigid grid systems and manufacturer recommendations shall be followed to apply the appropriate material for each application.
- Structural designs for permeable pavement shall be per the manufacturer's specifications. If any deviations are made from the manufacturer's recommendations or if the manufacturer's recommendations require engineering judgments to be made, the design shall be stamped by a geotechnical engineer.
- Refer to Chapter 5 of the DG&PWS for additional permeable pavement standards.

Drainage Conveyance

Flow Entrance/Presettling Requirements

- Run-on to permeable pavement must be dispersed as sheet flow or delivered subsurface to the storage reservoir. If subsurface delivery is used, primary settling is required (e.g., via catch basin, hooded outlet, sump) followed by distribution to storage reservoir (e.g., via perforated drain pipe).
- Run-on from upgradient adjacent impervious paved surfaces is not recommended, but permissible if the permeable pavement area is at least 50 percent larger than impervious area and the length of sheet flow from the impervious paved surface is no greater than half the length across the permeable pavement section.

Overflow Requirements

Roads should still be designed with adequate drainage conveyance BMPs 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 BMPs.

- In small area applications, the subgrade can be built up with permeable base material and graded to direct runoff through this material to an eventual discharge location, such as bioretention BMPs. In larger areas, an elevated underdrain system should be installed to collect and convey runoff to bioretention BMPs or open space. In this manner, stormwater is stored and metered out slowly, similar to the way the existing topsoil on a site captures and slowly releases runoff. (See also the Aggregate Storage Reservoir section below for additional details on underdrains.)
- An overflow route must be identified for stormwater flows that overtop the permeable pavement surface when infiltration capacity is exceeded or the BMP becomes plugged and fails. The overflow route must be able to convey the 100-year recurrence interval developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

- Overflow must be designed to convey excess flow to an approved point of discharge. Options include:
    - Subsurface slotted drain pipe(s) set at the design ponding elevation to route flow to a conveyance system
    - Lateral flow through the storage reservoir to a daylighted conveyance system.

Leveling Course

Depending upon the type of permeable pavement installation, a leveling course (also called a bedding or choker course) may be required (per manufacturer or designer recommendations). A leveling course is often required for porous asphalt, open-celled paving grids, and interlocking concrete pavers. This course is a layer of aggregate that provides a more uniform surface for laying pavement or pavers and consists of crushed aggregate smaller in size than the underlying aggregate storage reservoir. Course thickness will vary with permeable pavement type.

Leveling course material and thickness shall be included as required per manufacturer recommendations. Leveling course material must be compatible with underlying aggregate storage reservoir material.

Aggregate Storage Reservoir

Stormwater passes through the wearing and leveling courses to an underlying aggregate storage reservoir, also referred to as “base material,” where it is filtered and stored prior to infiltration into the underlying soil. The aggregate storage reservoir also serves as the pavement’s support base and must be sufficiently thick to support the expected loads and be free draining. The aggregate shall meet the following criteria:

- A 6-inch minimum depth of aggregate storage reservoir is recommended under the permeable wearing course and leveling course (if any) for water storage. The City may allow a reduced depth on a case-by-case basis.
- Aggregate storage reservoir shall consist of larger rock at the bottom and smaller rock directly under the top surface (e.g., a gradient from 2-inch to five-eighths inch)
- Designs utilizing an underdrain that is elevated within the aggregate base course to protect the pavement wearing course from saturation are still considered an LID BMP and can be used to satisfy Core Requirement #5, so long as the underdrain invert is set at or above the maximum design ponding depth.

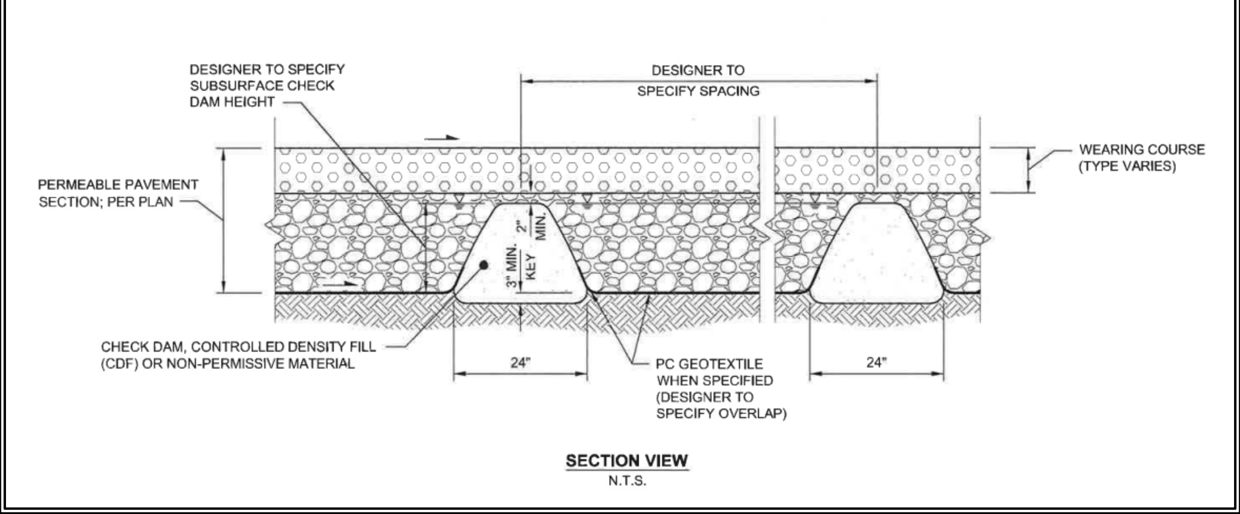
Refer to the DG&PWS for any updates to these standards.

Lateral Subsurface Impermeable Barriers

Sloped permeable pavement surfaces have an increased potential for lateral flows through the aggregate storage reservoir along the top of relatively impermeable subgrade soil.

This poses a risk of subsurface erosion and reduces the storage and infiltration capacity of the pavement BMP. To address this, the subgrade must be designed to create subsurface ponding to detain subsurface flow, increase infiltration, and reduce structural problems associated with subgrade erosion on slopes.

Ponding must be provided using periodic lateral impermeable barriers (e.g., check dams, impermeable liners, or low conductivity geotextiles) oriented perpendicular to the subgrade slope when the slope of the permeable pavement is 3 percent or greater. While the frequency of the barriers is calculated based on the required subsurface ponding depth and the subgrade slope, typical designs include barriers every 6 to 12 inches of grade loss. See Figure 7.10 for an example of subsurface permeable pavement check dams.



Source: Pierce County

Figure 7.10. Typical Permeable Pavement BMP with Checkdams.

Minimum requirements associated with lateral impermeable barriers include the following:

- Lateral impermeable barriers must be installed at regular intervals perpendicular to the subgrade slope to provide the average subsurface ponding depth in the aggregate storage reservoir required to meet the desired performance standard.
- The barriers must not extend to the elevation of the surrounding ground.
- Each barrier must have an overflow, as described below, or allow overtopping to the next downslope aggregate storage reservoir section without causing flows to express from the pavement surface or out the sides of the base materials that are above grade.

Nonwoven Geotextile

Generally, geotextiles and geogrids are applied:

- To prevent fines from migrating to more open-graded material and the associated structural instability

- For soil types with poor structural stability to prevent downward movement of the aggregate base into the subgrade.

- If a sand layer is utilized, geotextile is required between the aggregate storage reservoir and the sand layer. Geotextile is also required between the native soil and the sand layer.

Geotextiles between the permeable pavement subgrade and aggregate base are not required or necessary for many soil types and, if incorrectly applied, can clog, and reduce infiltration capability at the subgrade or other material interface. Therefore, the use of geotextiles is discouraged unless it is deemed necessary. As part of the pavement section design, the designer should review the existing subgrade or subbase characteristics and determine if a nonwoven geotextile is needed for separation of subbase from underlying soils.

Subgrade

- Compact the subgrade to the minimum compaction necessary for structural stability. Two guidelines currently used to specify subgrade compaction are “firm and unyielding” (qualitative), and 90 to 92 percent Standard Proctor (quantitative). Subgrade should not be subject to compaction beyond the qualitative and quantitative levels identified herein. Do not allow construction traffic and equipment onto the subgrade except when construction access on subgrade is required for the pavement section installation. Follow back dumping approach as noted below.

- 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.

Permeable Pavement as Runoff Treatment

The permeable pavement BMP is recognized as a basic treatment BMP (as further described in Chapter 8, Section 8.2.1 Step-by-Step Selection Process for Treatment BMPs) if it meets the following criteria:

- The native soils below the permeable pavement meet the requirements for treatment soil provided in Chapter 8, Section 8.6.

OR

- The permeable pavement design includes a 6-inch layer of sand that meets the size gradation (by weight) given in Chapter 8, Table 8.8: Sand Medium Specification.

Edge Treatments

Edge treatment is required around the perimeter of permeable pavers to prevent it from unraveling over time. Edge treatments can also be used to protect the subgrade of adjacent conventional pavement. Concrete edge treatments may be used for either of those purposes while geomembrane may only be used to protect adjacent pavement. A manufactured paver restraint may also be used at edges, but it shall be suitable for the pavement use (e.g., vehicular use vs. pedestrian only). Refer to the edge treatment standard details in the DG&PWS.

Signage

The City recommends that permeable pavement installations include informational signage upon completion of the installation, to help identify the area as a stormwater BMP and to inform maintenance crews and the general public about protecting the BMP’s function.

Construction Criteria

Minimum requirements associated with permeable pavement construction include the following:

- Proper installation is one of the key components to ensure the success of permeable pavement. As with any pavement system, permeable pavement requires careful preparation of the subgrade and aggregate storage reservoir to ensure success in terms of strength and permeability. The compressive strength of a permeable paver system relies on the strength of the underlying soils, particularly in the case of modular or plastic units where the pavement itself lacks rigidity. Design and installation of permeable pavement shall be according to manufacturer recommendations.

- Field infiltration and compaction testing of the optional runoff treatment course shall be conducted prior to placement of overlying courses.

- To prevent compaction when installing the aggregate storage reservoir, the following steps (back-dumping) should be followed:

    - The aggregate storage reservoir is dumped onto the subgrade from the edge of the installation and the aggregate is then pushed out onto the subgrade

    - Trucks then dump subsequent loads from on top of the aggregate storage reservoir as the installation progresses.

- The various aggregate storage reservoir materials shall be prevented from intermixing with fines and sediment. All contaminated material must be removed and replaced.

- Field infiltration test of the permeable surface shall be conducted after complete pavement section is installed (See Acceptance Testing section below).

- If possible, temporary roads should be used during construction and final construction of the aggregate storage reservoir material and permeable surfacing completed after building construction is complete. This construction method is similar to the installation of leveling courses of asphalt in a subdivision prior to building individual lots and installation of the final wearing course upon completion of building construction.

Refer to Chapter 5, Section 5.3, LID BMP Protection During Construction, for construction considerations specific to infiltration BMPs.

Acceptance Testing

The project engineer or designee shall inspect permeable pavement areas before, during, and after construction as necessary to ensure BMPs are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. Prior to placing the aggregate storage reservoir, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate. The project engineer shall verify that the aggregate storage reservoir has been adequately installed and protected (e.g., from compaction and sedimentation) per the design specifications, prior to paving.

Prior to accepting the installation of the permeable pavement, and also before release of the maintenance bond, the project engineer shall perform infiltration testing after construction to determine whether the BMP will operate as designed.

- Permeable pavement projects with less than 5,000 square feet of new plus replaced hard surface 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.

- For measuring initial surface infiltration rates for permeable pavement projects with 5,000 square feet or more of new plus replaced hard surface:

    - Porous asphalt or pervious concrete: a minimum of two tests following the Standard Test Method for Infiltration Rate of In Place Pervious Concrete (ASTM C1701) shall be performed.

    - Permeable pavers: a minimum of two tests following the Standard Test Method for Infiltration Rate of Permeable Unit Pavement Systems (ASTM C1781) shall be performed.

  - For grid systems, refer to manufacturer's testing recommendations.

The City must be notified of the scheduled infiltration testing at least two working days in advance of the test. If the tests indicate the BMP will not function as designed, this information must be brought to the immediate attention of the City along with any reasons as to why not and how it can be remedied.

Operations and Maintenance Criteria

- See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.
- Where run-on flows onto permeable pavement, these areas shall be identified in the Maintenance and Source Control Manual as requiring more frequent cleaning and inspection to ensure that the overall BMP is performing.
- Clogging is the primary mechanism that degrades infiltration rates. However, as discussed above, the surface design can have a significant influence on clogging of void space.
- Studies have indicated that infiltration rates on moderately degraded porous asphalts and pervious concrete can be partially restored by suctioning and sweeping of the surface. Highly degraded porous asphalts and concrete require high pressure washing with suction.
- For large scale cleaning use vacuum surface cleaning machines (such as Cyclone, Elgin, etc.) for cleaning pervious concrete and porous asphalt.
- Maintenance frequencies of suctioning and sweeping shall be specified in the Maintenance and Source Control Manual, or as specified in Chapter 10, whichever is more stringent.
- Permeable pavement systems designed with pavers have advantages of ease of disassembly when repairs or utility work is necessary. However, it is important to note that the paver removal area should be no greater than the area that can be replaced at the end of the day. If an area of pavers is removed, leaving remaining edges unconfined, it is likely that loading in nearby areas will create movement of the remaining pavers thereby unraveling significantly more area than intended.

7.4.7 Infiltration Trenches (Ecology BMP T7.20)

Description

Infiltration trenches are most appropriate for small contributing areas and retrofit situations where space is limited. Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in a stone trench.

Note that an infiltration trench with a perforated pipe is considered a UIC well and is required to be registered with Ecology unless the infiltration trench is located at a single-family home (or duplex) and only receives residential roof runoff or is used to control basement flooding (per WAC 173-218-070 (1)(e). See also Section 7.3 for more information on UIC well registration.

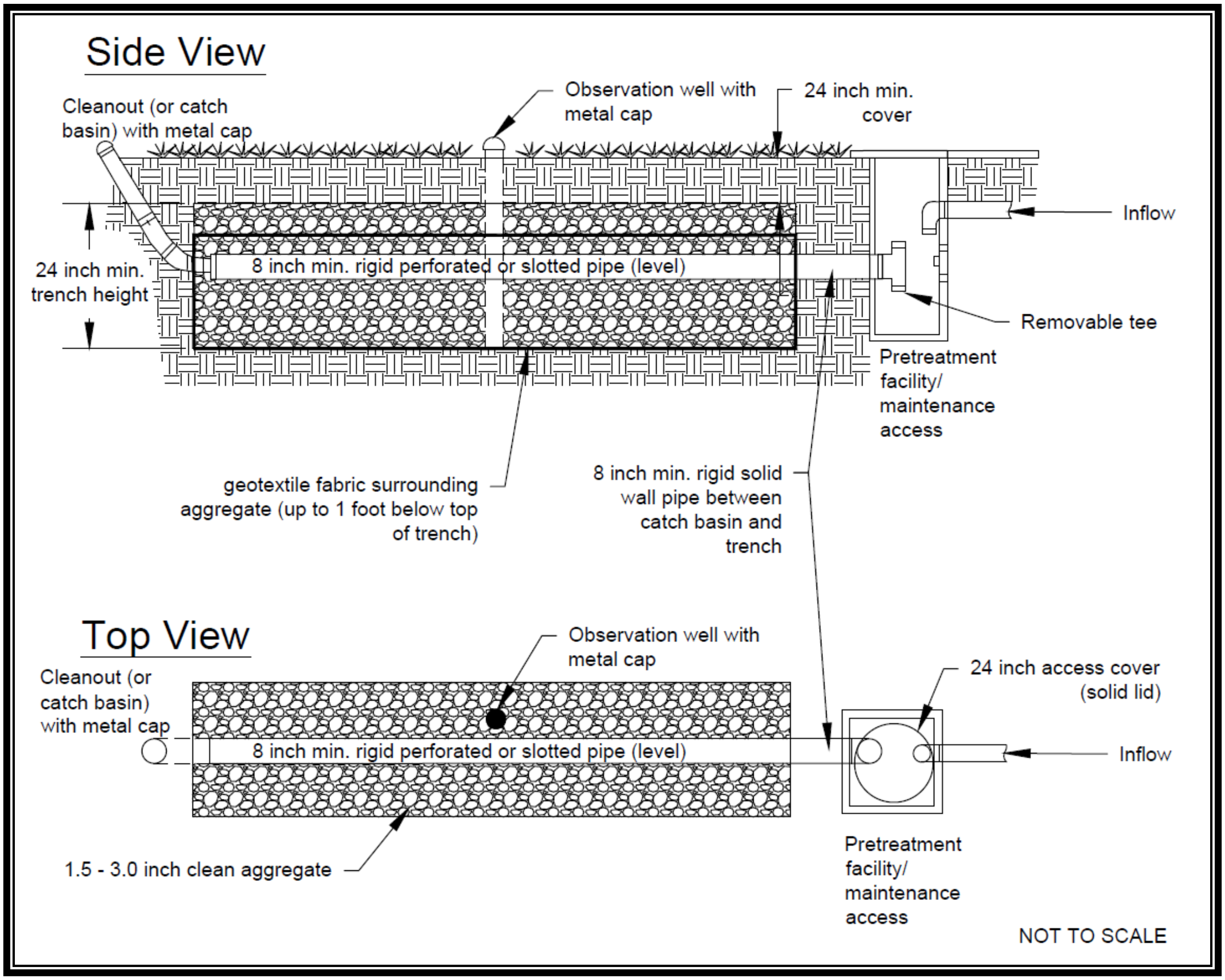
See Figures 7.11a, 7.11b, and 7.12 for examples of infiltration trench BMPs in various configurations and site settings. Included in the details are infiltration trenches with a grass buffer, as well as an example of a parking lot perimeter infiltration trench design. For trenches associated specifically with roof downspout infiltration, see Section 7.4.10.

Applications and Limitations

- Infiltration trenches can be used to meet the flow control standards of Core Requirement #7.
- When used in combination with other on-site stormwater management BMPs, they can also help achieve compliance with the LID Performance Standard option of Core Requirement #5.
- Infiltration trenches can be used to meet some of the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.
- Infiltration trenches require adequate separation from seasonally-high groundwater and adequate setback distances, per Section 7.2
- In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

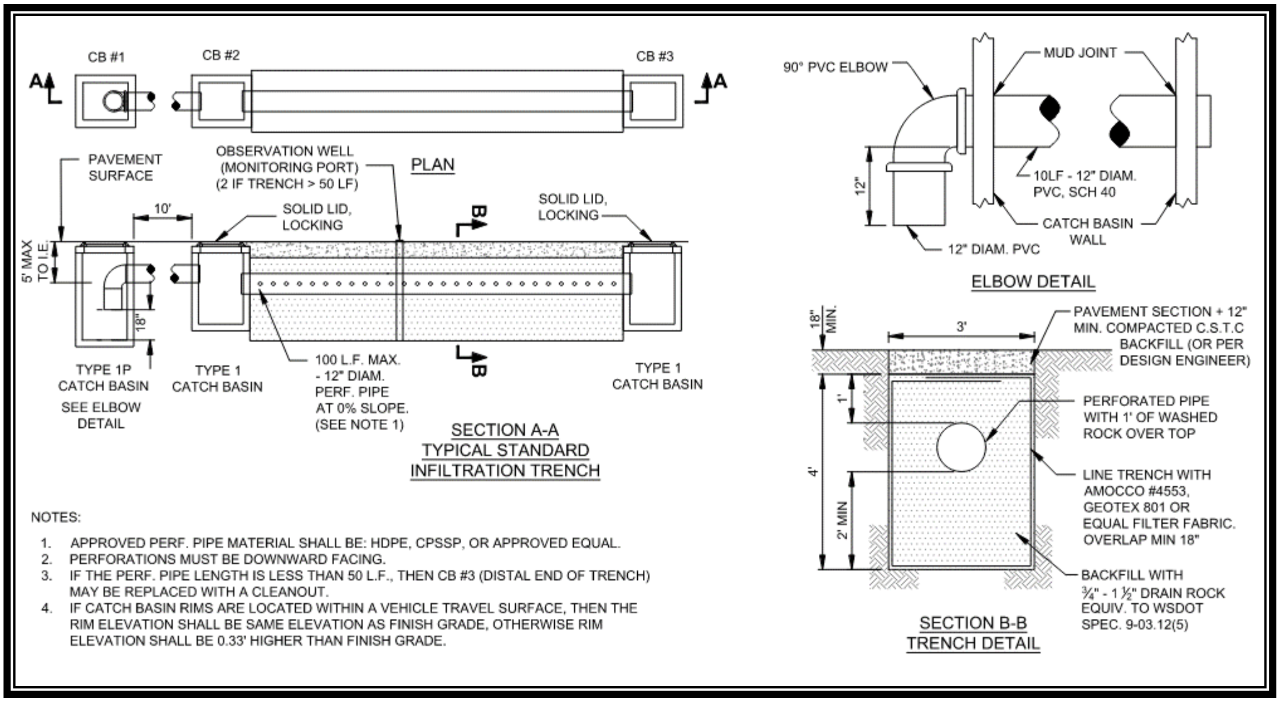
Modeling and Sizing

See Section 7.2.3 for guidance on modeling and sizing of infiltration BMPs.



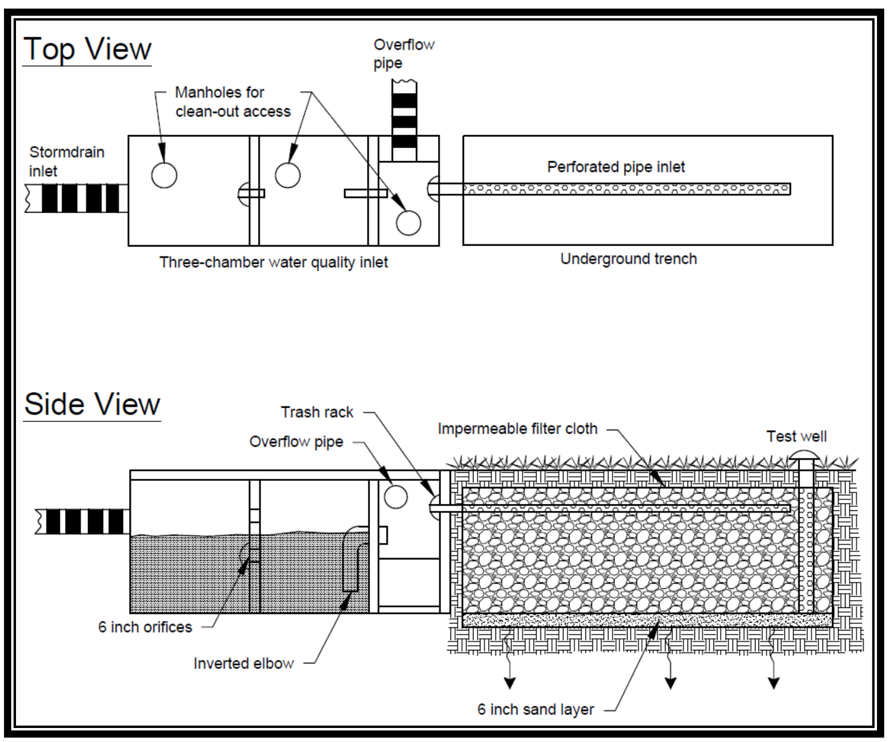
Source: Ecology

Figure 7.11a. Infiltration Trench Design.



Source: Pierce County

Figure 7.11b. Alternative Infiltration Trench Design.



Source: Ecology

Figure 7.12. Underground Trench with Oil/Grit Chamber.

Infiltration Trench Design Criteria

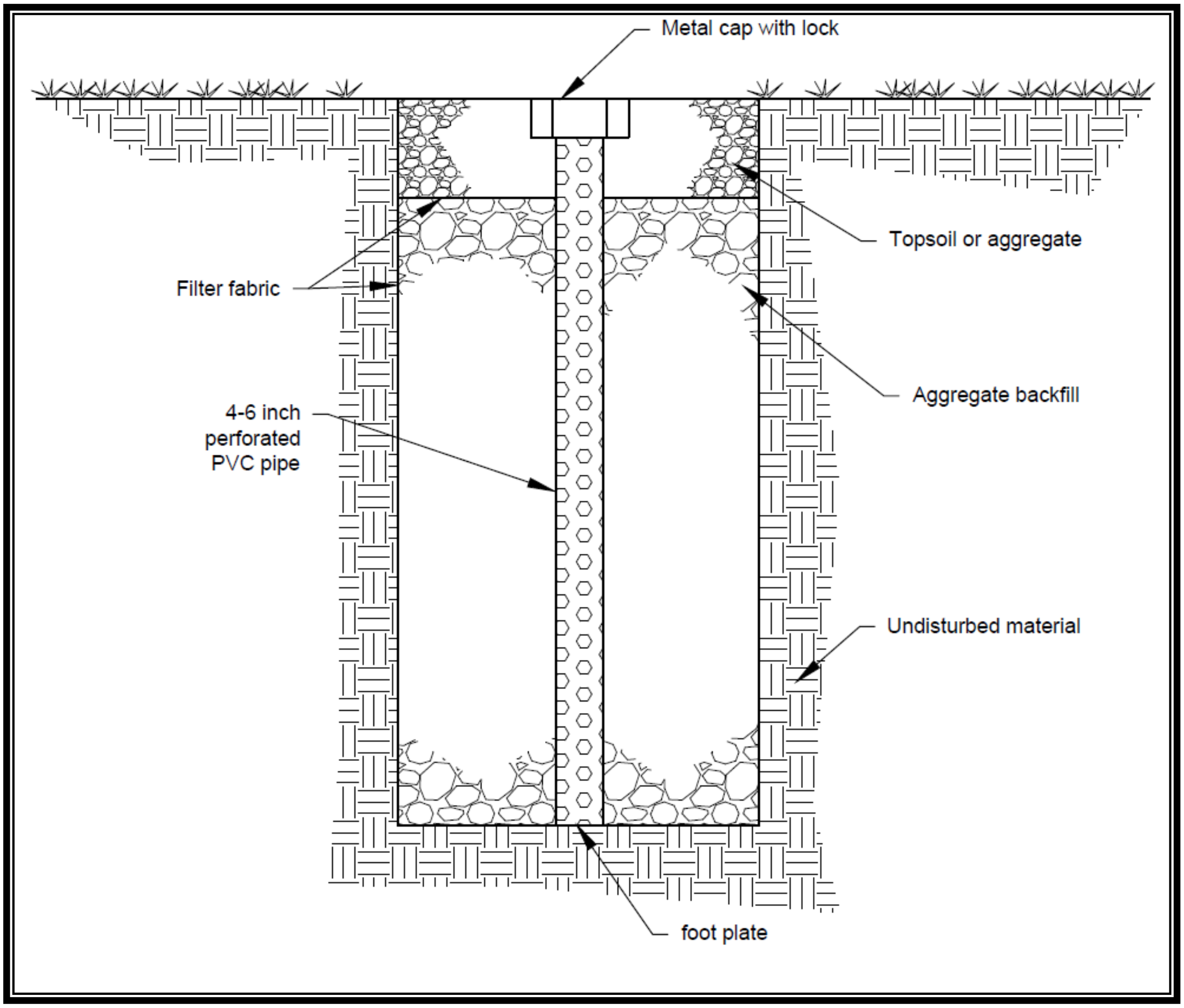
Refer to Section 7.2.3 for general procedures and design criteria applicable to infiltration basins, trenches, and galleries. This section provides additional design criteria specific to infiltration trench layout, access, bedding and geotextile, and overflow.

Trench Layout

- Surface cover: A stone filled trench can be placed under a porous or impervious surface cover to conserve space. If located under pavement, the following are required:
  - Observation wells must be placed no further than 100 feet apart.
  - The plans, details, and Maintenance and Source Control Manual must all clearly state that the pavement may have to be removed and/or other site improvements impacted due to maintenance, repair, or replacement of the stormwater infiltration system(s).
  - No infiltration trenches shall be allowed under any private or public streets.
- Flows must be evenly distributed across the trench to ensure that the trench will function as designed. Include appropriate measures to distribute flows (e.g., manifold system, level spreader).

Access

- A catch basin is required at the inlet of the infiltration trench for access.
- Provide a structure or cleanout at the end of each infiltration pipe for accessibility to conduct inspections and maintenance.
- Observation well: Install an observation well at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. See Figure 7.13 for an example observation well detail. 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- to 36-inch-diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. The top of the well must be equipped with a secure well cap to discourage vandalism and tampering.



Source: Ecology

Figure 7.13. Observation Well Details.

Trench Bedding and Geotextile

- Backfill material: The aggregate material for the infiltration trench must consist of a clean aggregate and meet WSDOT Standard Specification 9-03.12(5) that nominally ranges from 0.75-inch to 1.5-inch diameter. A maximum diameter of 3 inches and a minimum diameter of 1.5 inches may be approved if void space is maintained. Void space for these aggregates must be in the range of 30 to 40 percent.

- Geotextile fabric liner: Completely encase the aggregate fill material in an engineering geotextile material. Geotextile must surround all of the aggregate fill material except for the top 1 foot, which is placed over the geotextile. Carefully select geotextile fabric with acceptable properties to avoid plugging (see Chapter 8, Appendix 8A).

- A 6-inch minimum layer of sand may be used as a filter media at the bottom of the trench instead of geotextile.

- The bottom sand or geotextile fabric as shown in Figures 7.11 and 7.12.

  Refer to the *Geosynthetic Design and Construction Guidelines* (FHWA 1995) for design guidance on geotextiles in drainage applications. Refer *Long-Term Performance of Geosynthetics in Drainage Applications* (NCHRP 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

- Because an infiltration trench is generally used for small drainage areas, an emergency spillway is not necessary. However, provide a nonerosive overflow channel leading to a stabilized watercourse.

Construction Criteria for Trenches

- Most of the construction requirements for small-scale infiltration BMPs included in Chapter 5, Section 5.3, apply to all infiltration BMPs. Additional specific construction criteria for infiltration trenches are provided below. Criteria for residential roof downspout infiltration trenches are provided in Section 7.4.10.

- **Trench preparation:** Excavated materials must be placed away from the trench sides to enhance trench wall stability. 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 and sediment control criteria in Chapter 5, BMP C123 – Plastic Covering).

- **Stone aggregate placement and compaction:** Place the stone aggregate in lifts and compact using plate compactors. 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. Remove all contaminated stone aggregate and replace with uncontaminated stone aggregate.

- **Overlapping and covering:** Following the stone aggregate placement, 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 must 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 in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. This remedial process helps to avoid soil piping, geotextile clogging, and possible surface subsidence.

- **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. Trench boxes or trapezoidal, rather than rectangular, cross-sections may be needed.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

7.4.8 Infiltration Galleries

Description

The term "infiltration galleries" refers to manufactured detention structures, commonly referred to as "infiltration chambers," within a broad gravel trench. Infiltration chambers are buried structures, typically arch-shaped, within which collected stormwater is temporarily stored and then infiltrated into the underlying soil. Infiltration chambers create an underground cavity that can provide a greater void volume than infiltration trenches and often require a smaller footprint. Infiltration galleries may be allowed on a case-by-case basis and must be sized per the manufacturer's guidance.

Applications and Limitations

- Infiltration galleries can be used to meet the flow control standards of Core Requirement #7.

- When used in combination with other on-site stormwater management BMPs, they can also help achieve compliance with the LID Performance Standard option of Core Requirement #5.

- Infiltration galleries can be used to help meet the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.

- Infiltration galleries require adequate separation from seasonally-high groundwater and adequate setback distances, per Section 7.2

  In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

Modeling and Sizing

See Section 7.2.3 for guidance on modeling and sizing of infiltration BMPs.

Infiltration Gallery Design Criteria

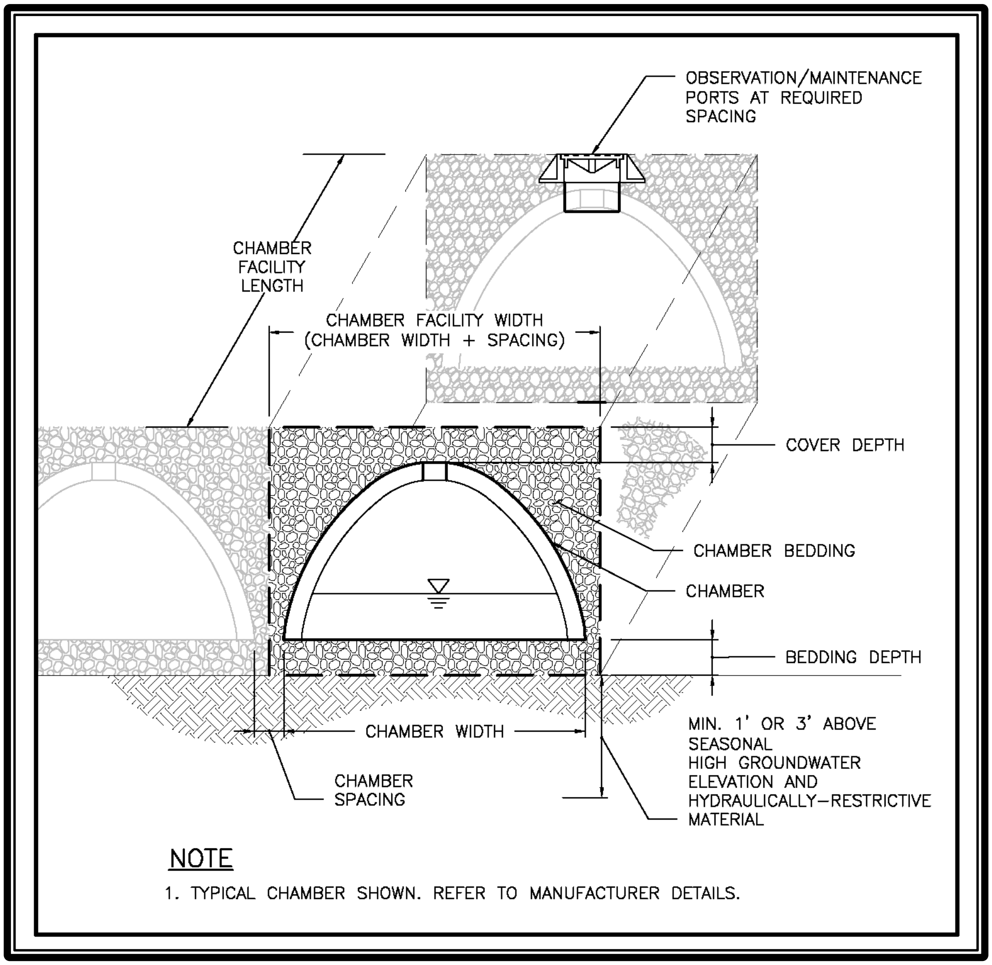
Refer to Section 7.2 for general procedures and design criteria applicable to infiltration basins, trenches, and galleries. Refer to Figure 7.14 for a schematic of a typical infiltration chamber. This section provides additional design criteria specific to infiltration trenches:

- Gallery layout
- Access
- Gallery bedding
- Subgrade
- Overflow

Gallery Layout

- Infiltration chambers can be constructed of a variety of different materials (e.g., plastic, concrete, aluminum, steel) and shapes (i.e., arch, box).
- Chamber spacing and depth of cover shall be per the manufacturer’s requirements, unless otherwise directed by the City.
- **Surface cover:** An infiltration chamber may be placed under a porous or impervious surface cover to conserve space. If located under pavement, the following are required:
  - Observation wells must be placed no further than 100 feet apart.
  - The plans, details, and the Maintenance and Source Control Manual must all clearly state that the pavement may have to be removed and/or other site improvements impacted due to maintenance, repair, or replacement of the stormwater infiltration system(s).

- No infiltration galleries shall be allowed under any private or public streets.



Source: City of Seattle

Figure 7.14. Typical Infiltration Chamber.

Access

- A catch basin or manhole is required at the inlet of each chamber of the infiltration gallery, for inspection and maintenance access to the entire gallery.
- An access port, cleanout, or catch basin is required at the distal end for accessibility to conduct inspections and maintenance.
- **Observation well:** Install an observation well near the center of the gallery (if level) or near the lower end of each chamber, to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. See Figure 7.13 for an example observation well detail. It should consist of a perforated PVC pipe which is a minimum of 6 inches in diameter and it should be constructed flush with the ground elevation. For larger galleries a 12- to 36-inch diameter well can be installed to facilitate maintenance operations such as

pumping out the sediment. The top of the well must be equipped with a secure well cap to discourage vandalism and tampering.

Gallery Bedding

- Minimum bedding shall be from 6 inches below the infiltration chamber to an elevation one-half the outside height of the chamber.

- Infiltration gallery bedding is specified by the manufacturer. The aggregate material for the infiltration gallery must consist of a clean aggregate and meet WSDOT Standard Specification 9-03.12(5) that nominally ranges from 0.75-inch to 1.5-inch diameter. A maximum diameter of 3 inches and a minimum diameter of 1.5 inches may be approved if void space is maintained. Void space for these aggregates must be in the range of 30 to 40 percent.

Subgrade

The minimum underlying native soil initial infiltration rate for infiltration galleries is 0.6 inches per hour.

During construction the subgrade soil surface can become smeared and sealed by excavation equipment. The design shall require scarification or raking of the side walls and bottom of the BMP excavation to a minimum depth of 4 inches after excavation to restore infiltration rate.

Freeboard

A minimum of 1 foot of freeboard is required when establishing the design chamber depth. Freeboard is measured from the rim of the chamber to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.

Construction Criteria

During construction, it is critical to prevent clogging and over-compaction of the subgrade. Refer to the minimum construction requirements for infiltration trenches in Section 7.4.7.

Operations and Maintenance Requirements

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements. Manufacturers of specific infiltration chambers may have additional operation and maintenance recommendations, which shall be included in the Maintenance and Source Control Manual for the finished project site.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

7.4.9 Infiltration Basins (Ecology BMP T7.10)

Description

Infiltration basins (sometimes referred-to as "dry ponds") are earthen impoundments used for the collection, temporary storage, and infiltration of stormwater runoff. (See schematic in Figure 7.15).

Applications and Limitations

Infiltration basins can be used to meet the flow control standards of Core Requirement #7. They can also meet some of the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.

In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

Modeling and Sizing

See Section 7.2.3 for guidance on modeling and sizing of infiltration BMPs.

Infiltration Basin Design Criteria

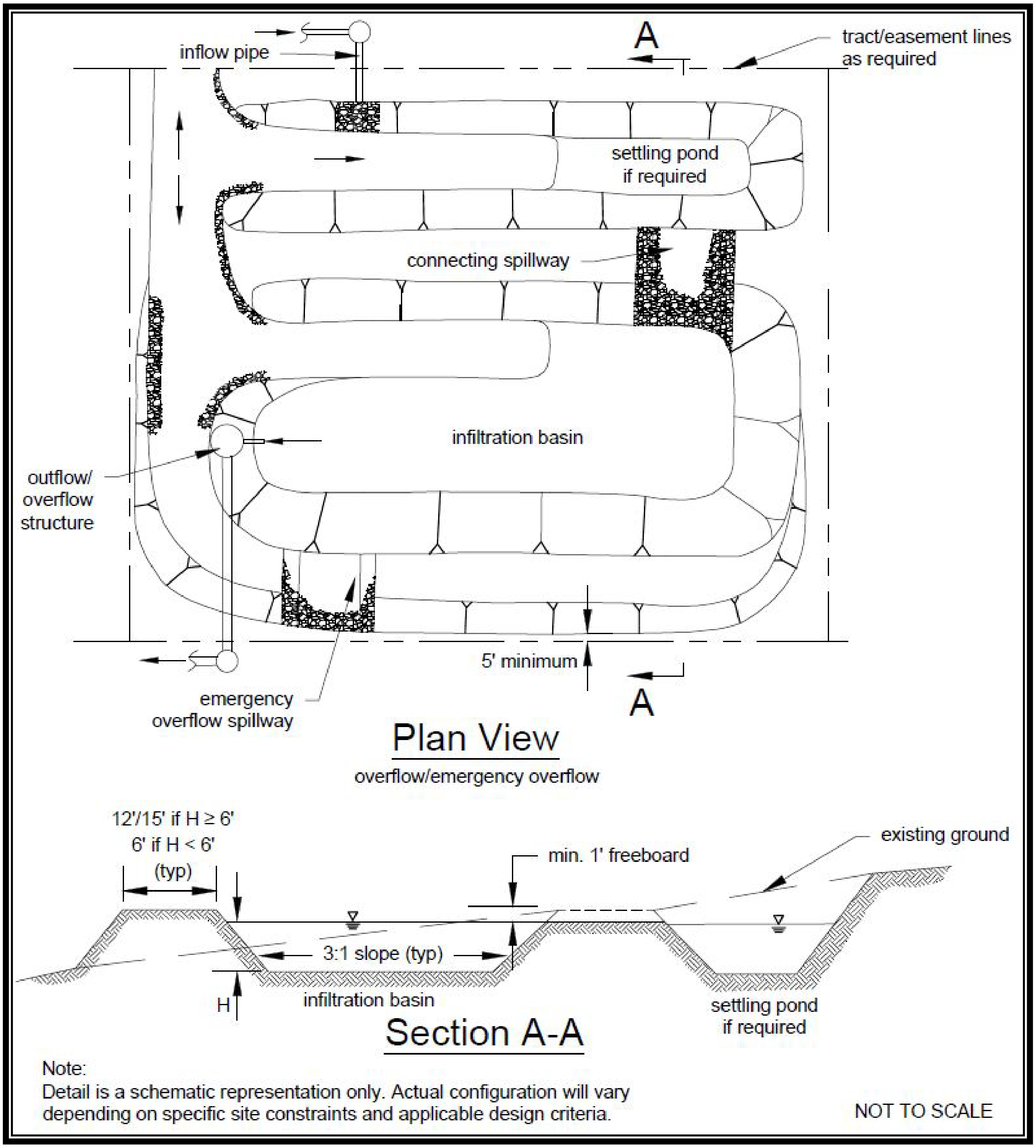
Refer to Section 7.2 for general procedures and design criteria applicable to infiltration basins, trenches, and galleries. This section provides additional design criteria specific to infiltration basins:

- Access must be provided for vehicles to easily maintain the forebay (presettling basin) area and not disturb vegetation, or re-suspend sediment any more than is absolutely necessary.

- The slope of the basin bottom shall not exceed 3 percent in any direction.

- A minimum of 1 foot of freeboard is required when establishing the design ponded water depth. Freeboard is measured from the rim of the infiltration BMP to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.

- **Vegetation:** The embankment, emergency spillways, spoil and borrow areas, and other disturbed areas shall be stabilized and planted, preferably with grass, in accordance with the Stormwater Site Plan (see Chapter 2, Core Requirement #1). Without healthy vegetation the surface soil pores would quickly plug. Infiltration basins designed to provide runoff treatment must have sufficient vegetation established on the basin floor and side slopes to prevent erosion and sloughing and to provide additional pollutant removal. Select suitable vegetative materials for the basin floor and side slopes. Refer to detention pond guidance in Section 7.5.1 for recommended vegetation. Use the seed mixtures recommended in Table 7.9 in Section 7.5.1, Detention Ponds.



Source: Ecology

Figure 7.15. Typical Infiltration Basin.

- **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 that will function sufficiently without plugging (see geotextile specifications in Chapter 8, Appendix 8A). Replace or clean the filter layer when/if it becomes clogged.

- **Signage:** See the signage requirements under Section 7.5.1 for detention pond sign requirements that apply to infiltration basins.

Construction Criteria

Most of the construction requirements for small-scale infiltration BMPs included in Chapter 5, Section 5.3, apply to all infiltration BMPs. Specific construction criteria for infiltration basins are provided below.

- Initial basin excavation must be conducted to within 2 feet of the final elevation of the basin floor. Excavate infiltration basins to final grade only after all disturbed areas in the upgradient project drainage area have been permanently stabilized. The final phase of excavation must remove all accumulation of silt in the infiltration basin before putting it in service.

- Generally, it is preferable to avoid using infiltration basins as temporary sediment traps during construction. If an infiltration basin is to be used as a sediment trap, do not excavate to final grade until after stabilizing the upgradient drainage area. Remove any accumulation of silt in the basin before putting it in service.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

Additional maintenance considerations for infiltration basins are provided below.

- Maintain the infiltration 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.

- Do not allow vegetation growth to exceed 18 inches in height. Mow the slopes periodically and check for clogging and erosion.

- The use of slow-growing, stoloniferous grasses will permit long intervals between mowing. Mowing twice a year is generally satisfactory. Apply fertilizers only as necessary and in limited amounts to avoid contributing to groundwater pollution. Consult the local agricultural or gardening resources such as Washington State University Extension for appropriate fertilizer type, including slow release fertilizers, and application rates.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

7.4.10 Roof Downspout Controls

Roof downspout controls include stormwater systems designed to infiltrate and/or disperse runoff from roof areas. Large lots in rural areas typically have enough area to infiltrate or disperse roof runoff. Lots created in urban areas will typically be smaller and have a limited amount of area in which to incorporate infiltration or dispersion trenches.

This section presents an overview of the types and applications of roof downspout controls. Additional details on specific BMPs are provided in subsequent sections.

Application to Core Requirements

The feasibility and applicability of roof downspout controls must be evaluated for all projects subject to Core Requirement #5 (see Chapter 2, Section 2.2.5). Projects must provide for individual downspout infiltration, bioretention, rain garden, dispersion systems, or perforated stub-out connection systems where practicable. Where roof downspout controls are required or planned, the following five types must be considered in order of preference, per Core Requirement #5 (note that some of the following BMPs are discussed in other sections):

1. Full dispersion (Section 7.4.2)

2. Downspout infiltration systems (see "Downspout Infiltration Systems" subsection below).

3. Bioretention cells, swales, and planter boxes (Section 7.4.4); or rain gardens (Section 7.4.5)

4. Downspout dispersion systems (see "Downspout Dispersion – Trenches and Splashblocks" subsection below)

5. Perforated stub-out connections (see "Perforated Stub-out Connections" subsection below)

Downspout Infiltration Systems (Ecology BMP T5.10A)

Description

Downspout 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. See Chapter 8, Section 8.3, for requirements related to infiltration designed for runoff treatment.

Applications and Limitations

- Trenches are preferred over drywells and shall be prioritized where space allows. Drywells should include slotted barrels, even for roof drains.
- Downspout infiltration can be used to help meet the flow control standards of Core Requirement #7.
- When used in combination with other on-site stormwater management BMPs, downspout infiltration can also help achieve compliance with Core Requirement #5.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for downspout infiltration systems. If one or more infeasibility criteria apply, then downspout infiltration systems are not required for consideration in the List #1 or List #2 option of Core Requirement #5. If a project proponent wishes to use a downspout infiltration system—though is not required to because of these infeasibility criteria—they may propose a functional design to the City. In addition, other design criteria and site limitations that make downspout infiltration systems infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

- 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 BMPs.
- The standardized table (Table 7.5 at the end of this section) can be used to facilitate sizing of infiltration trenches and drywells for smaller site applications. Standardized tables may be used under the following conditions:
    - If the project triggers Core Requirements #1 through #5, but not Core Requirements #1 through #9.
    - If the infiltration trench or drywell is designed and constructed in accordance with the design requirements.
- If the design or construction of the downspout infiltration system deviates from the design criteria or the standardized tables, the individual downspout infiltration must be designed by a professional engineer in accordance with the requirements presented in this chapter.
- All sites have the option to do their own engineered design in lieu of using Table 7.5 (in accordance with the design requirements presented below), subject to approval by the City.

Procedure for Evaluating Feasibility

Downspout infiltration is considered feasible on lots or sites that meet all of the following:

- Site-specific tests must indicate that soils are not silty clay loam, clay loam, clay, or any other soil having a percolation rate slower than 1 inch per hour. Silt and clay type soils have a saturated hydraulic conductivity that is too small for adequate infiltration and are infeasible for downspout infiltration systems.

- Site-specific tests must indicate 12 inches or more of permeable soil from the proposed bottom (final grade) of the infiltration system to the seasonal high groundwater table or other impermeable layer. (Refer to the soil investigation requirements below.)

- The downspout infiltration system can be designed to meet the minimum design criteria specified below.

Prepare Soils Report

For projects subject to Core Requirements #1 through #5, a Soils Report must be 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.

Refer to Chapter 3, Section 3.3.2, for Abbreviated Drainage Plan Soils Report requirements.

For projects subject to Core Requirements #1 through #9, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington. Refer to Chapter 3, Section 3.3.3, for Drainage Control Plan Soils Report requirements.

In addition, for downspout infiltration in particular, the soils investigation and report must evaluate the following:

1. 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 proposed final grade, identifying the NRCS series of the soil and the USDA textural class of the soil

horizon through the depth of the log, and noting any evidence of high groundwater level, such as mottling.

2. Document that soils in the location of the proposed infiltration system are not silty clay loam, clay loam, clay, or any other soil having a percolation rate slower than 1 inch per hour.

3. For sites that do not use the sizing tables presented in Table 7.5 at the end of this section, the site infiltration rates must be determined using the procedures outlined in Appendix 7A.

Downspout Infiltration Systems Design Criteria

This section provides design criteria for infiltration trenches and drywells:

- For sites with on-site or adjacent septic systems, the discharge point must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210. This requirement may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.

- Systems shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment and Soils Report must be prepared addressing the potential impact of the BMP on the slope. The geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.

- All systems shall be a minimum of 10 feet away from any structure or property line.

- All systems located within the 1-year capture zone of any drinking water well must be preceded by a runoff treatment BMP.

- In no case should infiltration systems be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.

- If the design or construction of the downspout infiltration system, deviates from the design criteria or the standardized tables, the individual downspout infiltration must be designed by a professional engineer in accordance with the requirements presented in this chapter.

Downspout Infiltration Trench System Design Criteria

The trench system is to be constructed according to the standard design shown in Figures 7.16 and 7.17 (following Table 7.5). The following design requirements apply to downspout infiltration trenches:

- Maximum length of trench must not exceed 100 feet from the inlet sump.
- Minimum spacing between distribution pipe centerlines must be 6 feet.
- The aggregate material for the infiltration trench shall consist of 0.75-inch to 1.5-inch diameter washed round rock that meets WSDOT Standard Specification 9-03.12(5).
- Filter fabric shall be placed over the drain rock as shown on Figure 7.16 prior to backfilling. Do not place fabric on trench bottom.
- 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 Appendix 7A.
- Provide a structure or cleanout at each end of the infiltration trench for accessibility to conduct inspections and maintenance.
- A structure with a sump shall be located upstream of the trench, which provides a minimum of 12 inches of depth below the outlet riser. The outlet riser pipe bottom shall be designed so as to be submerged at all times, and a screening material shall be installed on the pipe outlet.
- Trenches may be located under pavement if designed by a professional engineer. Trenches located under pavement must include a catch basin with grate cover such that the overflow would occur out of the catch basin at least 1 foot below the pavement, and in a location which can accommodate the overflow without creating a significant adverse impact to downhill properties or drainage systems. This is intended to prevent saturation of the pavement in the event of system failure. The trench depth must be measured from the overflow elevation, not the ground surface elevation.

If the design criteria above are met, Tables 7.5a through 7.5d may be used to size a downspout infiltration trench or drywell system. The table presents trench footprint areas per 1,000 square feet of roof area based on various depths and infiltration rates. The required trench footprint area may be determined based on the information and rate (square foot of trench required per 1,000 square feet of roof area) in the tables. The maximum design infiltration rate is 20 inches per hour. For infiltration rates that fall between the rates represented in each table, the designer must use the more conservative (i.e., lower) infiltration rate in their design. As noted previously, all sites have the option to do their own engineered design for infiltration trenches in lieu of using Tables 7.5a through 7.5d, subject to approval by the City.

Downspout Infiltration Drywell System Design Criteria

- The drywell system is to be constructed according to the standard design shown in Figure 7.18a for residential use and in Figures 7.18b and 7.18c for commercial/multifamily use.
- The drywell shall include a settling chamber, or its equivalent for particulate removal. If non-roof runoff is also draining to the drywell system, the contributing flows must also pass through a catch basin structure with a sump.
- Drywells must be 48 inches in diameter (minimum) and between 5 feet (minimum) and 20 feet (maximum) deep.
- Slotted concrete barrels are required for commercial and multifamily sites.
- Geotextile filter fabric shall be wrapped entirely around trench drain rock prior to backfilling, and also placed on top of the drain rock.
- Spacing between drywells must be a minimum of 10 feet measured from edge of gravel backfill.

Construction Criteria

See Chapter 5, Section 5.3 for infiltration BMP construction requirements.

Acceptance Testing

The project proponent shall inspect infiltration systems before, during, and after construction as necessary to ensure BMPs are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. If the project designee or City inspections indicate the BMP will not function as designed, the City may require acceptance testing as required for infiltration trenches in Section 7.2.2, as well as design modifications if needed.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

Table 7.5a. Square Feet of Downspout Infiltration Trench Bottom for Medium Sand/Type A Soils (12 in/hour).										
Total Depth Below Ground Surface [1] (ft)	Roof Area (square feet)									
	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	4,999
2.5	23	45	68	91	113	136	159	181	204	227
3.0	21	42	63	84	105	126	147	168	189	210
3.5	20	39	59	79	99	118	138	158	178	197
4.0	18	37	55	74	92	111	129	148	166	185
4.5	17	34	50	67	84	101	118	134	151	168
5.0	16	33	49	66	82	98	115	131	147	164
5.5	16	31	47	62	78	93	109	124	140	155

[1] The “total depth below ground surface” is the depth of the trench bottom. The trench consists of gravel covered by 6 inches of compacted backfill. Hence, the gravel thickness is 6 inches less than the depth listed.

Table 7.5b. Square Feet of Downspout Infiltration Trench Bottom for Loamy Sand/Type A Soils (4 in/hour).										
Total Depth Below Ground Surface [1] (ft)	Roof Area (square feet)									
	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	4,999
2.5	43	87	130	173	216	260	303	346	389	433
3.0	40	80	120	160	200	239	279	319	359	399
3.5	37	74	111	148	185	222	259	296	333	370
4.0	34	69	103	138	172	207	241	276	310	344
4.5	33	66	98	131	164	197	229	262	295	328
5.0	31	62	93	124	155	187	218	249	280	311
5.5	29	59	88	118	147	176	206	235	265	294

[1] The “total depth below ground surface” is the depth of the trench bottom. The trench consists of gravel covered by 6 inches of compacted backfill. Hence, the gravel thickness is 6 inches less than the depth listed.

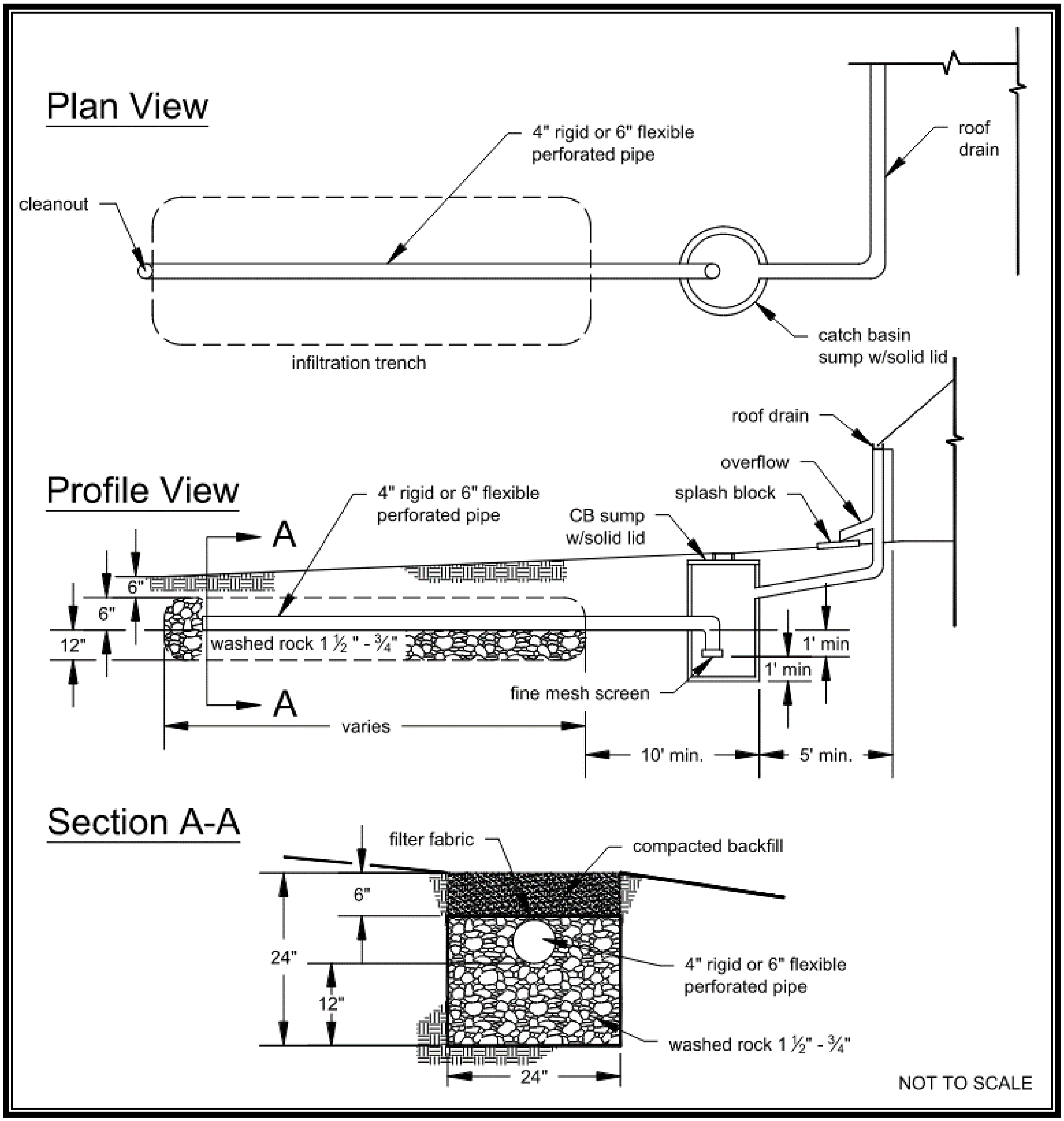
Table 7.5c. Square Feet of Downspout Infiltration Trench Bottom for Loam/Type B Soils (2 in/hour).										
Total Depth Below Ground Surface [1] (ft)	Roof Area (square feet)									
	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	4,999
2.5	65	130	195	260	326	391	456	521	586	651
3.0	60	121	181	242	302	363	423	484	544	605
3.5	56	113	169	225	281	338	394	450	507	563
4.0	53	106	159	212	265	318	371	423	476	529
4.5	50	101	151	202	252	302	353	403	454	504
5.0	48	96	144	192	239	287	335	383	431	479
5.5	45	91	136	181	227	272	318	363	408	454

[1] The “total depth below ground surface” is the depth of the trench bottom. The trench consists of gravel covered by 6 inches of compacted backfill. Hence, the gravel thickness is 6 inches less than the depth listed.

Table 7.5d. Square Feet of Downspout Infiltration Trench Bottom for Porous Silt Loam/Type C Soils (1 in/hour).

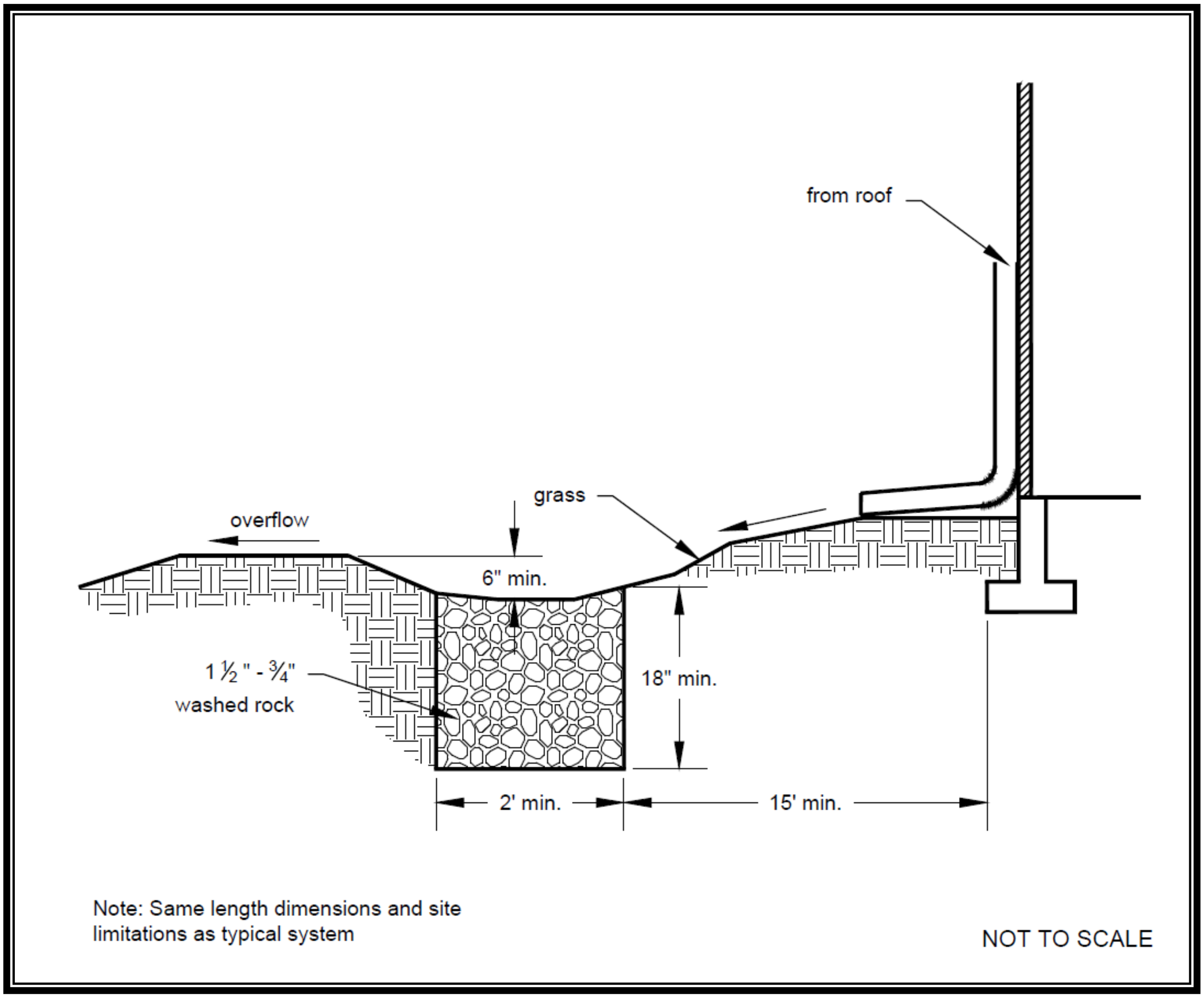
Total Depth Below Ground Surface [1] (ft)	Roof Area (square feet)									
	500	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	4,999
2.5	100	199	299	398	498	597	697	796	896	995
3.0	92	183	275	366	458	549	641	733	824	916
3.5	86	172	258	344	431	517	603	689	775	861
4.0	81	161	242	323	403	484	565	645	726	806
4.5	77	154	231	308	384	461	538	615	692	769
5.0	73	146	219	292	365	439	512	585	658	731
5.5	67	134	202	269	336	403	470	538	605	672

[1] The “total depth below ground surface” is the depth of the trench bottom. The trench consists of gravel covered by 6 inches of compacted backfill. Hence, the gravel thickness is 6 inches less than the depth listed.



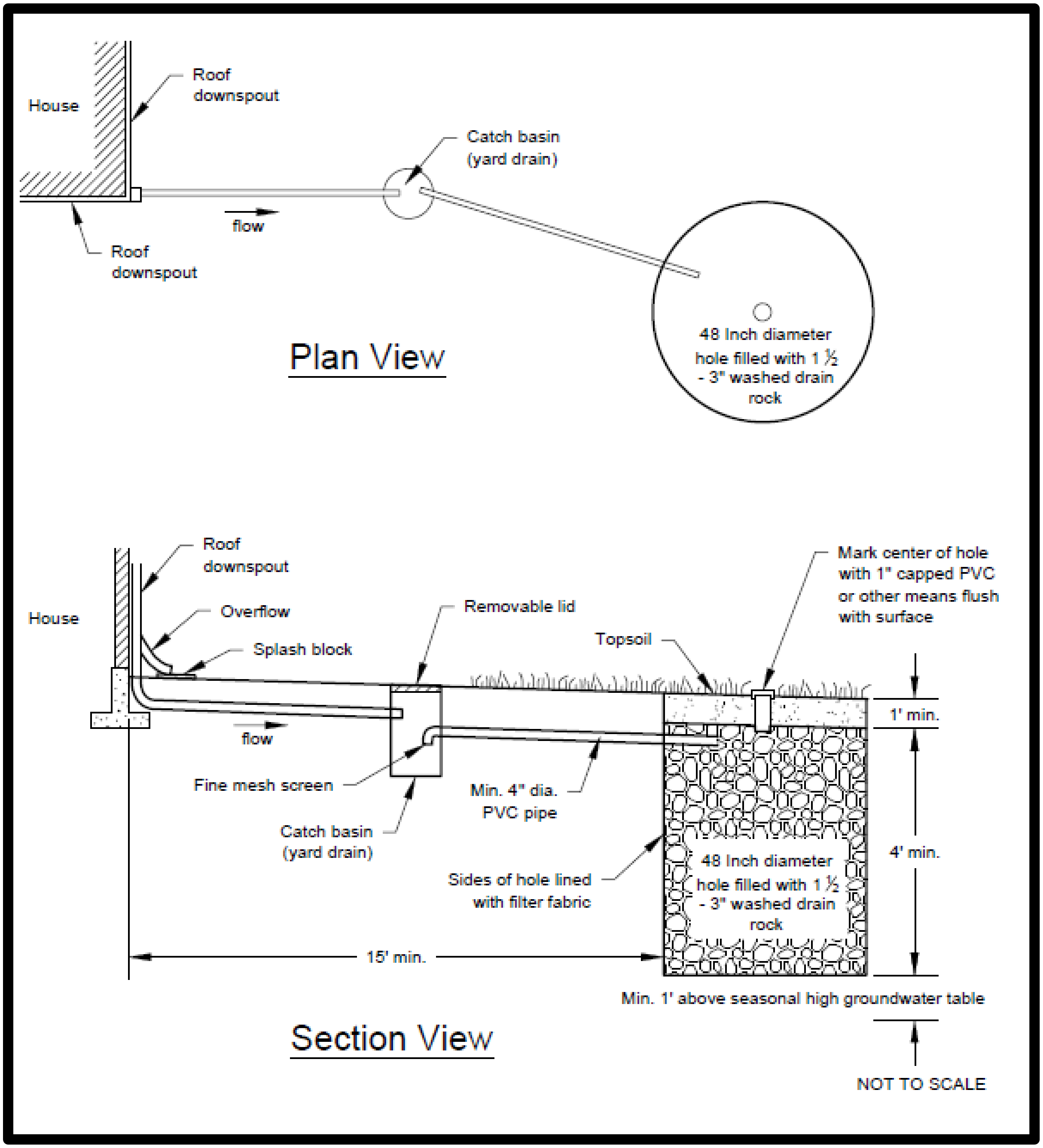
Source: Ecology

Figure 7.16. Typical Downspout Infiltration Trench for Residential Use.



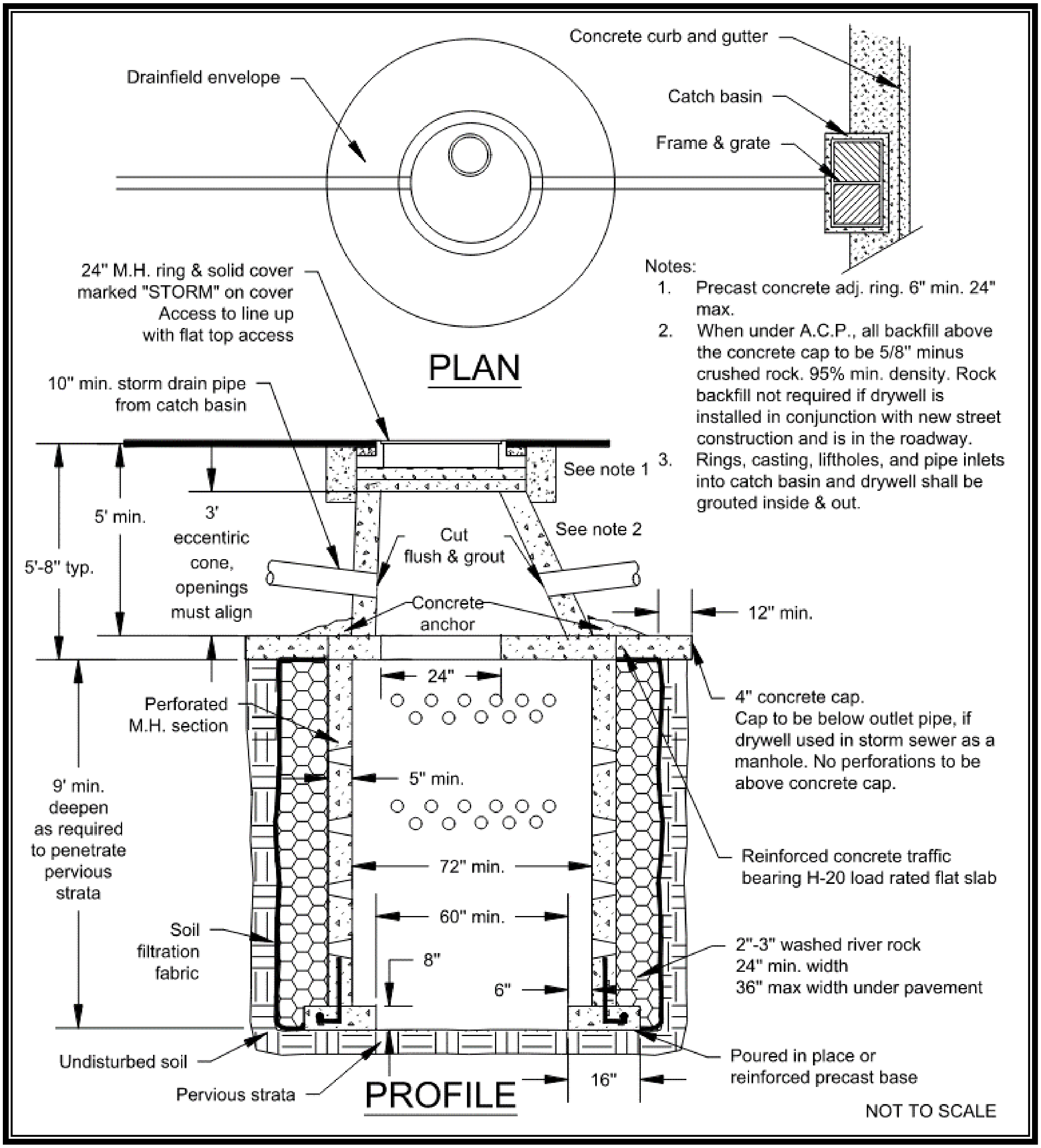
Source: Ecology

Figure 7.17. Alternative Downspout Infiltration Trench System for Coarse Sand and Gravel.



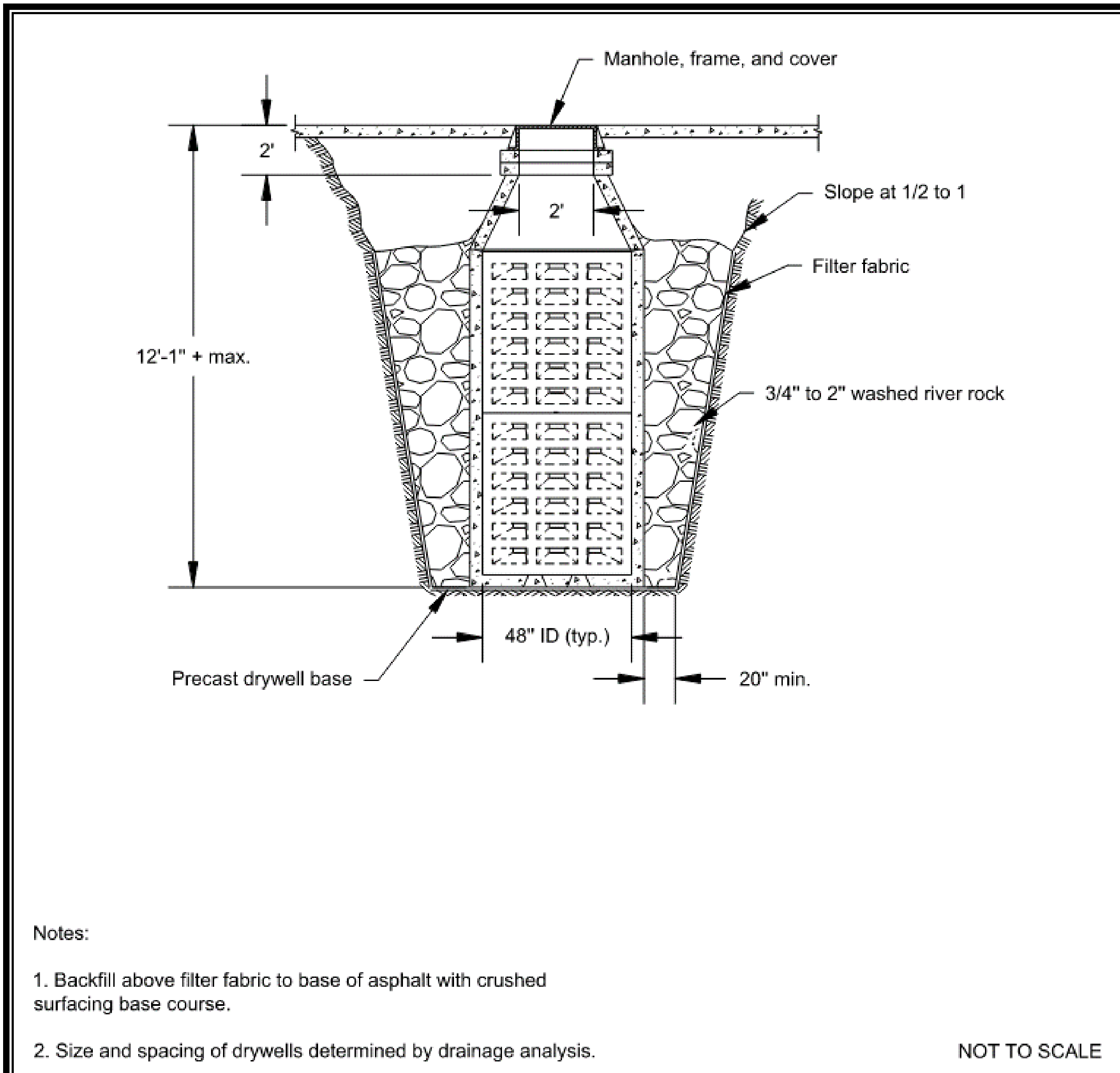
Source: Ecology

Figure 7.18a. Typical Infiltration Drywell for Residential Use.



Source: Ecology

Figure 7.18b. Typical Infiltration Drywell for Commercial/Multifamily Use – Type 1.



Source: Ecology

Figure 7.18c. Typical Infiltration Drywell for Commercial/Multifamily Use – Type 2.

Downspout Dispersion—Trenches and Splashblocks (Ecology BMP T5.10B)

Description

Downspout dispersion systems are gravel-filled trenches or splashblocks, which serve to spread roof runoff over vegetated areas. Dispersion attenuates peak flows by slowing runoff entering into the conveyance system, allowing some infiltration, and providing some water quality benefits.

Applications and Limitations

- Downspout dispersion can be used to help meet the flow control standards of Core Requirement #7.
- When used in combination with other on-site stormwater management BMPs, downspout dispersion can also help achieve compliance with Core Requirement #5.
- The layout of the natural resource protection areas adjacent to and downgradient of individual lots can provide opportunities to disperse runoff into the natural resource protection area.

Modeling and Sizing

If roof runoff is dispersed according to the requirements of this section over a vegetative flow path that is 50 feet or longer (for splashblocks) through undisturbed native landscape or lawn/landscape area that meets the soils criteria outlined in Section 7.4.1, the roof area may be modeled as grass/lawn surface. If the available vegetated flow path is 25 to 50 feet, use of a dispersion trench allows modeling the roof as 50 percent impervious/50 percent landscape.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for downspout dispersion. If one or more infeasibility criteria apply, then downspout dispersion is not required for consideration in the List #1 or List #2 option of Core Requirement #5. In addition, other design criteria and site limitations that make downspout dispersion infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Downspout Dispersion Design Criteria

General Downspout Dispersion Design Criteria

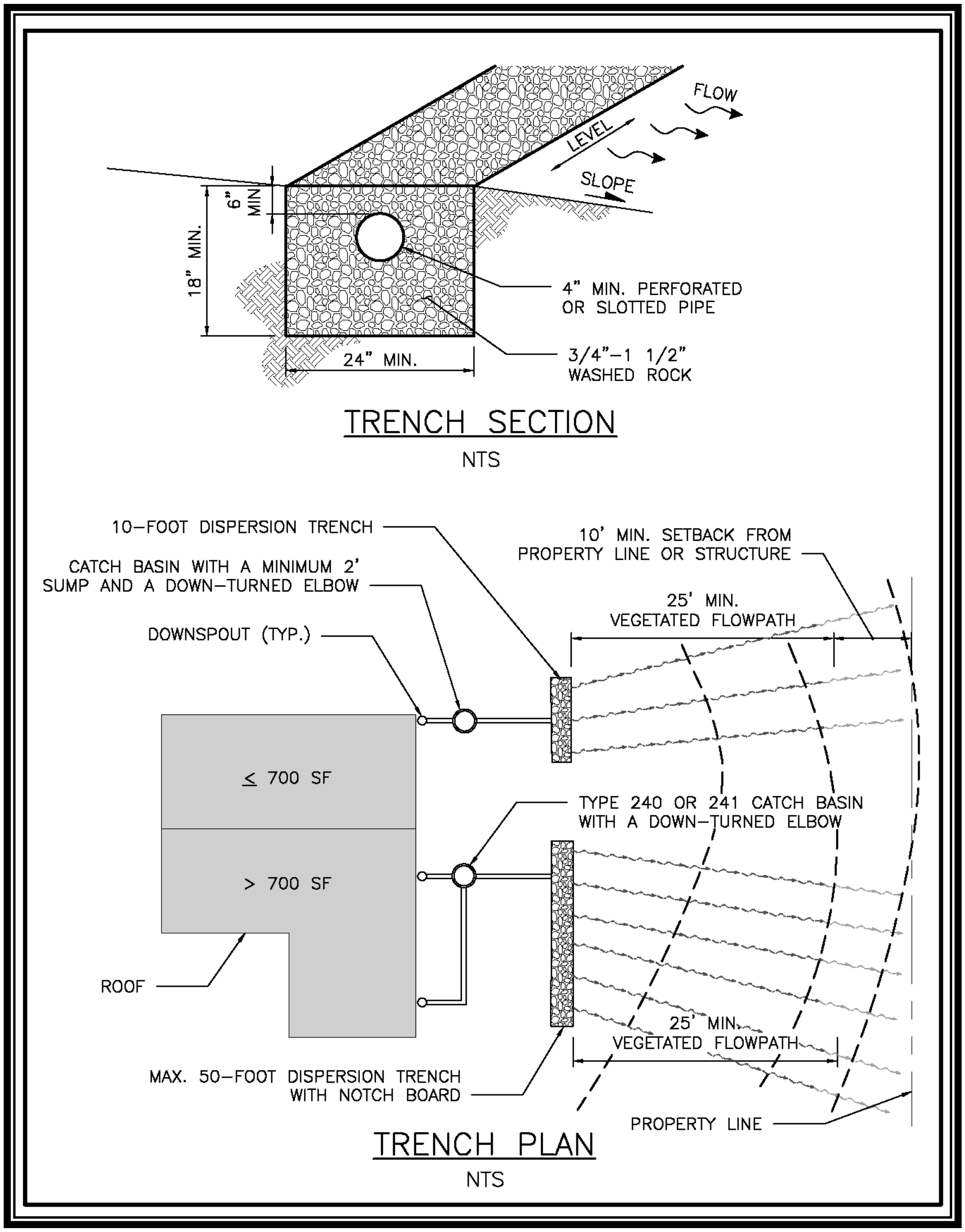
Refer to Section 7.4.2 for general dispersion design criteria. This section provides design criteria for both dispersion trenches and splashblocks:

- Each downspout dispersion trench shall have a separate flow path
- For the purpose of maintaining adequate separation of flows discharged from adjacent dispersion trenches, vegetated flow paths shall be at least 20 feet apart at the upslope end and must not overlap with other flow paths at any point along the flow path lengths
- See additional applicable dispersion area setbacks and design criteria in Section 7.4.2.

Dispersion Trench Design Criteria

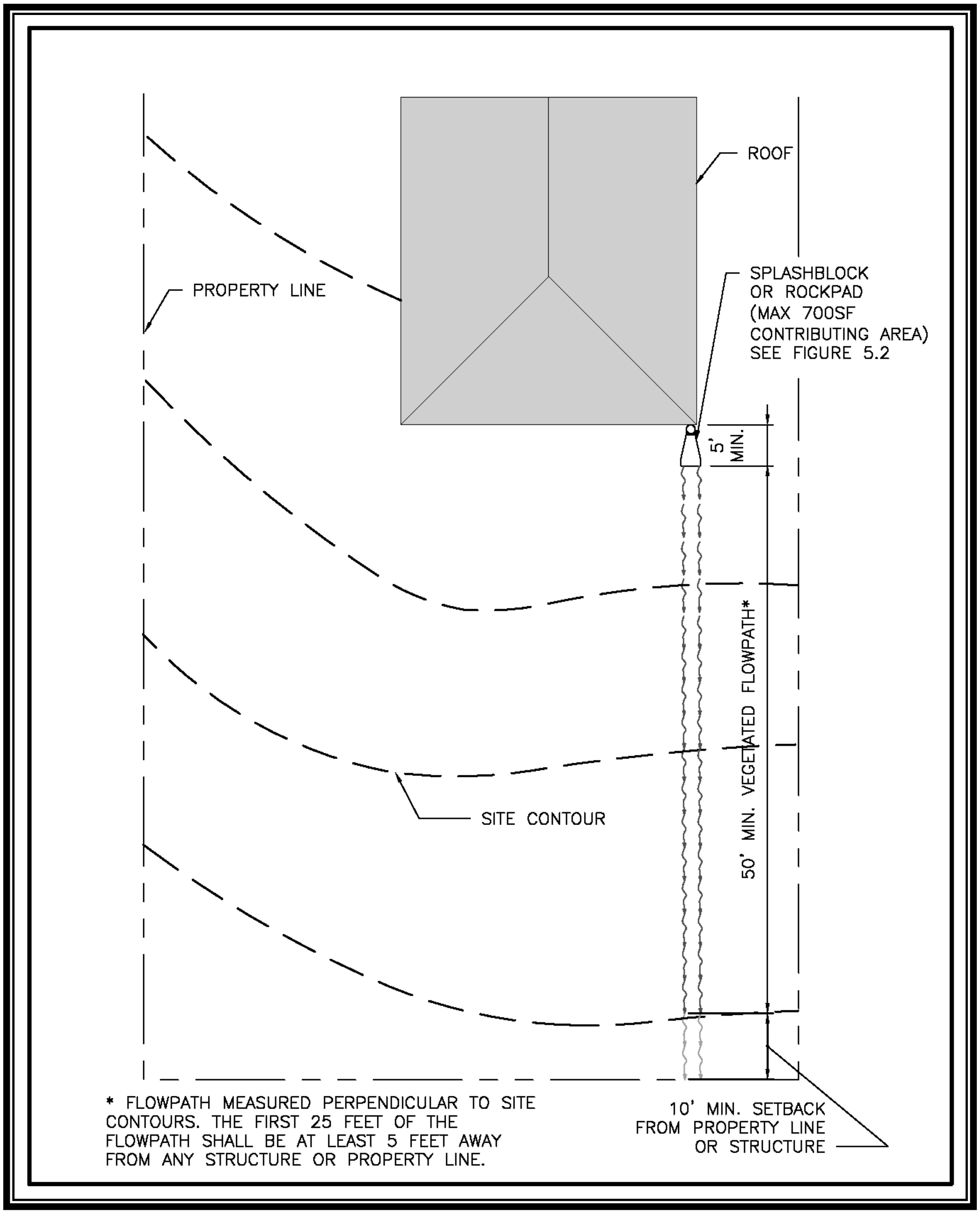
This section provides additional design criteria specific to dispersion trenches.

- Dispersion trenches shall be designed as shown in Figures 7.19 through 7.21.
- A vegetated flow path of at least 25 feet in length must be maintained between the outlet of a trench and any property line, structure, critical area (i.e., stream, wetland), or impervious surface.
- 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 Figures 7.19 and 7.20. For roof areas larger than 700 square feet, a dispersion trench with notched grade board as shown in Figures 7.21a and 21b may be used subject to approval by the City. It is acceptable to have multiple downspouts routed to a dispersion trench. 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. In both systems it is important to include a cleanout structure prior to discharge into the dispersal area. Although Figures 7.19, 7.21a, and 7.21b refer at times to a Type 1 catch basin being used, it is also acceptable to utilize an equivalent type structure which includes a lid, 1-foot minimum sump, and T-type outlet with screen.



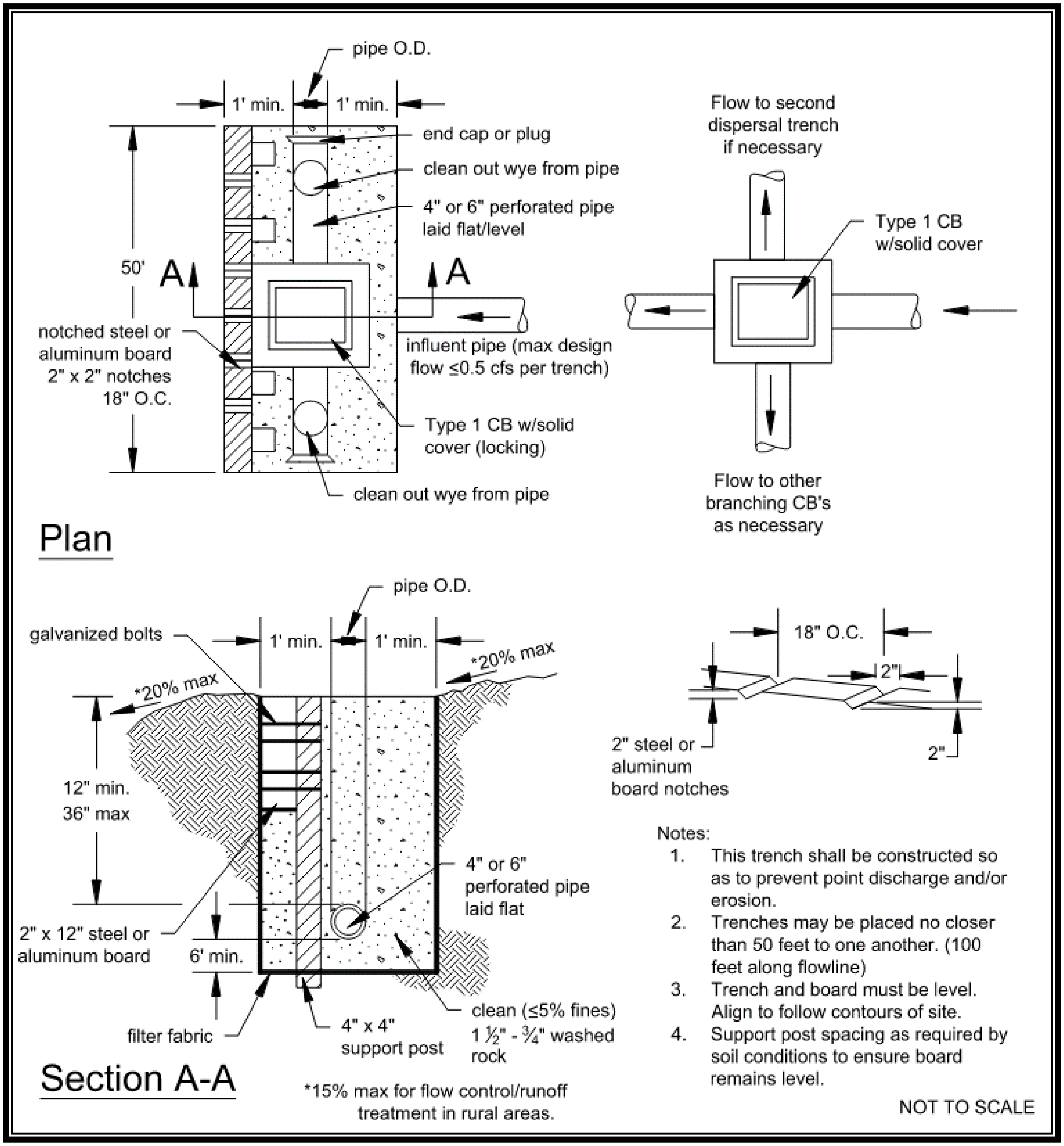
Source: City of Seattle

Figure 7.19. Typical Downspout Dispersion Trench.



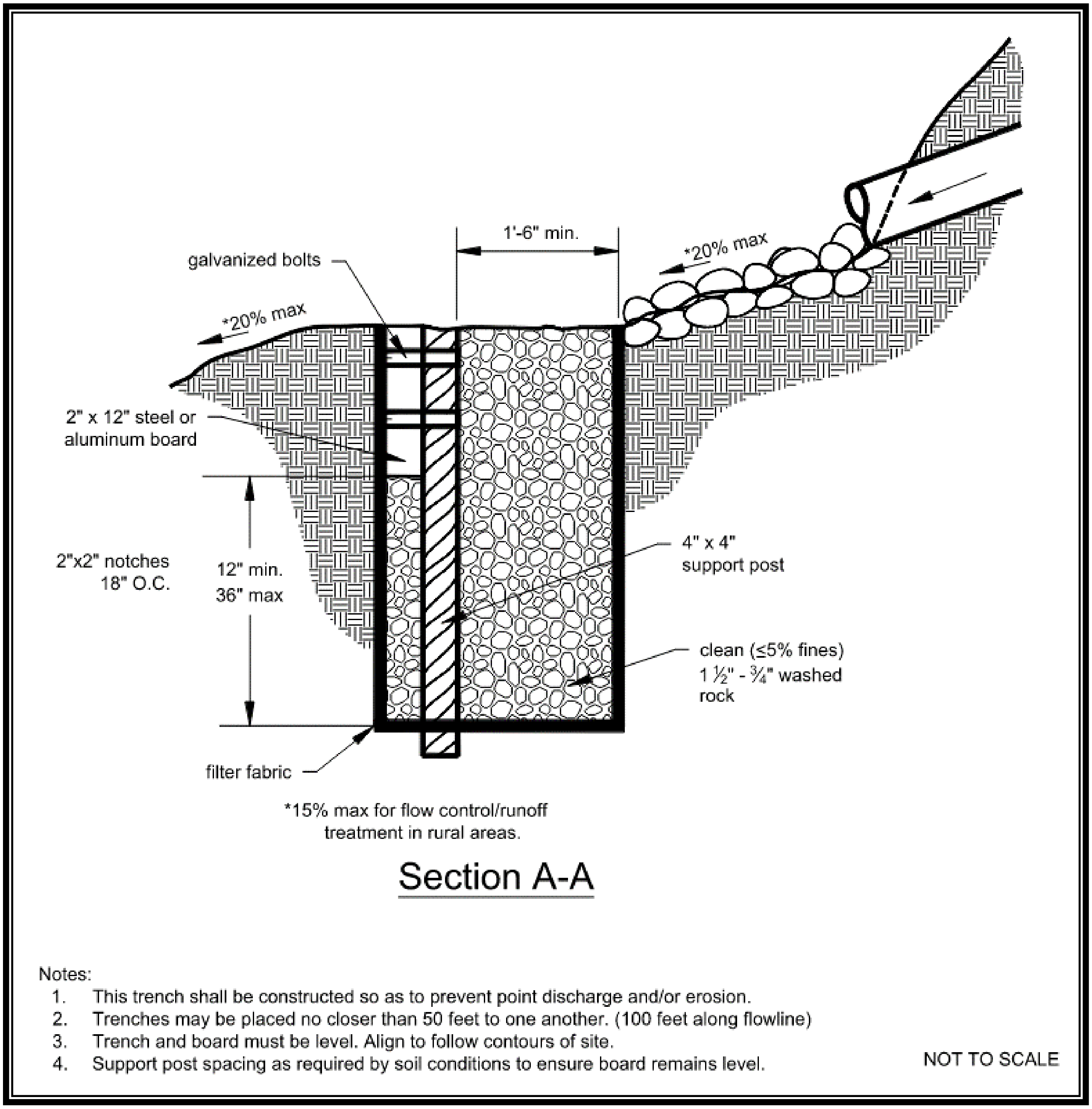
Source: City of Seattle

Figure 7.20. Typical Downspout Splashblock Flowpath.



Source: Ecology

Figure 7.21a. Flow Dispersal Trench.



Source: Ecology

Figure 7.21b. Alternative Flow Dispersal Trench.

Splashblocks

This section provides additional design criteria specific to splashblocks.

- Splashblocks shown in Figure 7.22 may be used for downspouts discharging to a vegetated flow path at least 10 feet in width and 50 feet in length as measured from the downspout to the downstream property line, structure, critical areas (i.e., stream, wetland), or other impervious surface.

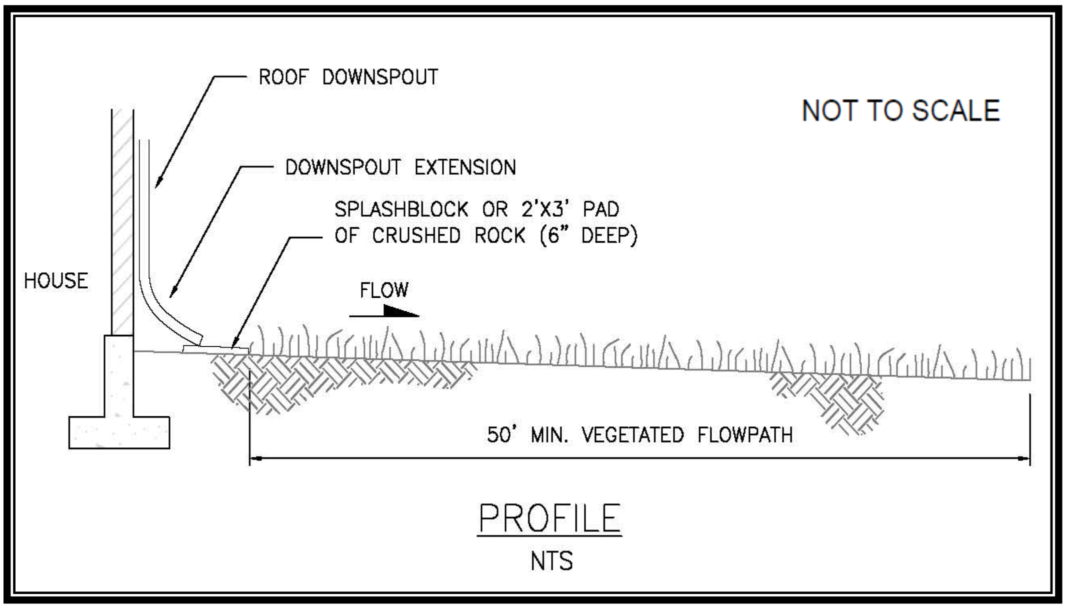
- A maximum of 700 square feet of roof area may drain to each splashblock.
- A splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) must be placed at each downspout discharge point.

Construction Criteria

See Chapter 5, Section 5.3, for dispersion BMP construction requirements.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.



Source: Pierce County

Figure 7.22. Typical Downspout Splashblock Dispersion.

Perforated Stub-Out Connections (Ecology BMP T5.10C)

Description

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 downstream drainage system. Figure 7.23 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.

Applications and Limitations

- In projects subject to Core Requirement #5 (see Chapter 2, Section 2.2.5), perforated stub-out connections may be used only when all other higher priority on-site stormwater management BMPs are not feasible.

- Select the location of the connection to allow a maximum amount of runoff to infiltrate into the ground (ideally a dry, relatively well-drained location).
- Use the same setbacks as for downspout infiltration systems (see “Downspout Infiltration Systems” subsection above), with the following modification to the setback from on-site or adjacent septic systems:
    - Apply the prescribed setbacks from on-site or adjacent septic systems to the perforated portion of the pipe (not the discharge point).
- Do not place the perforated portion of the pipe within 300 feet of an erosion hazard area, a landslide hazard area (as defined by Section 14.37.030 LMC), or above slopes greater than 20 percent, unless the slope stability impacts of such systems have been analyzed and mitigated by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for perforated stub-out connections. If one or more infeasibility criteria apply, then perforated stub-out connections is not required for consideration in the List #1 or List #2 option of Core Requirement #5. In addition, other design criteria and site limitations that make perforated stub-out connections infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City.

Modeling and Sizing

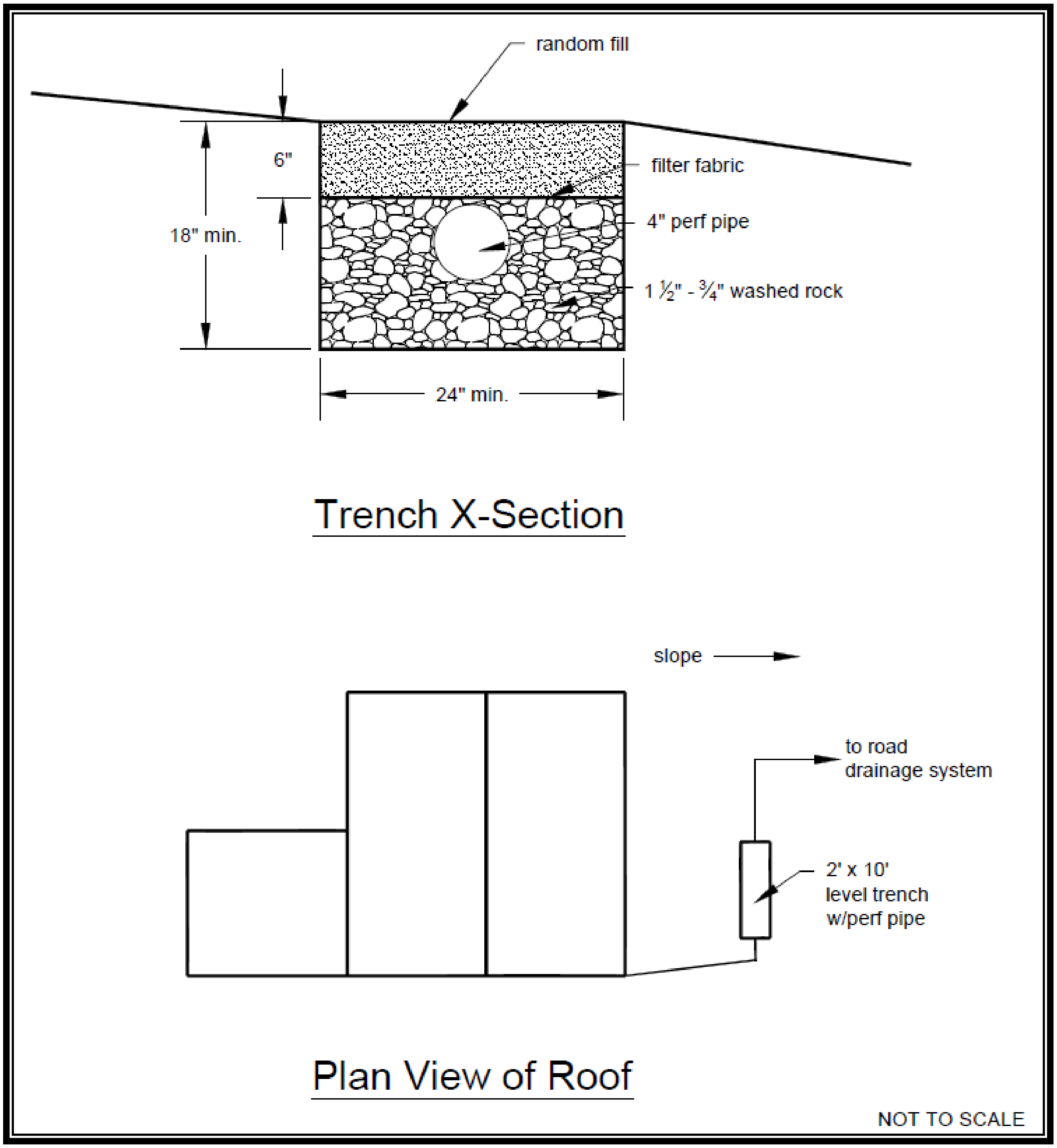
Any flow reduction is variable and unpredictable; therefore, no flow control credits are given for perforated stub-outs. No computer modeling techniques are allowed that allocate any reduction in flow rates or volumes from the connected area.

Perforated Stub-Out 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 12-inch minimum depth of washed drain rock. Lay the 4- or 6-inch-diameter perforated pipe level with 6 to 8 inches of drain rock below the bottom of the pipe. Cover the rock trench with filter fabric and minimum of 6 inches of fill (see Figure 7.23).

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements (refer to maintenance requirements for infiltration basins and trenches).



Source: Ecology

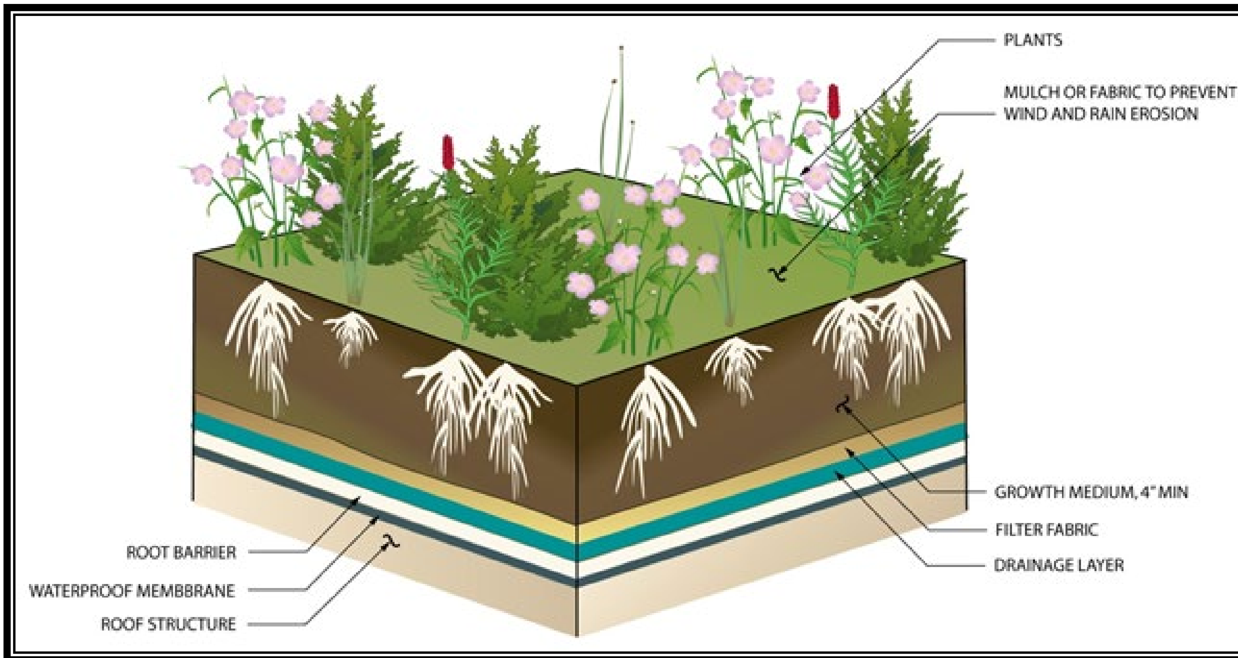
Figure 7.23. Perforated Stub-Out Connection.

7.4.11 Vegetated Roofs (Ecology BMP T5.17)

Description

Vegetated roofs are areas of living vegetation installed on top of buildings, or other above-grade impervious surfaces (e.g., at least 10 feet above grade). Vegetated roofs are also known as ecoroofs, green roofs, and roof gardens. Because vegetated roofs are an integral component of the building structure, and the design and construction approaches continue to get refined as this technology evolves, this section primarily focuses on the stormwater elements of vegetated roof design. Other technical resources are referenced in this section for additional guidance and information (such as the *Low Impact Development Technical Guidance Manual for Puget Sound* [Hinman and Wulkan 2012]).

A vegetated roof consists of a system in which several materials are layered to achieve the desired vegetative cover and stormwater management function (see Figure 7.24). Design components vary depending on the vegetated roof type and site constraints, but may include a waterproofing material, a root barrier, a drainage layer, a separation fabric, a growth medium (soil), and vegetation. Vegetated roofs are categorized by the depth and the types of courses used in their construction.



Source: Pierce County

Figure 7.24. Vegetated Roof.

Applications and Limitations

- Vegetated roofs can be used to help meet the flow control standards of Core Requirement #7.
- When used in combination with other on-site stormwater management BMPs, vegetated roofs can also help achieve compliance with Core Requirement #5.
- Vegetated roofs are generally applicable to roof slopes between 1 and 22 degrees (0.2:12 and 5:12).
- A primary consideration for the feasibility of vegetated roofs is the structural capability of the roof and building structure. Related factors, including design load, slipping and shear issues, and wind load, are outside the scope of this manual. Refer to International Building Code (IBC) Section 1604 for general structural requirements.

Modeling and Sizing

When using an approved continuous simulation model to quantify the on-site stormwater management and/or flow control performance of vegetated roofs, the assumptions listed in Table 7.6 must be applied. It is recommended that vegetated roofs be modeled as layers of aggregate with surface flows, interflow, and exfiltrating flow routed to an outlet.

Table 7.6. Continuous Modeling Assumptions for Vegetated Roofs.

Variable	Assumption
Computational Time Step	15 minutes
Inflows to BMP	None
Precipitation and Evaporation Applied to BMP	Yes
Depth of Material (inches)	Growth medium/soil depth (minimum of 4 inches).
Vegetative Cover	Ground cover or shrubs. Shrubs are appropriate only when growth medium is at least 6 inches.
Length of Rooftop (ft)	The average surface flow path length from the most upstream point to the roof drain
Slope of Rooftop (ft/ft)	The slope of the vegetated roof
Discharge from BMP	Surface flow, interflow and exfiltrated flow from vegetated roof module routed to downstream BMP or point of compliance. Note that the exfiltrated flow (flow infiltrated through the media and collected by the drainage layer) is tracked as “groundwater” in WWHM.

The medium depth can be modified to achieve various degrees of flow control. Because the on-site stormwater management and flow control standards cannot typically be achieved using a vegetative roof, additional downstream flow control measures may be required.

Vegetated Roof Design Criteria

The following sections provide a description and general specifications for the common components of vegetated roofs. Typical components of a vegetated roof are shown in Figure 7.24. Design criteria are provided in this section for the following elements:

- Roof slope
- Vegetation
- Growth medium
- Drainage layer
- Drain system and overflow.

While vegetated roofs will include additional system components (e.g., waterproof membrane, root barrier, separation fabric for multi-course systems), the design and construction requirements for these components are outside of the scope of this manual. Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for a more detailed description of the components of and design criteria for vegetated roofs, as well as additional references and design guidance.

Roof Slope

For flow control compliance, the vegetated roof slope must be between 1 and 22 degrees (0.2:12 and 5:12). Roofs of this slope are generally the easiest to install, are the least complex, and provide the greatest stormwater storage capacity per inch of growth medium. Roofs with slopes greater than 10 degrees (2H:12V) require an analysis of engineered slope stability.

Vegetation

Vegetation should be drought tolerant, self-sustaining, low maintenance, and perennial or self-sowing. Appropriate plants should also be able to withstand heat, cold, periodic inundation, and high winds. Vegetation with these attributes typically includes succulents, grasses, herbs, and wildflowers that are adapted to harsh conditions. Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional vegetation guidance for vegetated roofs.

Minimum requirements associated with vegetation design include the following:

- Plans must specify that vegetation coverage of selected plants must achieve 80 percent coverage within 2 years or additional plantings must be provided until this coverage requirement is met.
- For non-single family residential projects, plant spacing and plant size must be designed to achieve specified coverage by a licensed landscape architect.

- Vegetation must be suitable for rooftop conditions (e.g., hot, cold, dry, and windy).
- Application of fertilizer, pesticides or herbicides shall be minimized after a 3-year establishment period.

Growth Media

Vegetated roofs use light-weight growth media with adequate fertility and drainage capacity to support plants and allow filtration and storage of water. Growth media composition (fines content and water holding capacity) is key to flow control performance. Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional guidance on growth medium design.

Minimum requirements associated with the growth media design include the following:

- The growth media must be a minimum of 4 inches deep.
- For non-single family residential projects, growth media depth and characteristics must support growth for selected plant species and must be approved by a licensed landscape architect.
- Vegetated roofs must not be subject to any use that will significantly compact the growth media.
- Unless designed for foot traffic, vegetated roof areas that are accessible to the public must be protected (e.g., signs, railing, and fencing) from foot traffic and other loads.
- Mulch, mat, or other measures to control erosion of growth media must be maintained until 80 percent vegetation coverage is achieved.

Drainage Layer

Multi-course vegetated roof systems must include a drainage layer below the growth medium. The drainage layer is a multipurpose layer designed to provide void spaces to hold a portion of the water that passes through the growth medium and to channel the water to the roof drain system. The drainage layer can consist of a layer of aggregate or a manufactured mat or board that provides an open free-draining area. Many manufactured products include “egg carton” shaped depressions that retain a portion of the water for eventual evapotranspiration. Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional guidance on drainage layer design.

Drain System and Overflow

Vegetated roofs must be equipped with a roof drainage system capable of collecting subsurface and surface drainage and conveying it safely to a downstream BMP or an approved point of discharge. To facilitate subsurface drainage, interceptor drains are often installed at a regular spacing to prevent excessive moisture build up in the media and convey water to the roof drain. Roof outlets must be protected from encroaching plant growth and loose gravel and must be constructed and located so that they are permanently accessible.

Construction Criteria

The growth media must be protected from over compaction during construction.

Operations and Maintenance Criteria

Vegetated roofs are designed to need very little maintenance and if designed correctly should have a longer lifespan than traditional roofs because of the protective nature of the soil structure. Irrigation shall be provided for a minimum of 5 growing seasons. Inspections should be performed regularly to identify any leakage of the membrane system or blockages of the overflow system. See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

7.4.12 Roof Rainwater Collection Systems (Ecology BMP T5.20)

Description

Roof rainwater collection systems are designed to collect stormwater runoff from non-polluting surfaces (typically roofs), and to make use of the collected water. Reuse of the runoff can be for irrigation, potable, and non-potable uses, but requires different levels of storage and runoff treatment depending on the intended use. Rainwater collection systems have been designed and installed in many locations throughout the northwest, including Pacific Plaza in Tacoma, and the Bullitt Center in Seattle. The most abundant use of water collection and reuse systems in the northwest has been on some of the island communities where potable water is scarce. In these cases, the systems have been sized and designed to capture all rooftop runoff with adequate treatment for reuse as a potable water source. Rainwater collection and reuse systems are also commonly referred to as “rainfall catchment” and “rainwater harvesting” systems.

Because of the wide variety of uses and scenarios that can apply to rooftop rainwater collection and use, this section primarily focuses on the stormwater elements of rainwater collection design. Additional guidance and information on issues such as modeling indoor water use can be found in the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) (and other resources).

Applications and Limitations

- Rainwater collection systems can be used to help meet the flow control standards of Core Requirement #7.

- When used in combination with other on-site stormwater management BMPs, Rainwater collection systems can also help achieve compliance with Core Requirement #5.

- Rainwater collection systems can also be an effective volume reduction practice for projects where infiltration is not permitted or desired.

- Rainwater collection has higher stormwater management benefits when designed for uses that occur regularly through the wet season (e.g., toilet flushing and cold water laundry).

- Highly developed areas or commercial centers where larger buildings, especially multistory buildings, encompass nearly all of the area are highly suitable for rainwater collection systems where it might not be feasible to preserve natural protection areas. In these areas, any type of stormwater management is expensive due to the high cost of land and therefore the cost of a rainwater collection and reuse system can be more competitive.

- Roof rainwater collection systems have the additional benefit of decreasing demands on the treated potable water supply.

- Use of a roof rainwater collection system as a potable source will require approval by the Washington State Department of Health (WSDOH) and/or the Thurston County Public Health and Social Services Department.

Although use of rain barrels for capturing rainfall can be beneficial for providing a small amount of irrigation and also provide an educational aspect to the benefits of water reuse, they generally do not provide enough storage of seasonal runoff to be considered to meet the performance goals of Core Requirement #5 or #7, or the general performance requirements of LID projects, unless prior approval is obtained from the City.

Modeling and Sizing

- Roof rainwater collection systems must be sized according to roof area, monthly rainfall patterns, and anticipated water usage of connected plumbing fixtures. To estimate the storage volume required, the volume of rainfall off the roof surface should be plotted over time against curves showing the amount of water use anticipated. Use monthly average rainfall for the City, shown in Table 7.7.

Table 7.7. City of Lacey Monthly Average Rainfall.

Month	Amount	Month	Amount
January	7.80 inches	July	0.53 inches
February	5.09 inches	August	0.96 inches
March	5.68 inches	September	2.04 inches
April	3.67 inches	October	5.07 inches
May	2.26 inches	November	8.21 inches
June	1.46 inches	December	7.85 inches

Note: The rainfall depths above represent the average monthly rainfall from 1991-2020.
Source: NOAA National Weather Service.

- Rainwater collection systems also experience water losses due to roofing material texture, evaporation, and inefficiencies in the collection process, which can account for up to a 25 percent loss of annual rainfall. Additional guidance and information on modeling and sizing for indoor water use can be found in the *City of Seattle Stormwater Manual* (Seattle 2021).

General Roof Rainwater Collection System Design Criteria

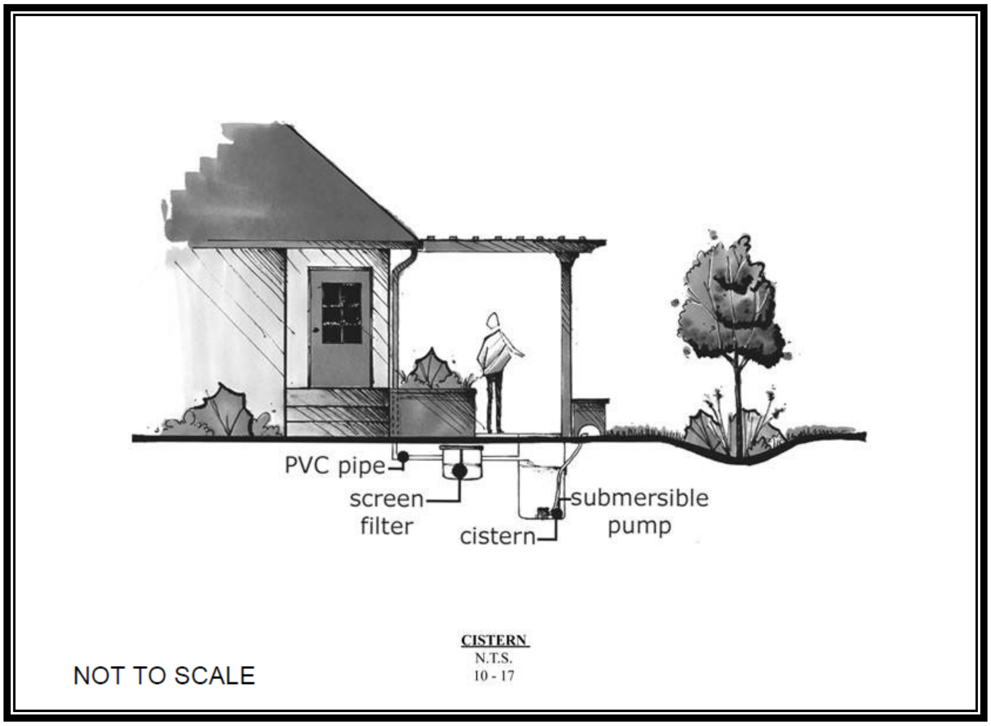
Rainwater collection systems can be designed as part of the foundation to fit under the house (adding about 1 foot in height), or can be placed next to the house, either above or below ground. When the storage of runoff is incorporated into the building design it must be submitted for approval as part of the building permit. Figure 7.25 provides an illustration of an example cistern installation.

- Rainwater reuse systems that supply non-potable water should be designed to augment the supply of treated water and therefore should be designed to use the stored rainfall runoff first and use the treated water supply when the rainfall runoff is depleted.

- Additional guidance for design of rainwater harvesting systems and cistern design requirements specific to indoor use of harvested rainwater can be found in the *City of Seattle Stormwater Manual* (Seattle 2021).

Construction Criteria

Rainwater harvesting systems must be constructed according to the manufacturer's recommendations, the I-Codes, and all applicable laws.



Source: Pierce County

Figure 7.25. Cistern.

Operations and Maintenance Criteria

Maintenance covenants shall provide for annual inspections of systems to ensure pumps and filters are working properly and the design level of water quality is being maintained.

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

7.5 Detention BMPs

This section presents the methods, criteria, and details for design and analysis of detention BMPs. These BMPs provide for the temporary storage of increased surface water runoff resulting from development pursuant to the performance standards set forth in Core Requirement #7 for flow control (Chapter 2, Section 2.2.7).

There are three primary types of detention BMPs described in this section: detention ponds, tanks, and vaults.

7.5.1 Detention Ponds

The design criteria in this section are for detention ponds. However, many of the criteria also apply to infiltration basins (Section 7.4.9), and water quality wet ponds and combined detention/wet ponds (see Chapter 8). Standard details for detention ponds and key detention pond structures are provided in Figure 7.26 through Figure 7.30. Control structure design requirements are provided in Section 7.5.4.

Methods of Analysis

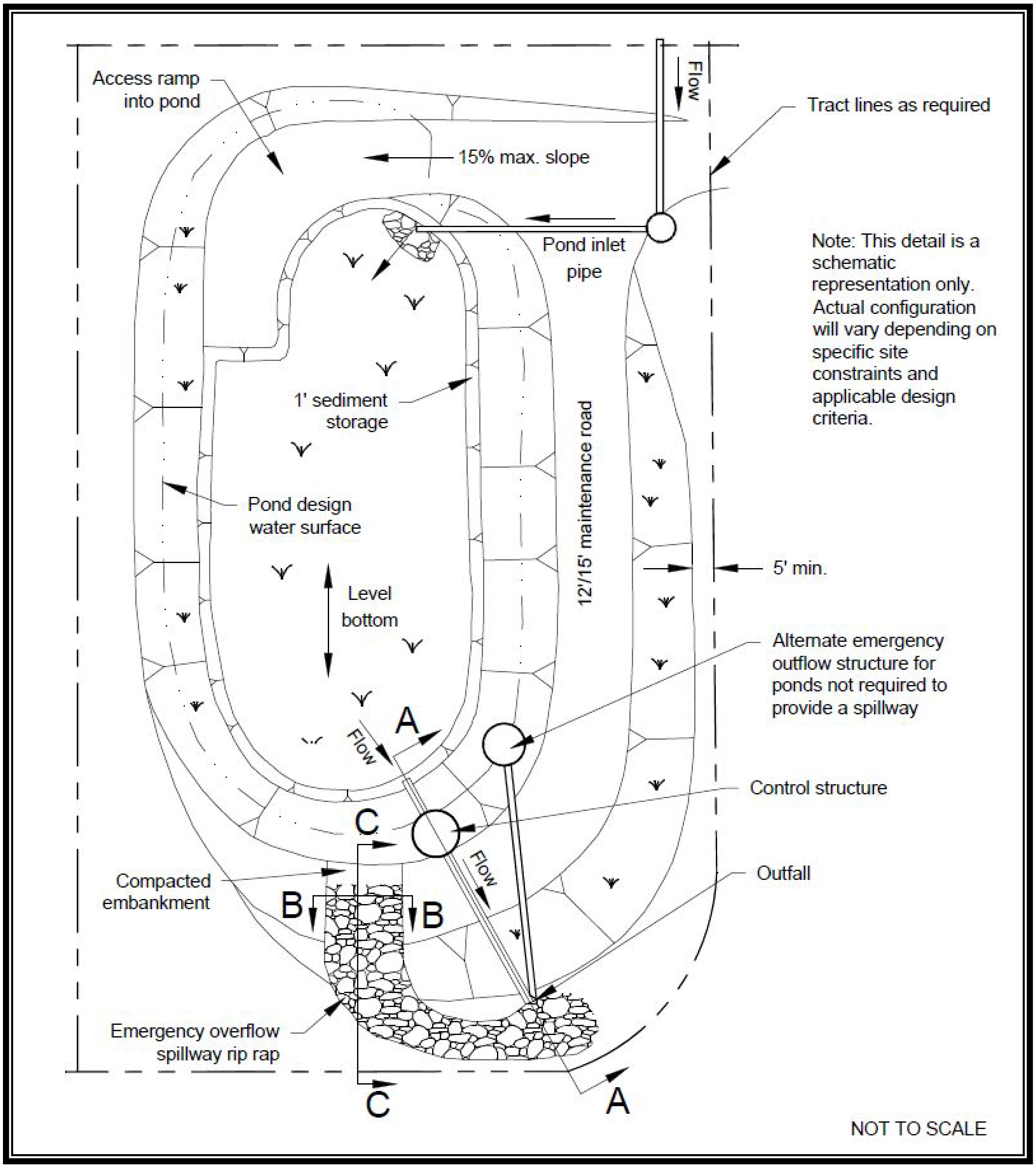
Detention Volume and Outflow

The volume and outflow design for detention ponds must be in accordance with Core Requirement #7 in Chapter 2 and the hydrologic analysis and design methods in Chapter 6. Design requirements for restrictor orifice structures are given in Section 7.5.4.

Note: The design water surface elevation is the highest elevation which occurs in order to meet the required outflow performance for the pond.

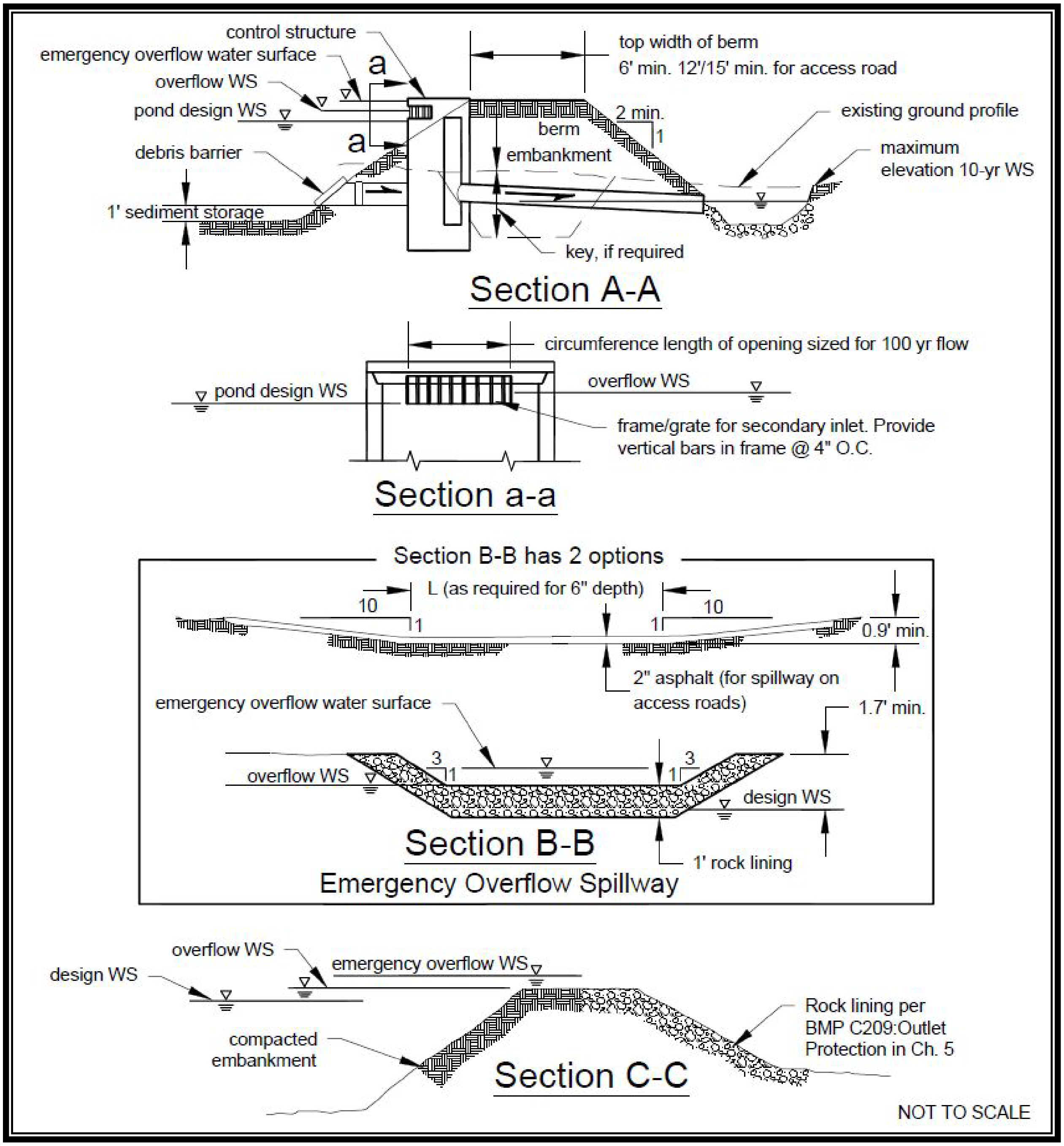
Detention Ponds in Infiltrative Soils

Detention ponds may occasionally be sited on till soils that are sufficiently permeable for a properly functioning infiltration system (see Section 7.2). These detention ponds have a surface discharge, but 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 7.2 for infiltration basins, including a Soils Report, testing, runoff treatment, groundwater protection, presettling, and construction techniques.



Source: Ecology

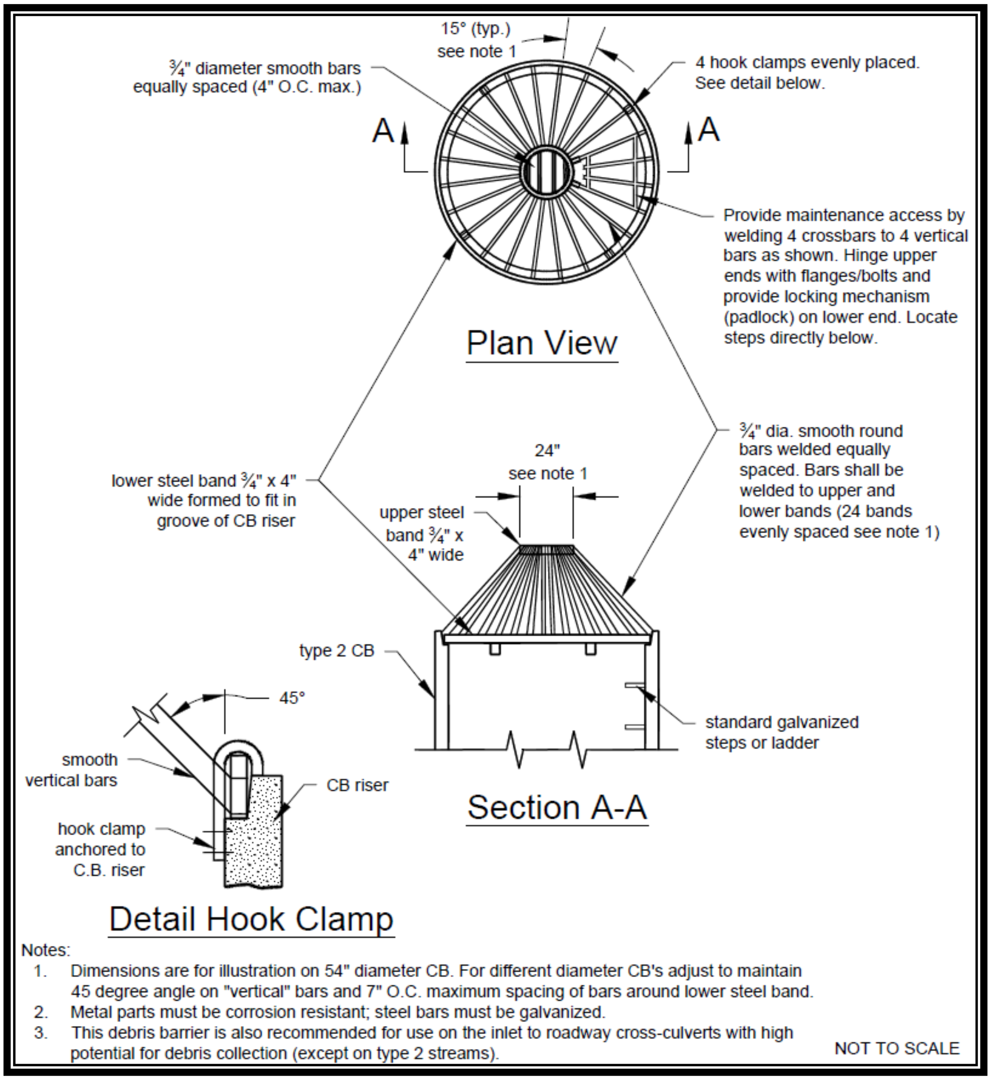
Figure 7.26. Typical Detention Pond.



Note: This detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

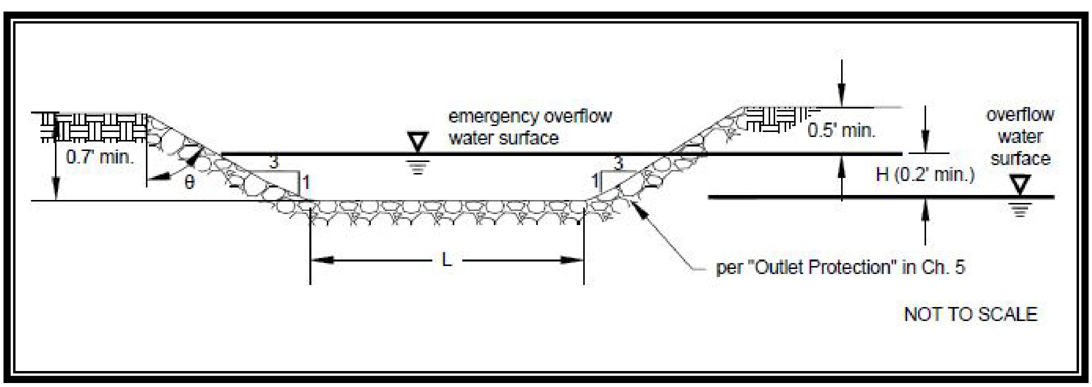
Source: Ecology

Figure 7.27. Typical Detention Pond Sections.



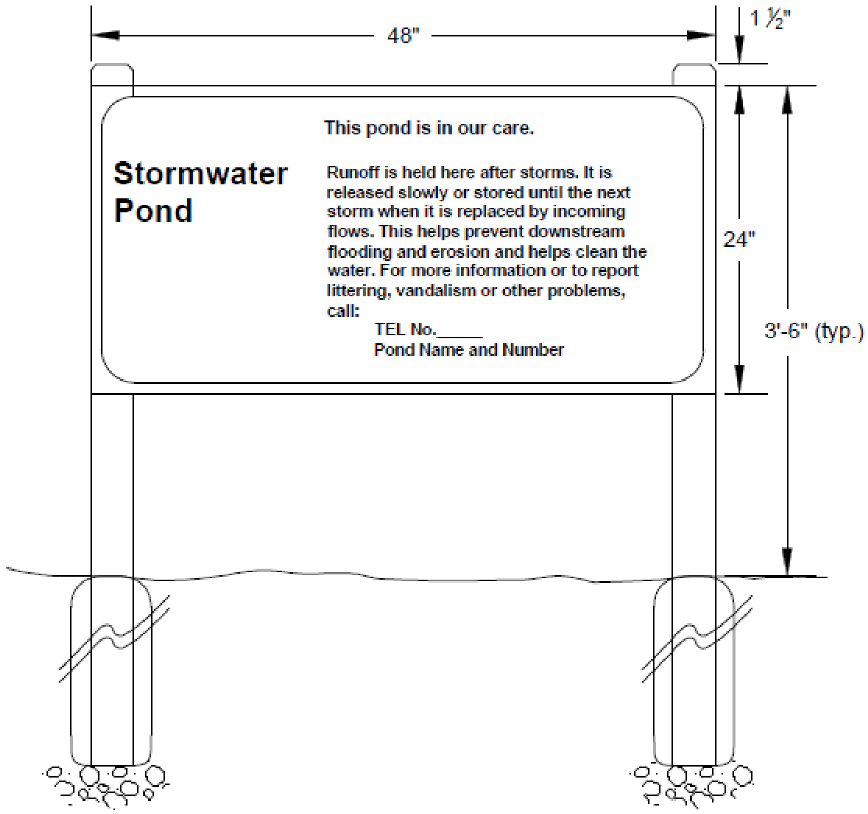
Source: Ecology

Figure 7.28. Overflow Structure.



Source: Ecology

Figure 7.29. Weir Section for Emergency Overflow Spillway.



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 ½ inch; Text: 1 inch; Outer Border:; ⅛ inch; Border Distance from Edge: ¼ inch; all text 1 ¾ inch from border.
Posts:	Pressure treated, beveled tops, 1 ½ inch higher than sign.
Installation:	Secure to chain link fence if available. Otherwise install on two 4" x 4" 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 (if a liner that restricts infiltration of stormwater exists).

NOT TO SCALE

Source: Ecology

Figure 7.30. Example of Permanent Surface Water Control Pond Sign.

Emergency Overflow Spillway Capacity

For impoundments under 10-acre-feet, the emergency overflow spillway weir section must be designed to pass the 100-year recurrence interval runoff event for developed conditions assuming a broad-crested weir. The **broad-crested weir equation** for the spillway section (see also Figure 7.29), for example, would be:

$$Q_{100} = C\,(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}(\tan\theta)\,H^{5/2}\right] \qquad \text{(Equation 1)}$$

Where:

Q_{100} = peak flow for the 100-year recurrence interval runoff event (cubic feet per second) indicated by an approved continuous runoff model using a 15-minute time step.

C = discharge coefficient (0.6)

g = gravity (32.2 ft/sec^2)

L = length of weir (ft)

H = height of water over weir (ft)

θ = angle of side slopes

Assuming C = 0.6 and Tan θ = 3 (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21[LH^{3/2} + 2.4\,H^{5/2}] \qquad \text{(Equation 2)}$$

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):

$$L = [Q_{100}/(3.21H^{3/2})] - 2.4\,H \quad \text{or 6 feet minimum} \qquad \text{(Equation 3)}$$

General Detention Design

- Ponds must be designed as flow-through systems (however, parking lot storage may be utilized through a back-up system; see Section 7.5.5). 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.

- Pond bottoms must be level and be located a minimum of 1 foot below the inlet and outlet to provide sediment storage.

- Design requirements for outflow control structures are specified in Section 7.5.4.

- A geotechnical assessment and Soils Report must be prepared for work located within 300 feet of the top of a steep slope, erosion hazard, or landslide hazard area (as defined in Section14.37.030 LMC). The scope of the Soils Report shall include the assessment of impoundment seepage on the stability of the natural slope where the BMP will be located within the setback limits set forth in this section.

- Drainage BMPs should be made attractive features of the urban environment. To this end, engineers are encouraged to be creative in shaping and landscaping BMPs and to consider aesthetics when choosing alternatives for parking lot paving, conveyance systems, detention BMPs, weirs, structures, etc.

Dam Safety for Detention BMPs

Stormwater BMPs that can impound 10 acre-feet (435,600 cubic feet; 3.26 million gallons) or more with the water level at the embankment crest, or have an embankment height of greater than 6 feet at the downstream toe, 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.

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. It is recommended and requested that dam safety be contacted early in the BMPs planning process. Additional information on dam safety requirements is available on Ecology's Dam Safety web page at: < https://ecology.wa.gov/Water-Shorelines/Water-supply/Dams>.

Side Slopes

- Interior side slopes up to the emergency overflow water surface shall not be steeper than 3H:1V unless a fence is provided (see "fencing").

- Exterior side slopes must not be steeper than 2H:1V unless analyzed and certified for stability and erosion resistance by a geotechnical engineer.

- Pond walls may be vertical retaining walls, provided: a) they are constructed of reinforced concrete per Section 7.5.3, 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; d) the design is stamped by a licensed civil engineer with structural expertise; e) an access ramp to the bottom of the pond is provided. 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.

Embankments

Pond berm embankments shall satisfy the following criteria:

- Construct pond berm embankments on native consolidated soil (or adequately compacted and stable fill soils analyzed by a geotechnical assessment), which is free of loose surface soil materials, roots, and other organic debris.
- Construct pond berm embankments greater than 4 feet in height by excavating a "key" equal to 50 percent of the berm embankment cross-sectional height and width (minimum 3 feet), unless specified otherwise by a geotechnical engineer (except on till soils where the "key" minimum depth can be reduced to 1 foot of excavation into the till).
- Pond berm embankments shall be lined with geomembrane or concrete liners. Till and clay liners are not permitted.
- Exposed earth on the pond side slopes shall be sodded or seeded with appropriate seed mixture (see Chapter 5). Establishment of protective vegetative cover shall be ensured with appropriate surface protection BMPs and reseeded as necessary.
- Where maintenance access is provided along the top of the berm, the minimum width of the top of the berm shall be 15 feet.
- Pond berm embankments greater than 6 feet in height shall be designed by a professional engineer with geotechnical expertise.
- Embankments less than 6 feet in height shall have a minimum 6-foot top width and slopes not to exceed 2H:1V. However, maintenance access for mowing and pond access must still be provided.
- Embankments adjacent to a stream or other body of water shall be sufficiently protected with riprap or bioengineering methods to prevent erosion of the pond embankment. Other control measures may be necessary to protect the embankment.

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 Ecology's Dam Safety Guidelines available on Ecology's Dam Safety web page at: <https://ecology.wa.gov/Water-Shorelines/Water-supply/Dams>

Overflow

- Provide a primary overflow (usually a riser pipe within the control structure; see Section 7.5.4) in all ponds, tanks, and vaults to bypass the 100-year recurrence interval developed peak flow over or around the restrictor system. This assumes the BMP 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.

- Provide a secondary inlet to the control structure 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 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 may also be used as a secondary inlet (see also Figure 7.28).

Emergency Overflow Spillway

- 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. For impoundments less than 10 acre-feet, ponds must have an emergency overflow spillway that is sized to pass the 100-year recurrence interval 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.

- Provide emergency overflow spillways 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 7.28. The emergency overflow structure must be designed to pass the 100-year recurrence interval developed peak flow (and in no case less than 6 inches of freeboard), directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a slope steeper than 15 percent, consideration shall be given to providing an emergency overflow structure in addition to the spillway.

- Armor the emergency overflow spillway with riprap in conformance with "BMP C209: Outlet Protection" in Chapter 5. 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.

- Emergency overflow spillway designs must be analyzed as broad-crested trapezoidal weirs as described in Methods of Analysis at the beginning of this section.

- Design the emergency overflow spillway to allow a minimum of 1 foot of freeboard above the maximum design storm (100-year, 24-hour storm) water surface level.

Access

Pond Access Roads

Pond access roads shall provide access to all drainage structures and alongside the pond for vehicular maintenance access to each pond cell. In addition, pond access roads are required around the entire pond perimeter in order to provide complete vehicular access to all points of the pond requiring regular maintenance, inspection, and repairs. Regular maintenance is considered activities that will be done on a regular basis such as vegetation control where removed vegetation will need to be loaded into a truck for removal. Because each site condition and design is unique there may be cases where the perimeter road is not necessary because no regular maintenance will be anticipated. In such cases, the designer may request to waive the perimeter road requirement by submitting a conceptual pond layout and a narrative that demonstrates that, where the perimeter road is being eliminated, no regular maintenance activities are anticipated. Approval will be at the discretion of the City.

Pond access roads shall be located in the same tracts when the ponds themselves are in tracts. When ponds are located in open space, the pond access roads may be located in open space also, provided that they are constructed so as to be aesthetically compatible with the open space use.

Pond Access Road Design

Access roads shall be a minimum of 15 feet in width. Perimeter roads may be 12 feet in width where not accessing a structure or being used for a circular loop road in lieu of turn around. Access roads may be constructed with an asphalt, gravel, or modular paver surface. However, access to all control structures, catch basins, and other drainage structures associated with the pond (e.g., inlet or bypass structures) must be via an asphalt surface designed to support heavy loads including Vactor trucks. Access to an emergency spillway is not required to be asphalt surface. A paved apron must be provided where access roads connect to paved public roadways. The inside road radius for access roads to ramps and all drainage structures shall not be less than 40 feet. Inside road radius for perimeter access roads shall not be less than 25 feet.

Manhole and catch basin lids must be in or at the edge of the access road and at least 3 feet from a property line.

When the length of a pond access road to a drainage structure or pond exceeds 75 feet, a vehicle turn-around must be provided, designed to accommodate vehicles having a maximum length of 31 feet and having an inside wheel path radius of 40 feet. The vehicle turn around requirement may be waived if the access road around the perimeter of the pond is entirely paved, and can be used in a continuous drive back to the entrance with no turnarounds.

Access roads to all drainage structures shall have a maximum slope of 12 percent.

Pond Access Gates or Bollards

Vehicle access shall be limited by a double gate if a pond is fenced or by bollards if the pond is not fenced. A minimum of one locking access road gate shall be provided that meets WSDOT State Standard Plan L30.10. Bollards shall consist of two fixed bollards, on the outside of the access road and two removable bollards equally spaced between the fixed bollards (or all four removable if placed in the traveled way).

Access gates and bollards must be set 20 feet back from property line where the road it is connecting from is posted 35 mph or greater (Arterials).

Fence gates located only on straight sections of road.

Access Ramps

Pond access ramps shall be provided to **all** cells unless all of following conditions apply: cell bottoms are accessible or reachable by trackhoes from the perimeter access road, a truck can be loaded without the truck accessing the bottom of the cell, and no point in the bottom of the cell is more than 40 feet from the center of the access road. Trackhoe maximum reach from an access road is 20 feet. Cell bottoms will be considered accessible where at least one of the side slopes of the cell is no steeper than 3H:1V. Truck loading will be considered achievable where the cell depth (measured as bottom of cell to access road surface) is 4 feet or fewer at a point along the pond perimeter where a truck can be parked and loaded.

Access Ramp Design

The access ramp shall have a minimum width of 15 feet and a maximum grade of 15 percent if paved. An alternate ramp surface can be constructed with a maximum slope of 12 percent by laying a geotextile fabric over the native soil, placing quarry spalls (2- to 4-inch) 6 inches thick, then providing a 2-inch-thick crushed rock surface.

When a ramp is required (see above), the ramp must extend to the pond bottom if the cell bottom is greater than 1,500 square feet (measured without the ramp). 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 cell bottom.

The internal berm of a wet pond or combined detention and wet pond may be considered the maintenance access to the next cell if the following conditions are met:

- The berm is no more than 4 feet above either cell bottom.

- The berm is designed to support the weight of a trackhoe (considering the berm is normally submerged and saturated).
- The berm side slopes are no steeper than 3H:1V.

Fencing

- Fences need only be constructed for those slopes steeper than 3H:1V, at the emergency overflow water surface elevation, or higher.
- A fence is also required where a pond impoundment wall is greater than 24 inches in height.
- Other regulations such as the IBC may require fencing of vertical walls. If more than 10 percent of slopes are steeper than 3H:1V, it is recommended that the entire pond be fenced.
- Detention ponds on school sites will need to comply with safety standards developed by the WSDOH and the superintendent for public instruction. 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 foothold for climbing. For school sites, and possibly for parks and playgrounds, the designer should consult the WSDOH’s Office of Environmental Programs.
- 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.
- Fencing shall be a minimum of 6 feet in height. Fences must be chain link fence Type 1. Fencing of tracts within the clear zone of roads with design speeds of 35 mph or higher shall use chain link fence Type 3. Access shall be provided as specified in the previous section. Any fencing shall be placed at the tract or easement boundary, and where applicable a minimum of 5 feet from the top slope catch point.
- Any pipe stem access to a basin shall be fenced with a WSDOT Type 4 chain link fence with a 14-foot gate. Access shall be provided as specified in the previous section.
- Access road gates shall be 16 feet in width consisting of two swinging sections 8 feet in width. Provide additional vehicular access gates as needed to facilitate maintenance access.
- Pedestrian access gates (if needed) shall be a minimum of 4 feet in width and meet WSDOT State Standard Plan L-3.

- Fence material shall be No. 9 gauge galvanized steel fabric with bonded vinyl coating. For steel fabric fences, the following aesthetic features may be considered:
    - Vinyl coating that is compatible with 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; or
    - Fence posts and rails that conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.
- For metal baluster fences, IBC standards apply.
- Wood fences may be used in subdivisions where the fence will be maintained by homeowners' associations or adjacent lot owners.
- Wood fences shall 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.

Signage

Detention ponds, infiltration basins, wet ponds, and combined ponds shall have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. Examples of suggested content to be included in a typical sign specification are outlined below and illustrated in Figure 7.30. Note that these are only example specification items, not suggested specifications. Designers should contact the City for further details on the latest guidelines and requirements related to sign specifications. For private BMPs, also include the owner's name and contact information. For homeowners' associations, the contact can be a residence address, P.O. Box, or email address. Contact the City for related open space and landscaping criteria.

Suggested Items to be Addressed in a Typical Sign Specification

- Size
- Sign material (e.g., 0.125-gauge aluminum)
- Face and lettering (e.g., non-reflective vinyl, or outdoor enamel).
- Colors
- Type face
- Post size, material, installation, etc. (if required)

- Sign/post installation, placement, and positioning
- Special notes/content (e.g., "This BMP is lined to protect groundwater" if a liner that restricts infiltration of stormwater exists)

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- to 20-foot-wide extension of the tract to an acceptable access location.

Setbacks

All setbacks shall be horizontal unless otherwise specified.

All **detention ponds** shall maintain minimum setback distances as follows unless modified with written approval by the Thurston County Public Health and Social Services Department for wells and septic:

- 1 foot positive vertical clearance from maximum water surface to structures within 25 feet.
- 5 feet from maximum water surface to septic tank or distribution box.
- 20 feet from maximum water surface to property lines and on-site structures.
- 10 feet from maximum water surface to building sewer.
- 30 feet from maximum water surface to septic drainfields and drainfield reserve areas for single family on-site sewage disposal systems.
- 100 feet from maximum water surface to septic drainfields and drainfield reserve areas for community on-site sewage disposal systems.
- 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A geotechnical assessment and Soils Report must be prepared addressing the potential impact of the BMP on the slope. The geotechnical assessment may recommend a reduced setback, but in no case shall the setback be less than the vertical height of the slope.
- 100 feet from well to stormwater control and runoff treatment BMP, maximum water surface.

In addition, all stormwater vaults and tanks shall be a setback from any structure or property line a distance equal to the depth of the ground disturbed in setting the structure. Vaults and tanks shall also be within tracts or easements with widths equivalent to those listed for conveyance systems in Chapter 6.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow groundwater 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 source. When continuous flows are intercepted and directed through flow control BMPs, adjustments to the BMP 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 sides with an appropriate seed mixture. Plant all remaining areas of the tract with grass or landscape and mulch with a 3-inch cover of hog fuel or shredded wood mulch (note: if implementing soil preservation and amendment in replanted areas per Section 7.4.1, 2 to 4 inches of hog fuel/woodchip mulch is required). Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. The mulch must be free of garbage and weeds and shall 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 BMPs may be placed in open space tracts.

Follow these guidelines if landscaping is proposed for BMPs:

- Do not plant trees or shrubs on berms meeting the criteria of dams regulated for safety.
- Do not plant trees and shrubs within a public stormwater tract.
- Do not plant trees or shrubs within 10 feet of inlet or outlet pipes or artificial drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, should be avoided within 50 feet of pipes or artificial structures.
- Restrict planting on berms that impound water permanently or temporarily during storms. This restriction does not apply to cut slopes that form pond banks, only to berms.
    - Do not plant trees or shrubs on portions of water-impounding berms taller than 4 feet high. Plant only grasses on berms taller than 4 feet.

  - Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

  - 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. 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. Examples of trees with these characteristics developed for the central Puget Sound are provided in Table 7.8.

- Plant all landscape material, including grass, in good topsoil. Native underlying soils may be made suitable for planting if amended with 4 inches of compost tilled into the subgrade. Refer to the Soil Amendment heading in Section 7.4.1 for additional information on soil quality standards.

- Soil in which trees or shrubs are planted may need additional enrichment or additional compost top-dressing. Consult a landscape professional, or arborist for site-specific recommendations.

- For a naturalistic effect as well as ease of maintenance, trees or shrubs should be planted in clumps to form “landscape islands” rather than evenly spaced.

- The landscaped islands should be a minimum of 6 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 6-foot 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.

- 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) 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 the branches will not extend over the pond.

- Drought tolerant species are recommended.

Table 7.8. Small Trees and Shrubs with Fibrous Roots.

Small Trees/High Shrubs	Low Shrubs
*Red twig dogwood (*Cornus stolonifera*)	*Snowberry (*Symphoricarpos albus*)
*Serviceberry (*Amelanchier alnifolia*)	*Salmonberry (*Rubus spectabilis*)
*Filbert (*Corylus cornuta*, others)	Rosa rugosa (avoid spreading varieties)
Highbush cranberry (*Vaccinium opulus*)	Rock rose (*Cistus* spp.)
Blueberry (*Vaccinium* spp.)	*Ceanothus* spp. (choose hardier varieties)
Fruit trees on dwarf rootstock	New Zealand flax (*Phormium tenax*)
Rhododendron (native and ornamental varieties)	Ornamental grasses (e.g., *Miscanthus*, *Pennisetum*)

*Native species

Guidelines for Naturalistic Planting

Stormwater BMPs 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:

- Landscaped islands (when mature) should cover a minimum of 30 percent or more of the tract, exclusive of the pond area.
- Underplant tree clumps with shade-tolerant shrubs and groundcover plants. The goal is to provide a dense understory that need not be weeded or mowed.
- Place landscaped islands at several elevations rather than "ring" the pond, and vary the size of clumps from small to large to create variety.
- 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 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 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:

- Landscape islands (when mature) should cover 10 percent or more of the site, exclusive of the pond area.

- Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.

- Landscape islands should be placed at several elevations rather than “ring” the pond.

- 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 7.9 gives an example of dwarf grass mix developed for central Puget Sound.

  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 in Table 7.9 were developed for central Puget Sound and rates are provided as pounds of pure live seed per acre.

Table 7.9. Low Growing Wet Area Seed Mix.		
Common Name	**Species**	**Pounds Pure Live Seed per Acre**
California brome	*Bromus carinatus*	10.5
Columbia brome	*Bromus vulgaris*	8.7
Tufted hairgrass	*Deschampsia cespitosa*	0.4
California oatgrass	*Danthonia californica*	5.0
Native red fescue	*Festuca rubra* var. *rubra*	2.4
Western manna grass	*Glyceria occidentalis*	3.5
Meadow barley	*Hordeum brachyantherum*	8.2
Total		**38.5**

Maintenance

Maintenance is of primary importance if detention ponds are to continue to function as originally designed. Hence, provisions to facilitate maintenance operations must be built into the project when it is installed. The City, a designated group such as a homeowners' association, the parcel owner, or some individual must accept the responsibility for maintaining the structures and the impoundment area. A specific Maintenance and Source Control Manual must be developed, outlining the schedule and scope of maintenance operations. See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

Handle any standing water and sediments removed during the maintenance operation in a manner consistent with the 2019 Ecology Manual, Volume IV, Appendix IV-B, and the approved Maintenance and Source Control Manual for the BMP.

7.5.2 Detention Tanks

Detention tanks are underground storage BMPs typically constructed with large diameter corrugated metal or HDPE pipe. Detention tanks are not to be perforated so as to provide infiltration of stormwater. Standard detention tank details are shown in Figures 7.31 and 7.32. Control structure details are covered in Section 7.5.4.

Methods of Analysis

Detention Volume and Outflow

The volume and outflow design for detention tanks must be in accordance with Chapter 2, Section 2.2.7, Core Requirement #7, and the hydrologic analysis and design methods in Chapter 6. Restrictor and orifice design are provided in Section 7.5.4.

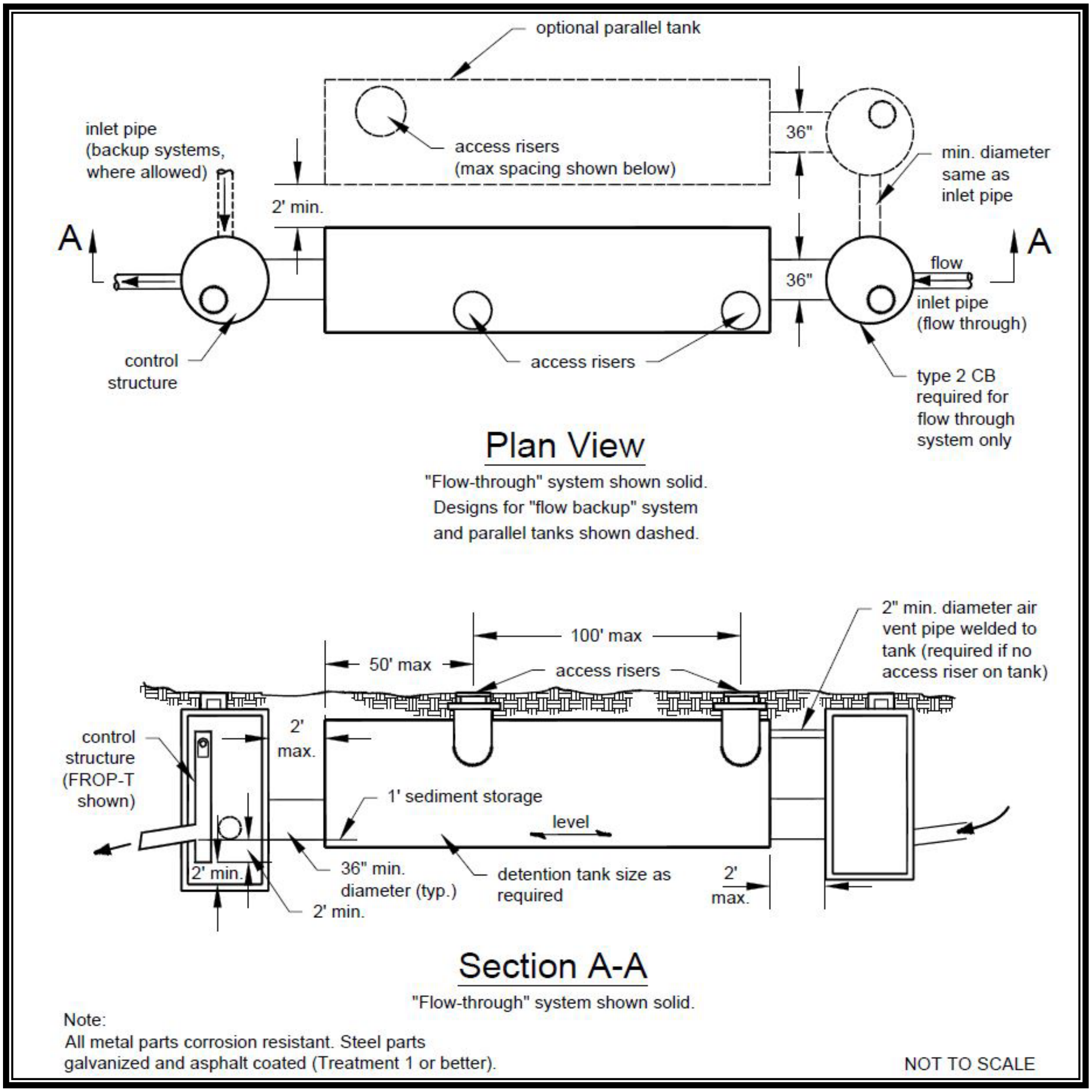
Detention Tank Design Criteria

General

Typical design guidelines are as follows:

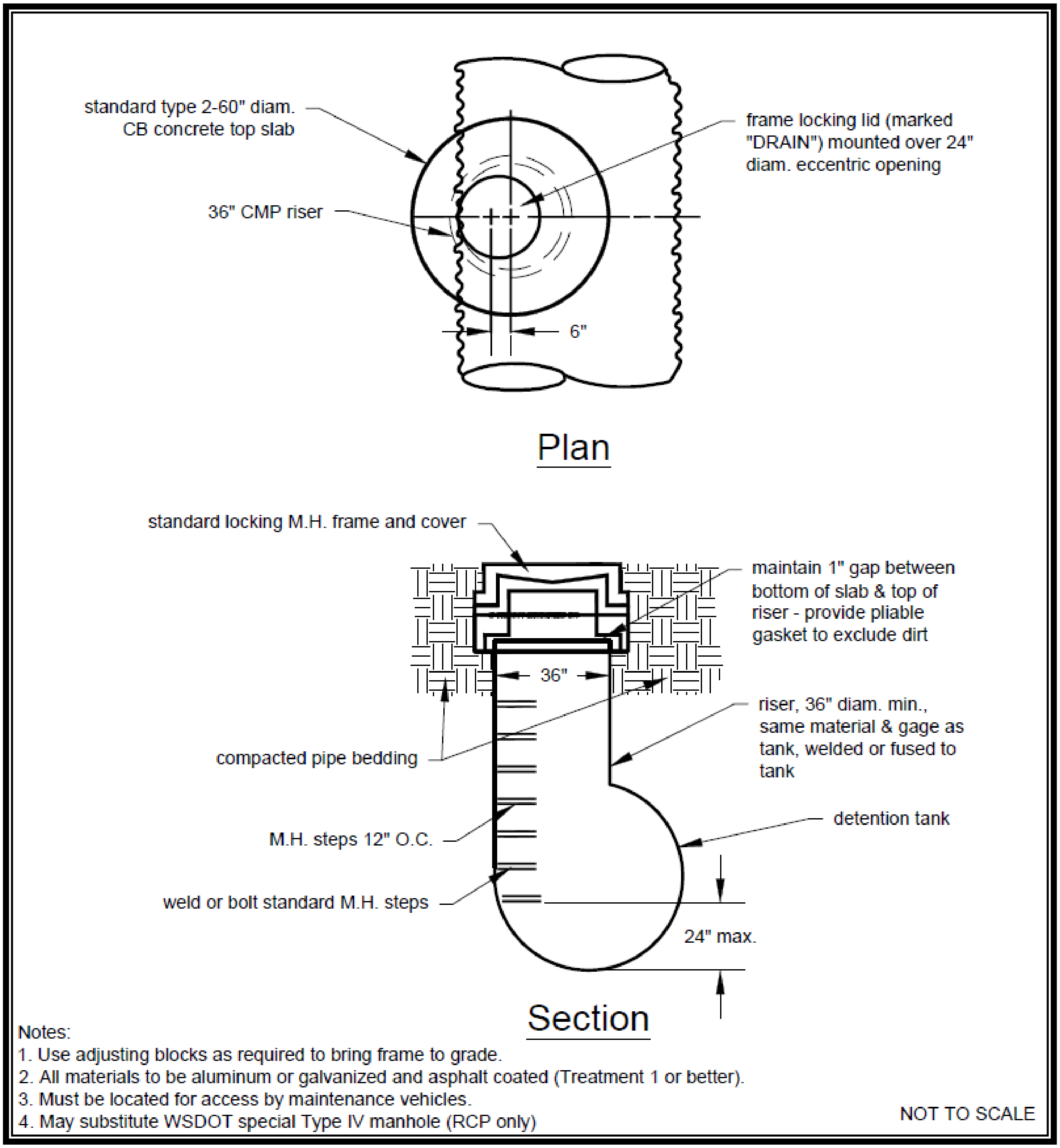
- Tanks may be designed as flow-through systems with manholes in line (see Figure 7.31) to promote sediment removal and facilitate maintenance. Tanks may be designed as back-up systems if preceded by runoff treatment BMPs, since little sediment should reach the inlet/control structure and low head losses can be expected because of the proximity of the inlet/control structure to the tank.
- The detention tank bottom must be located 1.0 foot below the inlet and outlet to provide dead storage for sediment.
- The minimum pipe diameter for a detention tank is 36 inches.
- 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.
- Tanks shall not be located under the travel way in public rights-of-way. For single-family plats and planned unit developments (PUDs), planned residential developments, or planning and development district detention tanks shall be located in separate tracts.
- If the tank has no access riser, provide an air vent (see Figure 7.31).
- Details of outflow control structures are given in Section 7.5.4.

  Note: Control and access manholes must have additional ladder rungs to allow ready access to all tank access pipes when the catch basin sump is filled with water.



Source: Ecology

Figure 7.31. Typical Detention Tank.



Source: Ecology

Figure 7.32. Detention Tank Access Detail.

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 BMPs and conveyance systems is prohibited. Use other metals, such as aluminum or stainless steel, or plastics. Pipe material, joints, and protective treatment for tanks shall be in accordance with Section 9.05 of the WSDOT Standard Specifications.

Structural Stability

Tanks must meet structural requirements for overburden support and traffic loading if appropriate. H-20 live loads must be accommodated for tanks lying under parking areas and access roads. Design metal tank end plates for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gauge material than the pipe and/or require reinforcing ribs. Place tanks on stable, well consolidated native material with suitable bedding. Do not place tanks in fill slopes, unless analyzed through a geotechnical assessment for stability and constructability.

Buoyancy

In moderately pervious soils where seasonal groundwater may induce flotation, balance buoyancy tendencies either by ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations that demonstrate stability must be documented.

Access

The following access requirements shall be used. See also Figure 7.32.

- The maximum depth from finished grade to tank invert shall be 12 feet.
- Position access openings a maximum of 50 feet from any location within the tank.
- All tank access openings shall have round, solid locking lids (usually one-half to five-eighths-inch diameter Allen-head cap screws).
- A 36-inch minimum diameter CMP riser-type manholes (see Figure 7.32) of the same gauge 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.
- Make all tank access openings readily accessible by maintenance vehicles.
- Tanks must comply with the Occupational Safety and Health Administration (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. Design and construct access roads as specified for detention ponds in Section 7.5.1.

Maintenance

Build provisions to facilitate maintenance operations into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

7.5.3 Detention Vaults

Detention vaults are box-shaped underground storage BMPs typically constructed with reinforced concrete. Detention vaults are not intended to infiltrate stormwater and should not be perforated. A standard detention vault detail is provided in Figure 7.33. Control structure details are covered in Section 7.5.4.

Methods of Analysis

Detention Volume and Outflow

The volume and outflow design for detention vaults must be in accordance with Chapter 2, Core Requirement #7 and the hydrologic analysis and design methods in Chapter 6. Restrictor and orifice design are given in Section 7.5.4.

Detention Vault Design Criteria

General

Typical design guidelines are as follows:

- Detention vaults may be designed as flow-through systems with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet should be maximized (as feasible).

- 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 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.

- The invert elevation of the outlet must be elevated above the bottom of the vault to provide an average 12 inches of sediment storage over the entire bottom. The outlet must also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.

- Details of outflow control structures are given in Section 7.5.4.

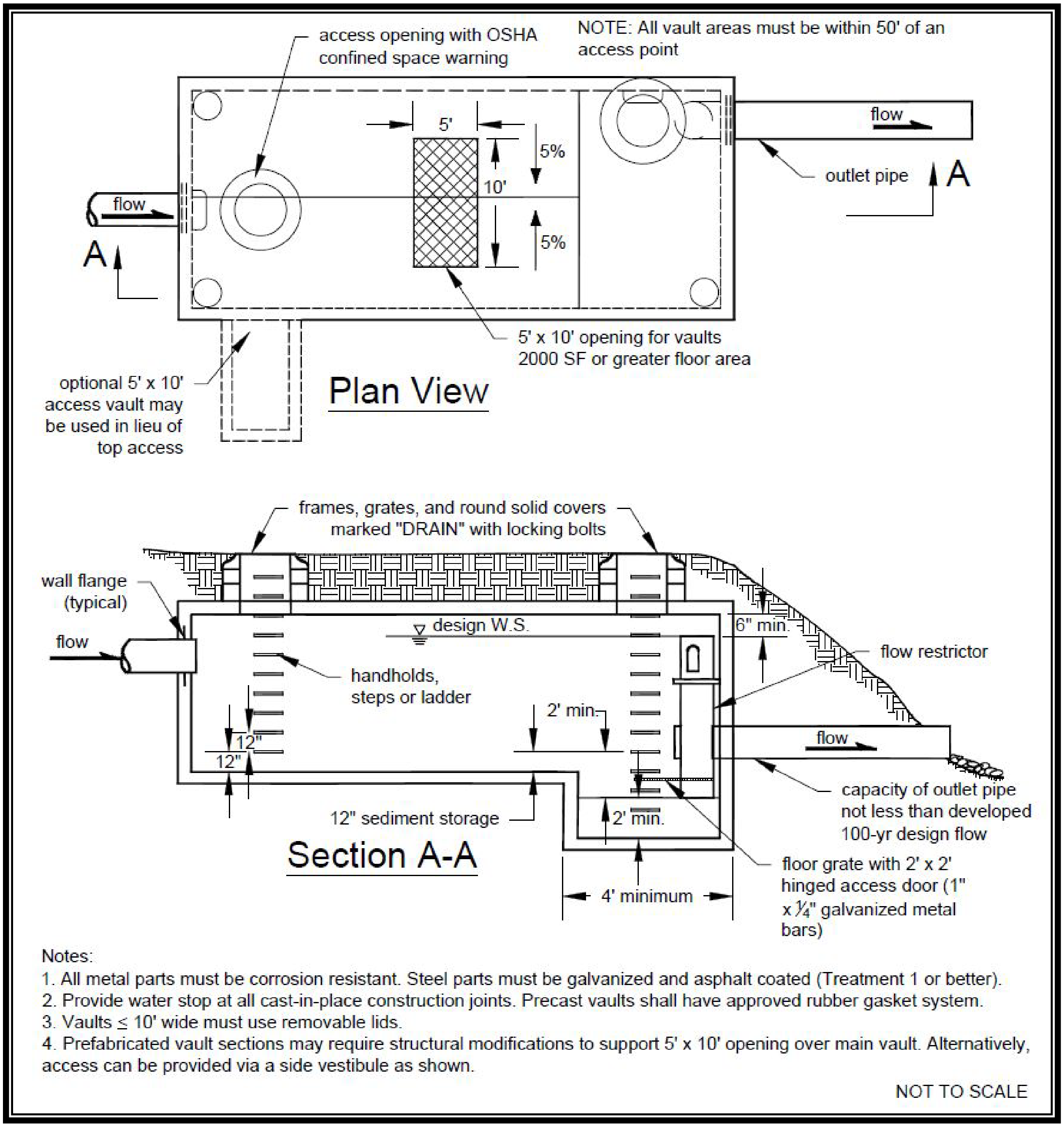
Materials

Minimum 3,000 psi structural reinforced concrete may be used for detention vaults. Provide all construction joints with water stops.

Structural Stability

All vaults must meet structural requirements for overburden support and H-20 traffic loading (See AASHTO 2002). 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. Place vaults on stable, well-consolidated native material with suitable bedding. Do not place vaults in fill slopes, unless analyzed through a geotechnical assessment for stability and constructability.

In addition to these requirements, vaults located within a fire apparatus access roadway (fire lane) location subject to the staging of fire-fighting operations shall be designed for actual fire apparatus loads and stabilizer (outrigger) loads.



Source: Ecology

Figure 7.33. Typical Detention Vault.

Access

Provide access over the inlet pipe and outlet structure. The following access requirements shall be met:

- Position access openings 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.

- For vaults with greater than 1,250 square feet of floor area, provide a 5 x 10-foot removable panel over the inlet pipe (instead of a standard frame, grate, and solid cover). Or, provide a separate access vault.

- For vaults under roadways, locate the removable panel outside the travel lanes. Or, provide multiple standard locking manhole covers. 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 below.

- All access openings, except those covered by removable panels, shall have round, solid locking lids, or 3-foot square, locking diamond plate covers.

- Vaults with widths 10 feet or less must have removable lids.

- The maximum depth from finished grade to the vault invert must be 20 feet.

- Internal structural walls of large vaults shall be provided with openings sufficient for maintenance access between cells. Size and situate the openings to allow access to the maintenance "V" in the vault floor.

- The minimum internal height must be 7 feet from the highest point of the vault floor (not sump), and the minimum width must 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.

- Vaults must comply with the OSHA confined space requirements, including 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.

- Provide ventilation pipes (minimum 12-inch diameter or equivalent) in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. Or, provide removable panels over the entire vault.

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 7.5.1.

Operations and Maintenance

Build provisions to facilitate maintenance operations into the project when it is installed. Maintenance must be a basic consideration in design and in determination of first cost. See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

7.5.4 Control Structure Design

Control structures are catch basins or manholes with a restrictor device for controlling outflow from a BMP to meet the desired performance. Riser type restrictor devices (“Ts” 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. Several publicly available and proprietary stormwater modeling programs are capable of sizing control structures. As such, the Methods of Analysis section (methods and equations for design of control structure restrictor devices) is included at the end of this section, rather than the beginning as with the flow control BMPs above.

Standard control structure details are provided in Figures 7.34 through 7.36.

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.

- 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. A smaller orifice diameter may be permitted if a screen is utilized to protect the orifice from fouling.

- Orifices may be constructed on a T-section or on a baffle, as shown in Figures 7.34 through 7.36 respectively.

- 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 7.39, presented later in this section).

- Consideration must be given to 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.

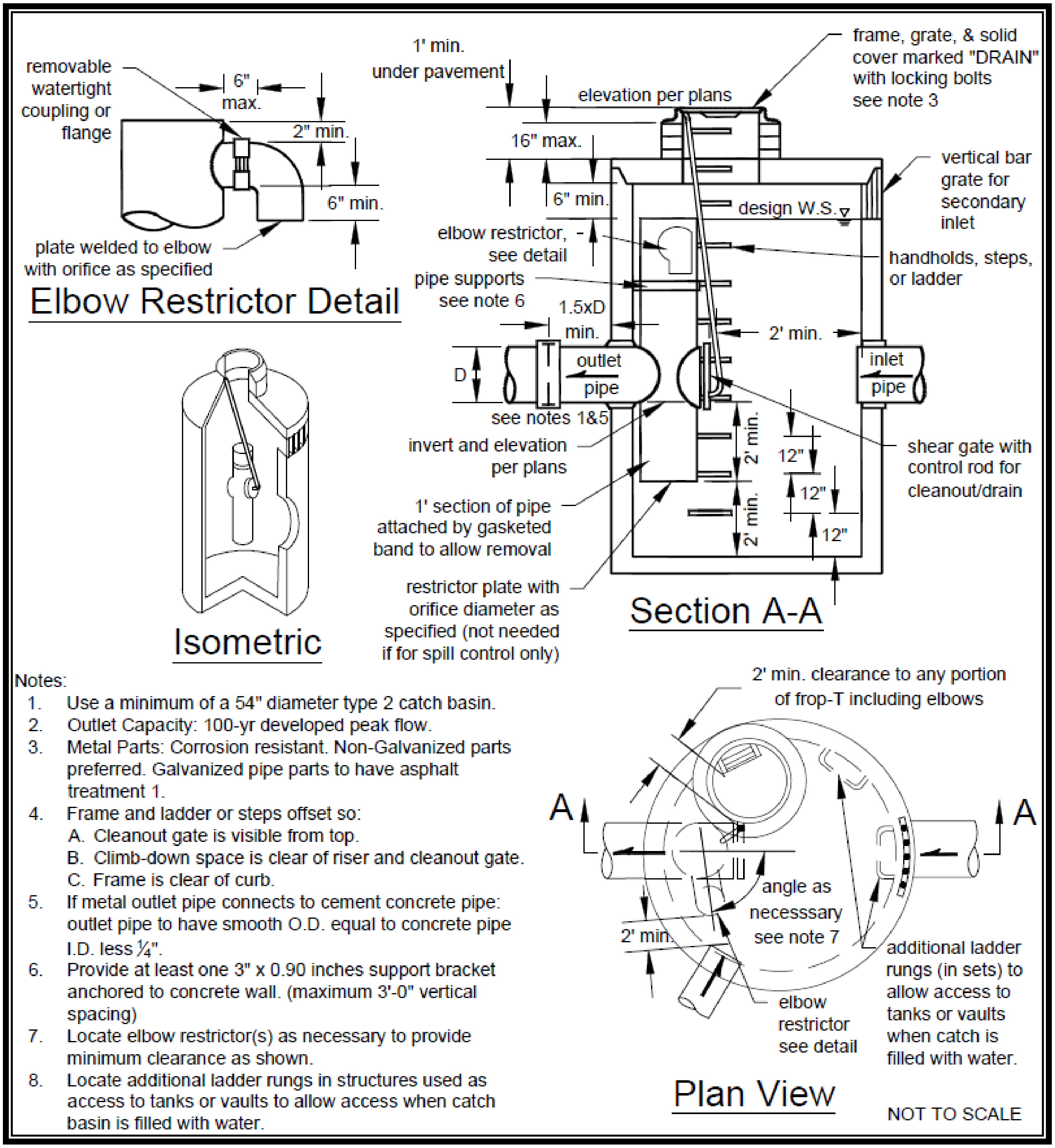


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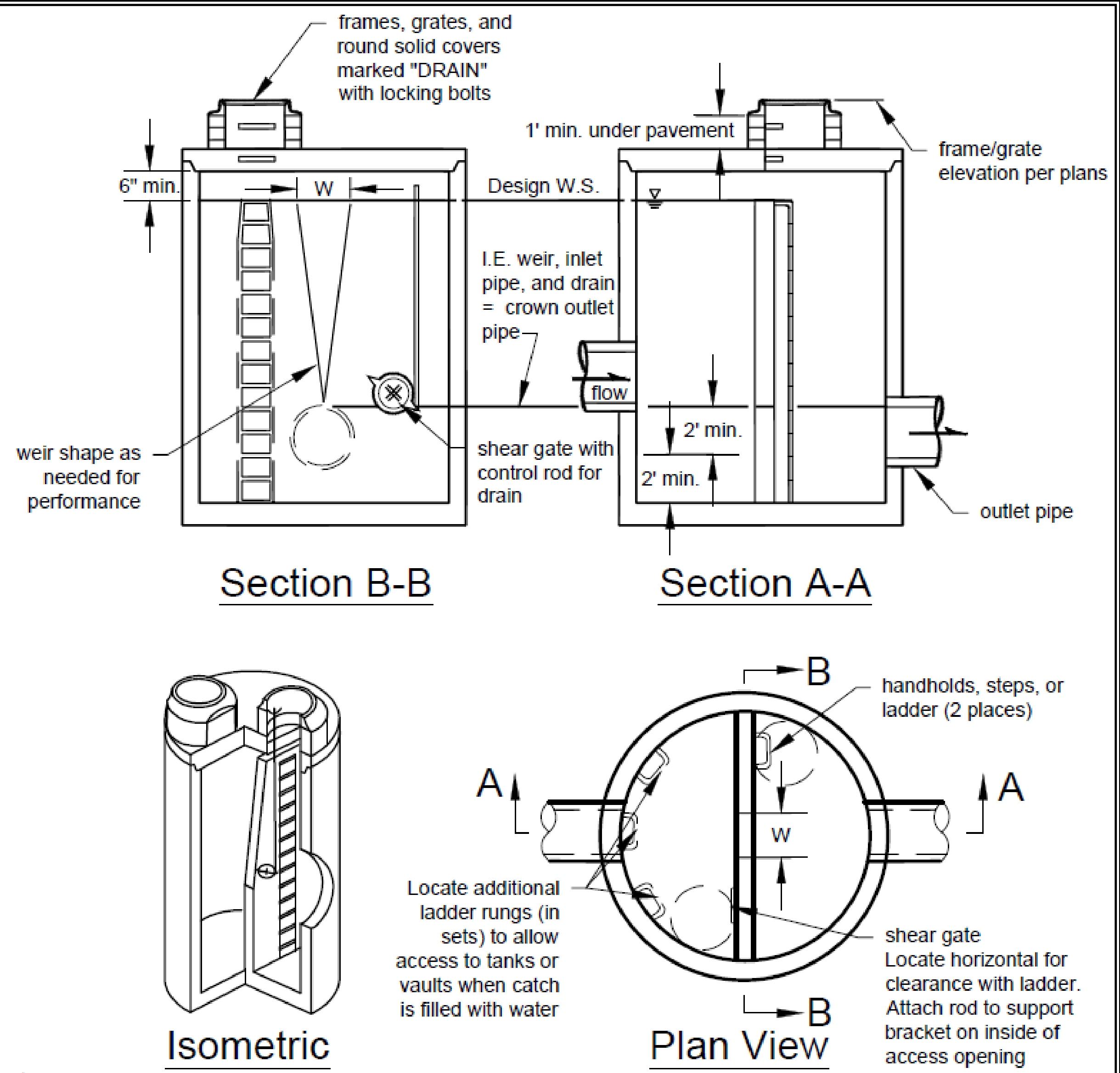
Figure 7.34. Flow Restrictor (Tee).



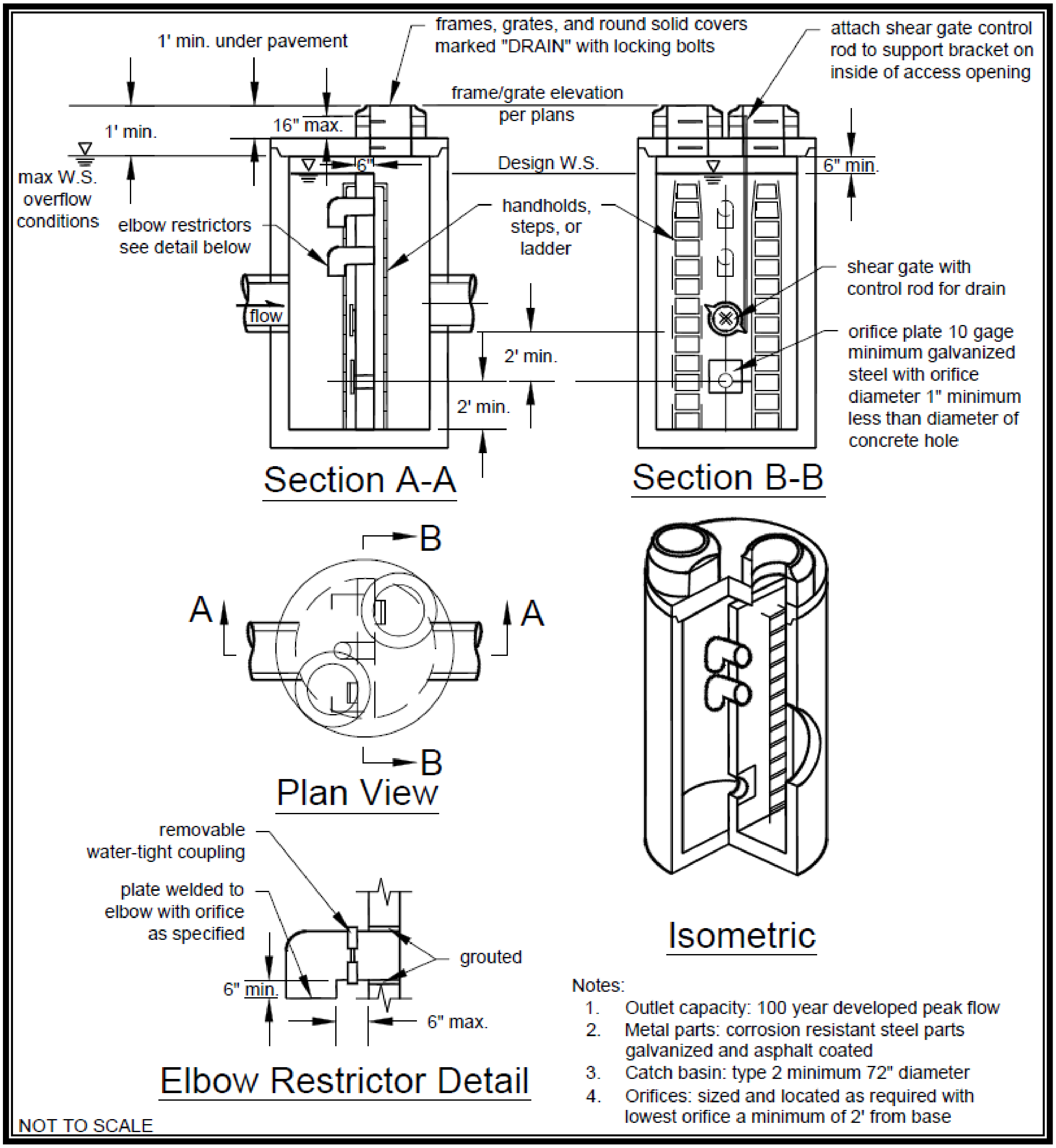
Notes:

1. Outlet Capacity: 100-year developed peak flow.
2. Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
3. Catch Basin: type 2 min. 72" diameter.
4. Baffle Wall: to be designed with concrete reinforcing as required.
5. Spill containment must be provided to temporarily detain oil or floatable pollutants in runoff due to accidental spill or illegal dumping.

NOT TO SCALE

Source: Ecology

Figure 7.35. Flow Restrictor (Weir).



Source: Ecology

Figure 7.36. Flow Restrictor (Baffle).

Riser and Weir Restrictor

- Properly designed weirs may be used as flow restrictors (see "Methods of Analysis" in this section). However, they must be designed to provide for primary overflow of the developed 100-year recurrence interval peak flow discharging to the detention BMP.

- 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 recurrence interval peak flow assuming all orifices are plugged. Figure 7.41 (presented later in this section) can be used to calculate the head in feet above a riser of given diameter and flow.

Access

The following access requirements shall apply:

- Provide an access road to the control structure for inspection and maintenance. Design and construct the access road as specified for detention ponds in Section 7.5.1.

- Manhole and catch basin lids for control structures must be locking, and rim elevations must match proposed finish grade.

- Manholes and catch basins must meet the OSHA 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

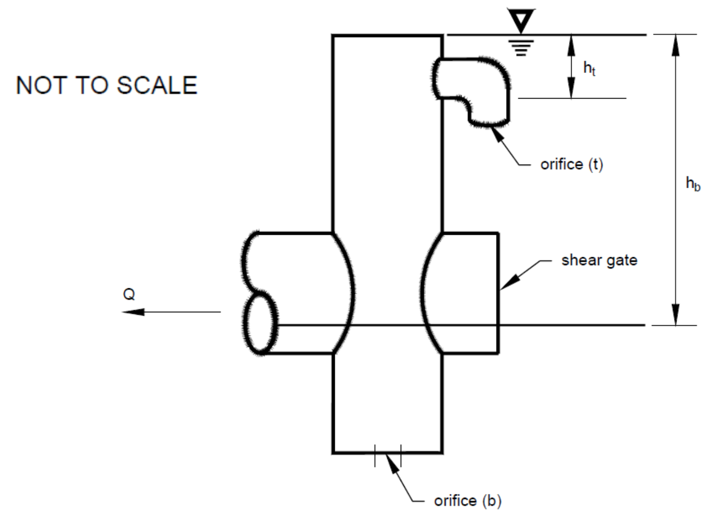
- Date of manual used for design

- Outflow performance criteria

- Release mechanism size, type, and invert elevation

- List of stage, discharge, and volume at 1-foot increments

- Elevation of overflow
- Recommended frequency of maintenance.



$$Q = CA_b\sqrt{2gh_b} + CA_t\sqrt{2gh_t}$$
$$= C\sqrt{2g}(A_b\sqrt{h_b} + A_t\sqrt{h_t})$$

h_b = distance from hydraulic grade line at the 2 – year flow of the outflow pipe to the overflow elevation

Source: Ecology

Figure 7.37. Simple Orifice.

Operations and Maintenance

Control structures and catch basins have a history of maintenance-related problems and it is imperative that a good maintenance program be established for their proper functioning. Typically, sediment builds up inside the structure, which blocks or restricts flow to the inlet. To prevent this problem, routinely clean out these structures at least twice per year. Conduct regular inspections of control structures to detect the need for non-routine cleanout, especially if construction or land-disturbing activities occur in the contributing drainage area.

Install a 15-foot-wide access road to the control structure for inspection and maintenance.

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for additional information on maintenance requirements.

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, sutro weirs, and overflow risers.

Orifices

Flow-through orifice plates in the standard T-section or turn-down elbow may be approximated by the general equation:

$$Q = C\,A\sqrt{2gh} \qquad \text{(Equation 4)}$$

where:

Q = flow (cubic feet per second)

C = coefficient of discharge (0.62 for plate orifice)

A = area of orifice (ft^2)

h = hydraulic head (ft)

g = gravity (32.2 ft/sec^2)

Figure 7.37 illustrates this simplified application of the orifice equation.

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \qquad \text{(Equation 5)}$$

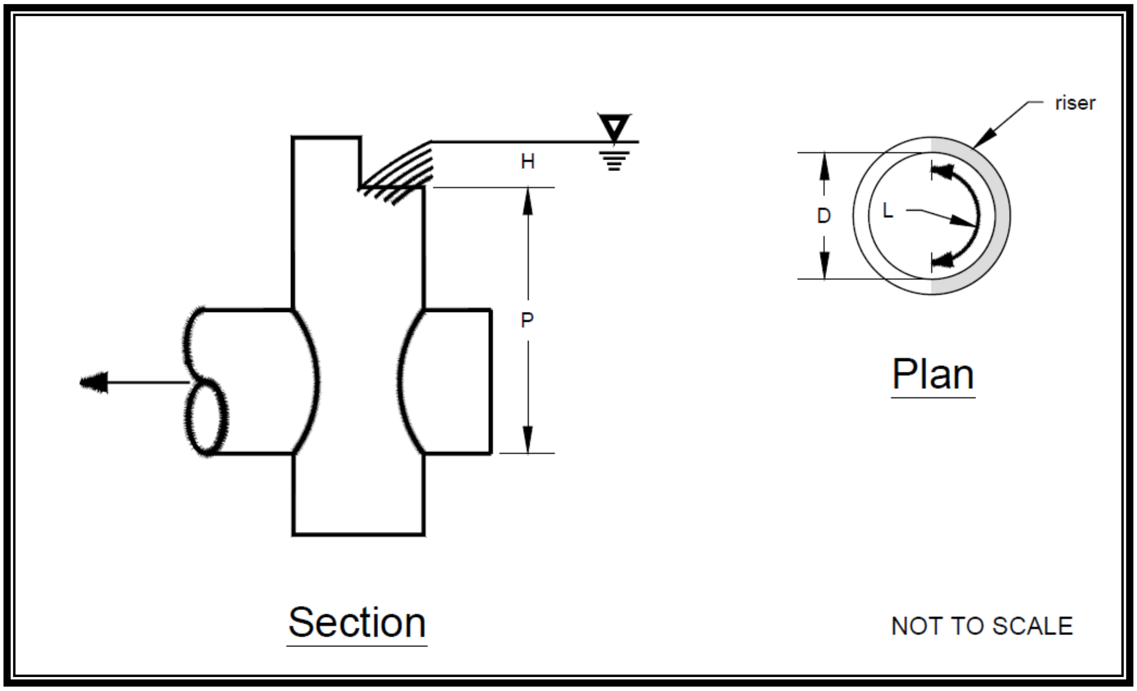
Where:

d = orifice diameter (inches)

Q = flow (cubic feet per second)

h = hydraulic head (ft)

Rectangular Sharp-Crested Weir. The rectangular sharp-crested weir design shown in Figure 7.38 may be analyzed using standard weir equations for the fully contracted condition.



Source: Ecology

Figure 7.38. Rectangular, Sharp-Crested Weir.

$$Q = C\,(L - 0.2H)H^{3/2} \quad \text{(Equation 6)}$$

Where:

Q = flow (cubic feet per second)

C = 3.27 + 0.40 H/P (ft)

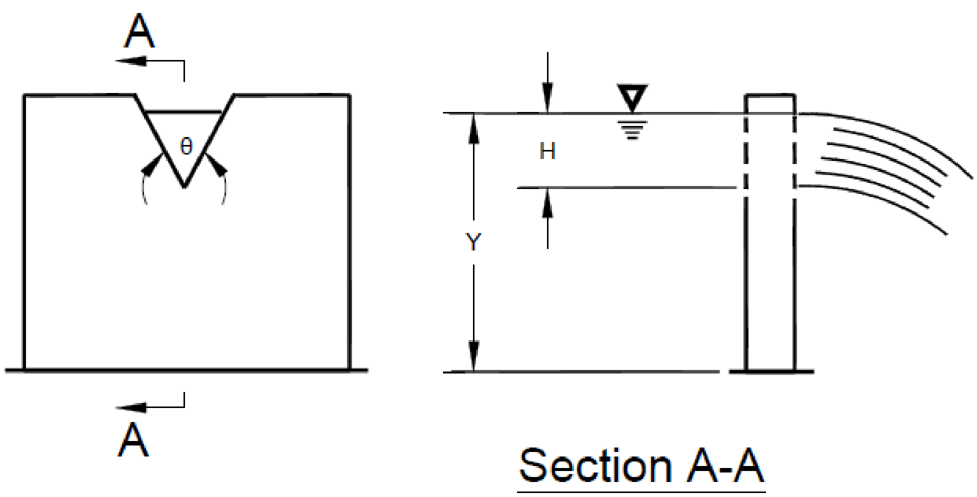
H, P are as shown above

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)

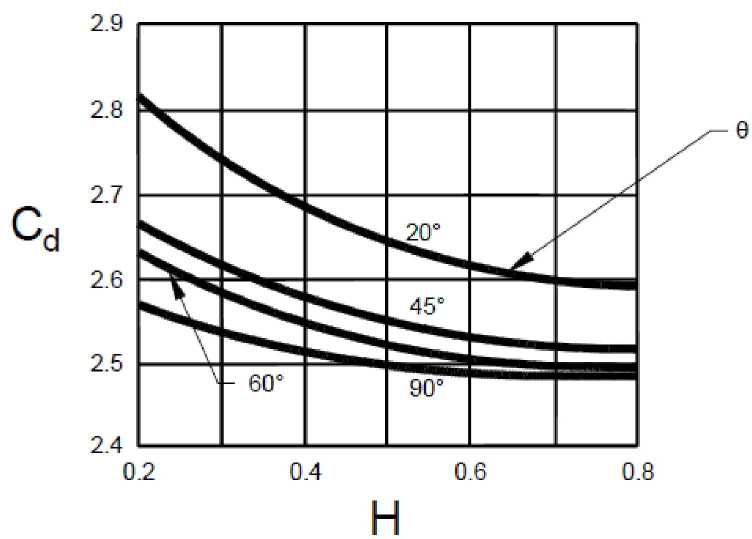
Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

V-Notch Sharp – Crested Weir. V-notch weirs as shown in Figure 7.39 may be analyzed using standard equations for the fully contracted condition.



$$Q = C_d(\tan\frac{\theta}{2})H^{\frac{5}{2}} \text{ in cfs}$$

Where values of C_d may be taken from the following chart:



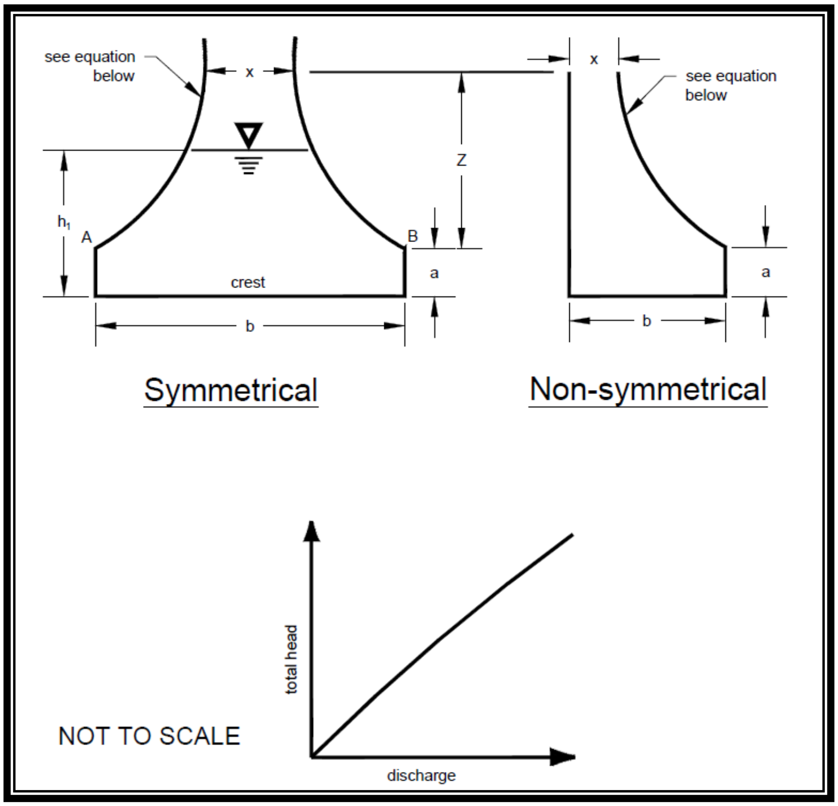
NOT TO SCALE

Source: Ecology

Figure 7.39. 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 7.40). The weir may be symmetrical or non-symmetrical.



Source: Ecology

Figure 7.40. Sutro Weir.

For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi} Tan^{-1} \sqrt{\frac{Z}{a}} \qquad \text{(Equation 7)}$$

where a, b, x, and Z are as shown in Figure 7.40. The head-discharge relationship is:

$$Q = C_d \, b \sqrt{2ga}(h_1 - \frac{a}{3}) \qquad \text{(Equation 8)}$$

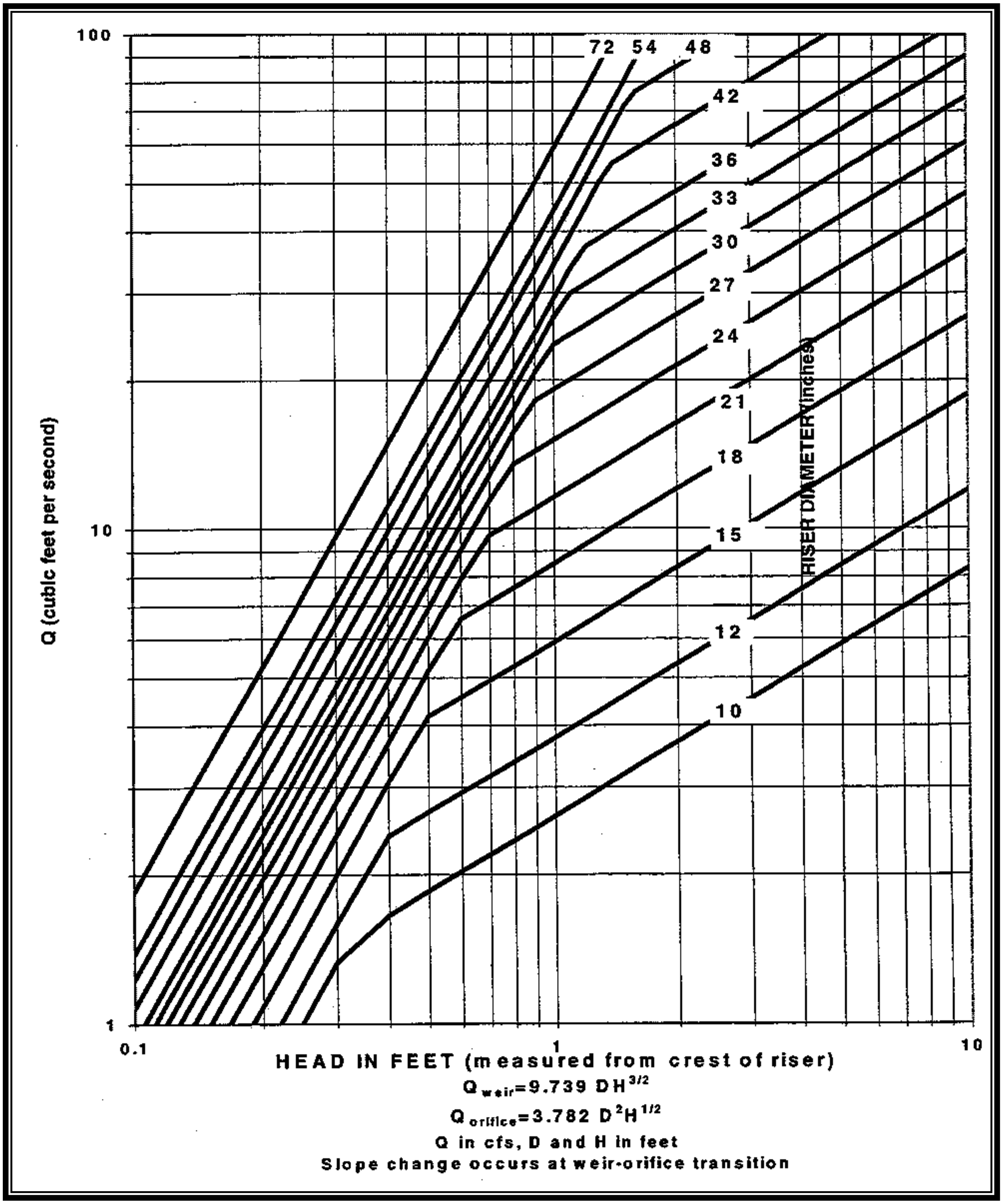
Values of C_d for both symmetrical and non-symmetrical sutro weirs are summarized in Table 7.10.

Table 7.10. Values of C_d for Sutro Weirs.

C_d Values, Symmetrical					
a (ft)	**b (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
C_d Values, Non-Symmetrical					
a (ft)	**b (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

Note: When $b > 1.50$ or $a > 0.30$, use $C_d = 0.6$.

Riser Overflow. The nomograph in Figure 7.41 can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year recurrence interval peak flow for developed conditions).



Source: Ecology

Figure 7.41. Riser Inflow Curves.

7.5.5 Other Detention Options

This section presents other design options for detaining flows to meet flow control BMP 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 recurrence interval runoff event provided all of the following are met:

- 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 recurrence interval event.
- The gradient of the parking lot area subject to ponding is 1 percent or greater.
- The detained water is completely contained on-site (exclusive of the designed overflow) and does not impact other properties or the public right-of-way.
- 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.
- Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year recurrence interval 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:

- The roof support structure is analyzed by a structural engineer to address the weight of ponded water.
- The roof area subject to ponding is sufficiently waterproofed to achieve a minimum service life of 30 years.
- The minimum pitch of the roof area subject to ponding is one-quarter inch per foot.
- An overflow system is included in the design to safely convey the 100-year recurrence interval peak flow from the roof.
- 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.

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Appendix 7A – Methods for Determining Design Infiltration Rates

7A.1 Determining the Design Infiltration Rate of the Native Soils

A crucial element to infiltration BMP design is the long term (design) infiltration rate of the native soils. In order to determine the design infiltration rate, the designer must first determine the measured (initial) saturated hydraulic conductivity (K_{sat}) of the native soils. Detailed below are three methods for determining initial K_{sat}. Ecology then offers a simplified approach and a detailed approach to use the initial K_{sat} to determine the design infiltration rate of the native soils. The design infiltration rate is used to size the infiltration BMP, including verifying compliance with the maximum drawdown time of 48 hours.

7A.1.1 Determining the Measured (Initial) K_{sat}

Initial K_{sat} rates can be determined using in-situ field measurements (PIT test options detailed below), or, if the site has soils unconsolidated by glacial advance, by a correlation to grain size distribution from soil samples (soil grain size analysis option detailed below). 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.

K_{sat} Determination Option 1:Large-Scale Pilot Infiltration Test (PIT)

The large scale Pilot Infiltration Test (PIT) is a large-scale in-situ infiltration measurement, and is the preferred method for estimating the initial K_{sat} of the soil profile beneath the proposed infiltration BMP. 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

- Testing should occur between December 1 and April 1.
- The horizontal and vertical locations of the PIT shall be surveyed by a licensed land surveyor and accurately shown on the design drawings.
- Excavate the test pit to the depth of the bottom of the proposed infiltration BMP. Note that for some proposed BMPs, such as bioretention cells, swales, and planter boxes (Section 7.4.4) and permeable pavements (Section 7.4.6), this will be below the proposed finished grade.
    - If the native soils will have to meet a minimum subgrade compaction requirement (for example, the road subgrade if using permeable pavements [Section 7.4.6]), compact the native soil to that requirement prior to testing.

  - 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 (long enough to measure the ponded water depth, minimum 5 feet 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 must not exceed the proposed maximum depth of water expected in the completed BMP. For infiltration BMPs 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 to 30 minutes, 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 1 hour after the flow rate into the pit has stabilized (constant flow rate; a goal of 5 percent variation or less variation in the total flow) while maintaining the same pond water level. The total of the pre-soak time plus 1 hour after the flow rate has stabilized should be no less than 6 hours.

- After the flow rate has stabilized for at least 1 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 the 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 initial K_{sat} rate in inches per hour in 30 minutes or 1-hour increments until 1 hour after the flow has stabilized.

Use statistical/trend analysis to obtain the hourly flow rate when the flow stabilizes. This would be the lowest hourly flow rate.

Example

The area of the bottom of the test pit is 8.5 feet by 11.5 feet (97.75 sq. 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 80.2 to 100 cubic feet per hour. Dividing this rate by the surface area gives an initial K_{sat} of 9.8 to 12.3 inches per hour.

K_{sat} Determination Option 2: Small-Scale Pilot Infiltration Test

A small-scale PIT can be substituted for K_{sat} Determination Option 1: Large Scale Pilot Infiltration Test (PIT) for any of the following instances:

- The drainage area to the infiltration site is less than 1 acre
- The testing is for bioretention BMPs or permeable pavement surfaces that either serve small drainage areas (refer to Sections 7.4.4, 7.4.5, and 7.4.6 for specific applications to bioretention, rain garden, and permeable pavements) and/or are widely dispersed throughout a project site
- The site has a high infiltration rate (> 4 in/hr), making a large-scale PIT difficult, and the site geotechnical investigation suggests uniform subsurface characteristics.

Infiltration Test:

Use the same procedures described above in K_{sat} Determination Option 1: Large Scale Pilot Infiltration Test (PIT) with the following changes:

- The horizontal surface area of the bottom of the test pit should be 12 to 32 square feet. It may be circular or rectangular. Document the size and geometry of the test pit.
- The rigid pipe with a splash plate used to convey water to the pit may be a 3-inch-diameter pipe for pits on the smaller end of the recommended surface area, or 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- to 12-inch water level above the bottom of the pit over a full hour. The depth must 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 to 12 inches) on the measuring rod. The specific depth should be the same as the maximum designed ponding depth (usually 6 to 12 inches).

- After 1 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 the 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 K_{sat} Determination Option 1: Large Scale Pilot Infiltration Test (PIT).

K_{sat} Determination Option 3 – Soil Grain Size Analysis

The following grain size analysis may be used to determine initial K_{sat} if the site has soils unconsolidated by glacial advance. This 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.

For each defined layer below an 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 K_{sat} in cm/sec using the following relationship (see Massman 2003). For large infiltration BMPs 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).

$$\log_{10}(K_{sat}) = -1.57 + 1.90D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08\mathrm{f}_{\mathrm{fines}}$$

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 U.S. #200 sieve (K_{sat} is in cm/sec and 1 cm/sec = 1,417 in/hr).

For bioretention BMPs (Section 7.4.4), analyze each defined layer below the top of the final bioretention BMP subgrade to a depth of at least 3 times the maximum ponding depth, but not less than 3 feet (1 meter).

For permeable pavements (Section 7.4.6), analyze for each defined layer below the top of the final sub-grade 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 BMP, soil layers at greater depths must be considered when assessing the site's hydraulic conductivity characteristics. Massman (2003) indicates that where the water table is deep, soil or rock strata up to 100 feet below an infiltration BMP 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 groundwater 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 K_{sat}.

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 PIT, as described above.

Once the K_{sat} for each layer has been identified, determine the effective average K_{sat} of the native soils. K_{sat} estimates from different layers can be combined using the harmonic mean:

$$K_{equiv} = \frac{d}{\sum \frac{d_i}{K_i}}$$

Where:

d is the total depth of the soil column

d_i is the thickness of layer "i" in the soil column

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 groundwater 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 need 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 basin. For sites where the lowest conductivity layer is within 5 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 BMPs or permeable pavement surfaces. 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 groundwater mounding.

7A.1.2 How to Calculate the Design Infiltration Rate of the Native Soils

Once the initial K_{sat} for a site has been determined using one of the methods above, use one of the methods below to determine the design infiltration rate.

The Simplified Approach to Calculating the Design Infiltration Rate of the Native Soils

The simplified approach was derived from high ground water and shallow pond sites in western Washington, and in general will produce conservative designs. This approach can be used when determining the trial geometry of the infiltration BMP and for small BMPs serving short plats or commercial developments less than 1 acre of contributing area. Designs of infiltration BMPs for larger projects should use the detailed approach (as described below) and may have to incorporate the results of a ground water mounding analysis as described in Section 7.2.2. Note: A ground water mounding analysis is advisable for BMPs 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.

Using the simplified approach, estimate the design (long-term) infiltration rate as follows:

- Use any of the three options above, or other method approved by the local jurisdiction (as appropriate for the site) to estimate the initial K_{sat}
- Assume that the K_{sat} is the measured (initial) infiltration rate for the native soils.
- Determine the design infiltration rate by adjusting the initial infiltration rate using the appropriate correction factors, as detailed below.

  Correction factors account for site variability, number of tests conducted, uncertainty of the test method, and the potential for long-term clogging due to siltation and bio-buildup. Table 7A-1 summarizes the typical range of correction factors to account for these issues. The specific correction factors used shall be determined based on the professional judgment of the licensed engineer in the state of Washington or other site professional, considering all issues that may affect the infiltration rate over the long term, subject to the approval of the local jurisdictional authority.

  - **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 proposed location of the infiltration BMP. 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 high end of the range.

    If the level of uncertainty is high, a partial correction factor near the 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 PITs (or several grain size test locations), the level of uncertainty may still be high.

    A partial correction factor near the 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 influent control to prevent siltation and bio-buildup (CF_m)** Even with a pre-settling basin or a basic treatment BMP for pretreatment, the 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 BMP is infiltrating at only 90 percent of its design capacity. Therefore, a correction factor, CF_m, of 0.9 is called for.

Table 7A-1. Correction Factors to be Used With In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates.

Issue	Partial Correction Factor
Site variability and number of locations tested	CF_v = 0.33 to 1.0
Test Method	
Large-scale PIT	CF_t = 0.75
Small-scale PIT	CF_t = 0.50
Other small-scale (e.g., Double ring, falling head)	CF_t = 0.40
Grain Size Method	CF_t = 0.40
Degree of influent control to prevent siltation and bio-buildup	CF_m = 0.9

$$\text{Total Correction Factor, } CF_T = CF_v \times CF_t \times CF_m$$

The design infiltration rate (K_{sat} design) is calculated by multiplying the initial K_{sat} by the total correction factor:

$$K_{sat}\text{ design} = K_{sat}\text{ initial} \times CF_T$$

The Detailed Approach to Calculating the Design Infiltration Rate of the Native Soils

This detailed approach was obtained from (Massman, 2003).

Using the detailed approach, estimate the design (long-term) infiltration rate as follows:

1. Use any of the three options above, or other method approved by the local jurisdiction (as appropriate for the site) to estimate the initial K_{sat}.

2. Calculate the steady state hydraulic gradient as follows:

$$gradient = i \approx \frac{D_{wt} + D_{pond}}{138.62(K^{0.1})} CF_{size}$$

Where:

D_{wt} is the depth from the base of the infiltration BMP to the water table in feet,

K is the initial saturated hydraulic conductivity in feet/day,

D_{pond} is one-quarter of the maximum depth of water in the BMP in feet, and

CF_{size} is the correction for pond size. The correction factor was developed for ponds with bot-tom 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.

$$CF_{size} = 0.73(A_{pond})^{-0.76}$$

Where:

A_{pond} is the area of pond bottom in acres.

This equation generally will result in a calculated steady state hydraulic gradient of less than 1.0 for moderate to shallow ground water depths (or to a low permeability layer) below the BMP, 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 the equation above.

If the calculated steady state hydraulic 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 BMP, 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 continuous runoff modeling software. As of the date of this update, no Ecology approved continuous runoff models have that capability. However, updates to those models may incorporate the capability. Until that time, calculate the steady-state hydraulic gradient using the equation above assuming a ponded depth of 1/4 of the maximum ponded depth – as measured from the pond floor to the overflow.

3. Calculate the preliminary design infiltration rate using Darcy's law as follows:

$$f = K\left(\frac{dh}{dz}\right) = Ki$$

Where:

f is the preliminary design infiltration rate of water through a unit cross-section of the infiltration BMP (L/t),

K is the initial saturated hydraulic conductivity (L/t),

dh/dz is the hydraulic gradient (L/L), and

i is the gradient (as calculated in Step 2 above).

4. Adjust the preliminary design infiltration rate to determine the design (long term) infiltration rate:

$$CF_{aspect} = 0.02A_r + 0.98$$

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:

final design (long-term) infiltration rate = K_{sat} x i x CF_{aspect}

Appendix 7B – On-Site Stormwater Management BMP Infeasibility Criteria

The following tables present infeasibility criteria that can be used to justify not using various on-site stormwater management best management practices (BMPs) for consideration in the List #1 or List #2 option of Core Requirement #5. If a project is limited by one or more of the infeasibility criteria specified below, but still wishes to use the given BMP, a functionally equivalent design may be proposed to the City for review and approval.

Lawn and Landscaped Areas	
BMP	**Infeasibility Criteria**
Postconstruction Soil Quality and Depth	• Siting and design criteria provided in Section 7.4.1 cannot be achieved.
Roofs	
BMP	**Infeasibility Criteria**
Full Dispersion	• Site setbacks and design criteria provided in Section 7.4.2 (under Full Dispersion) cannot be achieved. • A 65 to 10 ratio of forested or native vegetation area to impervious area cannot be achieved. • A minimum forested or native vegetation flow path length of 100 feet (25 feet for sheet flow from a non-native pervious surface) cannot be achieved.
Downspout Infiltration Systems	• Site setbacks and design criteria provided in Section 7.4.10 (Downspout Infiltration Systems) cannot be achieved. • The lot(s) or site does not have outwash or loam soils. • There is not at least 12 inches or more of permeable soil from the proposed bottom (final grade) of the infiltration system to the seasonal high groundwater table or other impermeable layer.
	• Site setbacks and design criteria provided in Section 7.4.10 (Downspout Dispersion) cannot be achieved. • For splashblocks, a vegetated flow path at least 50 feet in length from the downspout to the downstream property line, structure, stream, wetland, or other impervious surface is not feasible. • For trenches, a vegetated flow path of at least 25 feet in between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface is not feasible.

<table>
<tr><th colspan="2">Roofs</th></tr>
<tr><th>BMP</th><th>Infeasibility Criteria</th></tr>
<tr><td>Bioretention or Rain Gardens</td><td>
Note: criteria with setback distances are as measured from the bottom edge of the bioretention soil mix.
To demonstrate infeasibility of bioretention BMPs for Core Requirement #5, a small-scale pilot infiltration test (PIT) or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
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 downgradient flooding.
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 stormwater drainage system or private storm sewer system.
Where there is a lack of usable space for bioretention BMPs 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 infeasibility without further justification (though some require professional services to make the observation):

Within setbacks provided in Section 7.4.4, “Setbacks and Site Constraints.”
Where they are not compatible with surrounding drainage system as determined by the City (e.g., project drains to an existing stormwater collection system whose elevation or location precludes connection to a properly functioning bioretention BMP).
Where land for bioretention is within an erosion hazard, or landslide hazard area (as defined by Section 14.37.030 LMC).
Where the site cannot be reasonably designed to locate bioretention BMPs on slopes less than 8 percent.

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Roofs	
BMP	**Infeasibility Criteria**

Bioretention or Rain Gardens (continued)	• For properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act [MTCA]):
	  o Within 100 feet of an area known to have deep soil contamination.
	  o Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater.
	  o Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area.
	  o Any area where these BMPs 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 10 feet of an underground storage tank and connecting underground pipes when the capacity of the tank and pipe system is 1,100 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 percent 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 1,100 gallons.
	• Where 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. A small-scale or large-scale PIT in accordance with Appendix 7A shall be used to demonstrate infeasibility of bioretention BMPs. If the measured native soil infiltration rate is less than 0.30 in/hour, bioretention/rain garden BMPs are not required to be evaluated as an option in List #1 or List #2. In these slow draining soils, a bioretention BMP with an underdrain may be used to treat pollution-generating surfaces to help meet Core Requirement #6. If the underdrain is elevated within a base course of gravel, it will also provide some modest flow reduction benefit that will help achieve Core Requirement #7.
	• Where the minimum vertical separation of 3 feet to the seasonal high groundwater elevation or other impermeable layer would not be achieved below bioretention that would serve a drainage area that exceeds the following thresholds:
	  o 5,000 square feet of pollution-generating impervious surface (PGIS)
	  o 10,000 square feet of impervious area
	  o 0.75 acres of lawn and landscape.

Roofs	
BMP	**Infeasibility Criteria**
Bioretention or Rain Gardens (continued)	• Where the minimum vertical separation of 1 foot to the seasonal high groundwater or other impermeable layer would not be achieved below bioretention that would serve a drainage area less than the above thresholds. • For sites with onsite or adjacent septic systems, the discharge point must be at least 30 feet upgradient, and 10 feet downgradient, of the septic drainfield primary and reserve areas (WAC 246-272A-0210). This requirement may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (e.g., soil permeability, distance between systems) indicate that this is unnecessary.
Perforated Stub-Out Connections	• Site setbacks and design criteria provided in Section 7.4.10 (Perforated Stub-Out Connections) cannot be achieved. • There is not at least 1 foot of permeable soil from the proposed bottom (final grade) of the perforated stub-out connection trench to the highest estimated groundwater table or other impermeable layer. • The only location available for the perforated stub-out connection is under impervious or heavily compacted soils. • For sites with septic systems, the only location available for the perforated portion of the pipe is located upgradient of the septic drainfield primary and reserve areas. This requirement can be waived if site topography will clearly prohibit flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary. • The connecting pipe discharges to a stormwater BMP designed to meet Core Requirement #7.

Other Hard Surfaces	
BMP	**Infeasibility Criteria**
Full Dispersion	• See Full Dispersion in “Roofs” section of this table, above.

Permeable 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.
	Note that to demonstrate infeasibility of permeable pavement for Core Requirement #5, a small-scale PIT or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
	• Where professional geotechnical evaluation recommends infiltration not be used due to reasonable concerns about erosion, slope failure, or downgradient flooding.
	• Where infiltrating and ponded water below the 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 subgrade 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 cannot 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 subgrades.
	The following criteria can be cited as reasons for infeasibility without further justification (though some require professional services to make the observation):
	• Within setbacks provided in Section 7.4.6, “Setbacks and Site Constraints.”
	• For properties with known soil or groundwater contamination (typically federal Superfund sites or state cleanup sites under the Model Toxics Control Act [MTCA]):
	  o Within 100 feet of an area known to have deep soil contamination.
	  o Where groundwater modeling indicates infiltration will likely increase or change the direction of the migration of pollutants in the groundwater.
	  o Wherever surface soils have been found to be contaminated unless those soils are removed within 10 horizontal feet from the infiltration area.
	  o Any area where these BMPs 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.

<table>
<tr><th colspan="2">Other Hard Surfaces (continued)</th></tr>
<tr><th>BMP</th><th>Infeasibility Criteria</th></tr>
<tr><td>Permeable Pavement (continued)</td><td>
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 percent 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 subgrade slope exceeds 6 percent after reasonable efforts to grade. Where the permeable pavement wearing course slope exceeds 6 percent after reasonable efforts to design grade.
Where the subgrade soils below a pollution-generating permeable pavement (e.g., road or parking lot) do not meet the soil suitability criteria for providing treatment. See soil suitability criteria for treatment in Chapter 8, Section 8.6. Note: In these instances, the City may approve installation of a 6-inch sand filter layer meeting City specifications for treatment as a condition of construction, but this does not meet runoff treatment requirements for sites subject to Core Requirement #6.
Where underlying soils are unsuitable for supporting traffic loads when saturated. Soils meeting a California Bearing Ratio of 5 percent are considered suitable for residential access roads.
Where appropriate field testing indicates soils have a measured (a.k.a., initial) subgrade soil saturated hydraulic conductivity less than 0.3 inches per hour. Only small-scale PIT or large-scale PIT methods in accordance with Appendix 7A shall be used to evaluate infeasibility of permeable pavement areas. (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.)
Roads that receive more than very low traffic volumes, and areas having more than very low truck traffic. Roads with a projected average daily traffic volume of 400 vehicles or less are very low volume roads (AASHTO 2001; U.S. Department of Transportation 2013). Areas with very low truck traffic volumes are roads and other areas not subject to through truck traffic but may receive up to weekly use by utility trucks (e.g., garbage, recycling), daily school bus use, and multiple daily use by pick-up trucks, mail/parcel delivery trucks, and maintenance vehicles. Note: This infeasibility criterion does not extend to sidewalks and other non-traffic bearing surfaces associated with the collector or arterial.
</td></tr>
</table>

Other Hard Surfaces (continued)	
BMP	**Infeasibility Criteria**
Permeable Pavement (continued)	• 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 4 inches per hour or greater. • At sites defined as "high-use sites." For more information on high-use sites, refer to the Glossary in Chapter 1; and Chapter 8, Section 8.2.1, Step 3. • In areas with "industrial activity" as defined in the Glossary (located in Chapter 1). • 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. • Where the seasonal high groundwater or an underlying impermeable/low permeable layer would create saturated conditions within 1 foot of the bottom of the lowest gravel base course. • Where permeable pavement in active zones of a skate park, bike park, or sport court violates safety standards.
Bioretention or Rain Gardens	• See Bioretention in "Roofs" section of this table, above.
Sheet Flow Dispersion	• Site setbacks and design criteria provided in Section 7.4.2 (Sheet Flow Dispersion) cannot be achieved. • Positive drainage for sheet flow runoff cannot be achieved. • Area to be dispersed (e.g., driveway, patio) cannot be graded to have less than a 15 percent slope. • For flat to moderately sloped areas, at least a 10-foot-wide vegetation buffer for dispersion of the adjacent 20 feet of contributing surface cannot be achieved. For variably sloped areas, at least a 25-foot vegetated flow path between berms cannot be achieved.
Concentrated Flow Dispersion	• Site setbacks and design criteria provided in Section 7.4.2 (Concentrated Flow Dispersion) cannot be achieved. • A minimum 3-foot length of rock pad and 50-foot flow path OR a dispersion trench and 25-foot flow path for every 700 sq. ft. of drainage area followed with applicable setbacks cannot be achieved. • More than 700 sq. ft. drainage area drains to any dispersion device.

Appendix 7C – Underground Injection Control (UIC) Program Guidelines

7C.1 Introduction to UIC Wells

This appendix defines site suitability, treatment requirements, and design criteria for discharges of stormwater to Underground Injection Control (UIC) wells. The requirements of this appendix may be superseded by the Industrial Stormwater General Permit for those permitted sites. See Chapter 1, Section 1.7.13 and Section 7C.19 for the UIC well definition and a list of examples.

All UIC wells receiving stormwater, except those located on tribal lands and UIC wells at single-family homes (or duplexes) receiving only residential roof runoff or used to control basement flooding, must be registered with the state of Washington. The majority of UIC wells receiving stormwater runoff can be authorized by the UIC program without requiring individual permits, provided the non-endangerment standard is met by fulfilling the requirements detailed throughout this appendix. Sub-surface infiltration (UIC wells) may be used to provide flow control for stormwater runoff under any of the following conditions:

- Pollutant concentrations expected to reach groundwater will meet Washington State groundwater quality standards.
- Stormwater is treated according to the requirements of this section prior to reaching the aquifer.
- Flows are greater than the water quality design flow rate (see Chapter 8, Section 8.4.1).

The unsaturated geological material between the bottom of the UIC well and the top of an unconfined aquifer, herein called the vadose zone, usually provides some level of treatment by removing contaminants by filtration, adsorption, and/or degradation. In some cases, the treatment provided by the vadose zone is suitable for protecting groundwater quality from contamination by stormwater runoff. In other cases, additional treatment may be required to protect groundwater quality. Section 7C.16 and Section 7C.17 describe these assessments and their applications.

This appendix does not address the following:

- UIC wells that receive fluids other than stormwater (precluding accidental spills and illicit discharges, which are addressed in Chapter 9)
- The infiltration capacity of the vadose zone below the UIC well

- The ability of the UIC well to meet local operational requirements to infiltrate a certain volume of water in a given amount of time (see Chapter 2, Section 2.2.7 for more detail on flow control).

The UIC rule, WAC 173-218, requires a well assessment (see Section 7C.5) for UIC wells that were constructed prior to February 3, 2006. The rule refers to these UIC wells as “existing” UIC wells.

The UIC program considers an infiltration trench where the design includes perforated pipe to be classified as a UIC well. Registration requirements do not apply to infiltration trenches without perforated pipes. Infiltration trenches designed, constructed, operated, and maintained according to the specifications in Chapter 7, Section 7.4.7 and UIC registration with Ecology can be rule-authorized by the presumptive approach (see Section 7C.8).

UIC wells that extend below an upper confining layer and discharge into the underlying vadose zone are designated by Ecology as deep UIC wells. Deep UIC wells have additional restrictions and requirements that are described in Section 7C.15.

7C.2 Rule-Authorization or Permit

UIC wells must either be rule-authorized or covered by a state waste discharge permit to operate. If a UIC well is rule-authorized, an individual permit is not required. Rule-authorization can be rescinded if a UIC well no longer meets the non-endangerment standard, i.e., the discharge does not meet groundwater quality standards.

A UIC well may be rule-authorized when both of the following required actions are completed:

- Submit a registration form to Ecology (unless the UIC well is on tribal land, then registration is through U.S. Environmental Protection Agency (U.S. EPA), Region 10).

- Protect groundwater quality. The discharge from the UIC well must meet the non-endangerment standard.

7C.3 Registration

Register UIC wells using Ecology’s online registration process. For more information and details on the registration process, visit Ecology’s web page for the UIC program: <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program>

All UIC wells must be registered except: UIC wells at single-family homes (or duplexes) receiving only residential roof runoff used to collect stormwater runoff from roof surfaces on an individual home (or duplex) or for basement flooding control.

7C.3.1 New UIC Wells

Ecology considers UIC wells constructed on or after February 3, 2006, to be new wells. The registration provides Ecology with information to determine if the new UIC well meets the conditions to be rule-authorized:

- Applicants must submit the registration form 60 days prior to construction to allow a full review of the application by Ecology and other interested stakeholders.
- The UIC well must meet the non-endangerment standard, i.e., it complies with all the siting, design, and treatment requirements through either the presumptive approach (Section 7C.8) or the demonstrative approach (Section 7C.9). The demonstrative approach is required for deep UIC wells (Section 7C.15).

Applicants must identify the land use and proposed activities for the site and design the UIC well so that prohibited discharges are not conveyed to the UIC well. Section 7C.12 lists activities and conditions that will generate prohibited discharges.

7C.3.2 Existing UIC Wells

The UIC rule considers UIC wells constructed prior to February 3, 2006, as "existing." Existing wells used to manage stormwater runoff do not have to meet the new UIC well treatment requirements; however, registration is required if the UIC well is not already registered, and the owners must also complete a well assessment (Section 7C.5) to determine if an existing UIC well is a high threat to groundwater. See WAC 173-218-090(2) and Ecology's UIC web page for more details <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Underground-injection-control-program>

7C.4 Meeting the Non-Endangerment Standard

According to WAC 173-218-080(3), UIC wells must be constructed, operated, and maintained in a manner that protects water quality.

7C.4.1 New UIC Wells

Ecology determines if a new UIC well is either rule-authorized or needs a state waste discharge permit based on whether the UIC well meets the non-endangerment standard.

Designers may either use the presumptive or demonstrative approach described in Section 7C.4.8 and Section 7C.4.9 to meet the non-endangerment standard. UIC wells installed according to the specifications throughout this appendix are not considered a high threat to groundwater.

7C.4.2 Existing UIC Wells

To determine compliance with the UIC rule, owners of existing UIC wells must complete a well assessment to determine if an existing UIC well is a high threat to groundwater (Section 7C.5). The owner of a UIC well that is a high threat to groundwater must retrofit the well to protect groundwater quality.

7C.4.3 Requirements for Municipal UIC Wells

The UIC program rule is the regulatory authority for UIC wells in Washington. The UIC program rule applies to Class V wells that receive stormwater regardless of whether a UIC well is located in a municipality permitted under the Phase I or Phase II Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) Permit for Western Washington (Municipal Stormwater Permit).

The Municipal Stormwater Permit does not authorize stormwater discharges to/from UIC wells unless the overflow or discharge from a UIC well drains to a NPDES municipal separate storm sewer system (MS4). In those cases, the Municipal Stormwater Permit does authorize the discharge and the conditions of the MS4 Permit directly apply. For example, if a UIC well is designed to infiltrate the 10-year storm and route larger storms to the MS4, then the requirements of the Municipal Stormwater Permit apply to the well.

To prevent redundancy between the NPDES and the UIC programs, the UIC program rule allows the City to satisfy the UIC rule by the presumptive approach (Section 7C.8). The City also has the option of applying their Stormwater Management Programs (SWMPs) that comply with the Municipal Stormwater Permit to the areas served by their municipal UIC wells pursuant to WAC 173-218-090(1)(c)(C) in the manner described below. Note that the Municipal Stormwater Permit does not require the City to fulfill all the requirements of the UIC program.

The City may fulfill the source control and operation and maintenance requirements for new and existing municipal UIC wells under the following conditions:

- All areas served by City owned and operated UIC wells must be included in a SWMP that ensures appropriate siting, treatment, design, operation, and maintenance of new municipal UIC wells as well as source control activities (including targeted education and outreach) that are well-suited for the land uses in these areas. The City can create a combined SWMP that addresses UIC and NPDES permit requirements together, or two separate SWMPs for the areas served respectively by their municipal UIC wells.

- To comply with the UIC rule, the City must implement all of the following activities and include them in their SWMP:

    - Register all UIC wells, including existing and new wells.

- Design, construct, operate, and maintain new UIC wells according to the specifications throughout this appendix.

- Operate and maintain existing wells according to the specifications throughout this appendix.

If the City chooses not to develop and implement their SWMP in areas served by existing Class V UIC wells, the City must:

- Conduct a well assessment (Section 7C.5) for each UIC well, and

- Create a Stormwater Site Plan (SSP) for the area served by each existing municipal UIC well. The SSP will include source control best management practices (BMPs) applicable to the activities present in the area and describe operation and maintenance procedures to keep the UIC well functioning properly to provide necessary treatment to protect groundwater.

- All new municipal UIC wells must be sited, designed, constructed, managed, operated, and maintained according to the requirements throughout this appendix.

7C.5 Well Assessment

The assessment of an existing UIC well evaluates the potential risks to groundwater from the use of the well and includes information such as:

- The land use and activities around the well (which affect the quality of discharge),

- The local geology,

- Depth of the groundwater table in relation to the UIC well, and

- Whether the UIC well is located in a groundwater protection area.

Use this information to assess whether the well is a high threat to groundwater quality, by applying the information in Section 7C.16 and Section 7C.17. If an existing UIC well is located in a groundwater protection area and the assessment determines that sufficient BMPs are not provided under the current conditions, retrofitting is required to protect groundwater quality. Existing UIC wells in groundwater protection areas that receive prohibited discharges (Section 7C.12) must either be decommissioned or the activities must be moved and separated from the areas served by the existing UIC well.

A UIC well that was in use prior to the project is considered an existing well only if it remains in place. The well may be retrofitted or reconstructed in place without being considered a new well. Otherwise, if an existing well is moved, it is considered a new well, and the UIC requirements pertaining to new UIC wells apply.

7C.5.1 Evaluating High Threat to Groundwater

For existing UIC wells, Ecology considers any of the following a high threat to groundwater for which the UIC well must be retrofitted.

- Existing UIC wells receiving prohibited discharges (Section 7C.12); these wells also require a separate groundwater discharge permit.
- Existing UIC wells receiving a high pollutant load where the vadose zone between the bottom of the UIC well and the top of the groundwater has no treatment capacity or the vadose zone conditions are unknown; retrofits must provide treatment prior to the discharge to the well.
- Existing UIC well structures completed below the groundwater table; retrofits must provide separation and, if needed (Section 7C.16 and Section 7C.17), treatment. (If a UIC well has standing water when it has not received recent stormwater inflows, it is likely completed below the groundwater table. See WAC 173-218-090(1)(b) for separation requirements between the bottom of the UIC well and the top of the groundwater table.)
- Site-specific information indicates that a groundwater quality problem exists in the vicinity of the existing UIC well.

A UIC well retrofit means to reduce the pollutant load from a UIC well to meet the non-endangerment standard by applying source control activity and/or structural controls such as a treatment BMP or create separation between the base of the well and the top of the groundwater table, WAC 173-218-030.

7C.6 Preservation and Maintenance Projects

A preservation or maintenance project is defined as preserving/protecting infrastructure by rehabilitating or replacing existing structures to maintain operational and structural integrity, and for the safe and efficient operation of the UIC well. Maintenance projects do not increase the traffic capacity of a roadway or parking area.

A UIC well that was in use prior to preservation or maintenance project is considered an existing well only if it remains in place. The well may be retrofitted or reconstructed in place without being considered a new well. Otherwise, if an existing UIC well is moved, it is considered a new well and the UIC requirements pertaining to new UIC wells apply.

7C.7 Emergency Situations

In emergency situations, such as roadway flooding, a jurisdiction may install a UIC well that does not meet the requirements in this manual on a temporary basis. When weather permits, and within a year of the event, the jurisdiction must either fully decommission the well or ensure that the UIC well meets the requirements of the rule.

For example, excessive winter rainfall overwhelms the capacity of the existing drainage system along a road. The water drains onto the road and turns to ice. The jurisdiction installs a new UIC well to fix the immediate problem and, once the weather permits, implements the required runoff treatment BMPs.

7C.8 The Presumptive Approach

New UIC wells that are not classified as deep UIC wells (see Section 7C.15) that meet all of the requirements detailed throughout this appendix meet the presumptive approach to comply with the non-endangerment standard. Otherwise, the demonstrative approach (Section 7C.9) is required.

The presumptive approach requires the implementation of BMPs in Chapters 7, 8, and/or 9 of this manual. The manual addresses the following issues:

- The potential pollutant loading expected in the stormwater runoff for the planned land use(s) (see Section 7C.17)
- Source control of pollutants, especially those that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies (see Chapter 9)
- Known treatment methods (see Chapter 8)
- The potential treatment capacity of the vadose zone (see Section 7C.16)
- Siting (see Section 7C.18)
- Design (see Section 7C.10)
- Operation and Maintenance (O&M) (see Chapter 10).

Section 7C.10 details the siting and design criteria to meet the presumptive approach for drywells designed to meet runoff treatment. Chapter 7 details the design requirements for infiltration trenches and drywells.

The presumptive approach may not be used when none of the source control or runoff treatment BMPs in the manual are expected to eliminate or reduce concentrations of the pollutant(s) of concern (WAC 173-218-090(1)(i)(D)) to meet the non-endangerment standard.

7C.9 The Demonstrative Approach

New UIC wells must meet the demonstrative approach to meet the non-endangerment standard if:

- The proposed UIC well will penetrate a confining layer (Section 7C.15),
- The presumptive approach is not completely followed, or
- If for any reason a project proponent chooses not to directly apply all of the requirements of this manual.

The documentation for the demonstrative approach is a site-specific analysis that demonstrates that the proposed discharge will comply with groundwater quality standards.

To be eligible for rule-authorization using the demonstrative approach, the following topic areas must be addressed and documented with the UIC well registration:

- Site-specific analysis of pollutant loading
- Site-specific analysis of the treatment capacity of the vadose zone, if used for treatment
- BMP selection process used
- Pollutant removal expected from the selected BMPs
- Technical basis supporting the performance claims for the selected BMPs
- Assessment of how the selected BMPs will comply with state groundwater quality standards and satisfy state all known, available, and reasonable methods of prevention, control, and treatment (AKART) requirements.

7C.10 Siting and Design of New UIC Wells

The requirements in this section apply to UIC wells built on or after February 3, 2006.

7C.10.1 Minimum Siting Requirements for Rule-Authorization of New UIC Wells

The following Site Suitability Criteria (SSC) from Section 7C.18 apply to all UIC wells:

- SSC-1 Setback Criteria
- SSC-2 Groundwater Protection Areas
- SSC- 3 High Vehicle Traffic Areas

- SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer
- SSC-7 Seepage Analysis and Control
- SSC-8 Cold Climate and Impact of Roadway Deicers

UIC wells may be used provide flow control for stormwater runoff where pollutant concentrations that reach groundwater will meet the Washington State groundwater quality standards in the following situations:

- For flows greater than the water quality design flow rate (see Chapter 8, Section 8.4.1); or
- Where stormwater is treated prior to discharge into the UIC well according to the requirements in Section 7C.16.

Furthermore, if SSC-4 Soil Infiltration Rate/Drawdown Time and SSC-6 Soil Physical and Chemical are met, the site is considered to have a high treatment capacity, and the existing site soils may be used to provide runoff treatment for flows through the UIC well (see Section 7C.13).

Restrictions on Siting UIC Wells

- Prohibited areas: A UIC well may not be sited in prohibited areas; see Section 7C.12 for the list of areas where stormwater discharges to UIC wells are prohibited.
- Soil contamination: UIC wells may not be sited where there are soil contaminants that could be transported to groundwater or groundwater contamination that could be mobilized, unless the site is remediated prior to construction.

Siting UIC Wells Near Drinking Water Wells

- Because a UIC well could be a potential source of contamination, it must be sited ≥ 100 feet from a drinking water well, outside of the sanitary control area of a public drinking water system, and ≥ 200 feet from a spring used for drinking water supplies. The design must consider the distance between the UIC well and a drinking water well based on the direction and rate of groundwater flow, and the vulnerability of the drinking water supply well to potential contamination, which is influenced by the following factors:
  - Depth/distance from the bottom of the UIC well to the drinking water well screened interval(s), and
  - Presence or lack of confining layer(s) between the bottom of the UIC well and the aquifer interval(s) used as the water supply, and

 - Characteristics of the geologic material between the bottom of the UIC well and the aquifer.

- Characterizing a drinking water well's susceptibility to contamination is a required element of wellhead protection plans, as required under WAC 246-290-135(3). Susceptibility assessments for the City's source wells are listed in Lacey's Wellhead Protection Plan and were determined following the Washington State Wellhead Protection Program Guidance Document (WSDOH 2010). For the City and other water systems, susceptibility assessments can be found online in the WSDOH Source Water Protection (SWAP) mapping tool: <https://doh.wa.gov/community-and-environment/drinking-water/source-water/gis-mapping-tool>.

Groundwater Protection Areas

At a minimum, basic treatment to remove solids prior to discharge to the UIC well is required for UIC wells located:

- In a wellhead protection area where the drinking water well is categorized with a high-susceptibility rating by the Washington State Department of Health (WSDOH), and/or

- Where a confining layer is not present between the base of the UIC well and the top of the aquifer used as a drinking water source, except when a UIC well receives insignificant and or low pollutant load from stormwater (see Table 7C.3 in Section 7C.17).

Refer to Chapter 16.54 Lacey Municipal Code (LMC) and Chapter 14.36 LMC for requirements and additional information that apply to development within groundwater protection areas, such as sole source aquifers, groundwater management areas, wellhead protection areas, and areas designated as Critical Aquifer Recharge Areas. To locate the wellhead protection areas (WHPA) of City wells, see the WHPA maps provided in Appendix 8B (as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>). For other water systems within or adjacent to the City, use the WSDOH SWAP mapping tool <www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/SourceWater/GISMappingTool> to determine whether WHPAs may be influenced by the project.

7C.10.2 Design and Construction Requirements for Rule-Authorization of New UIC Wells

In order to be rule-authorized under the presumptive approach, UIC wells must be designed and installed in accordance with this manual. The following subsections include additional requirements for design and construction of UIC wells.

Prevention of Clogging During Construction

In order to prevent clogging, UIC wells must be protected from sediment in runoff generated during construction. See Chapter 5 for construction BMPs to prevent other pollutants from entering the UIC well during the construction phase of a project.

Stormwater Infiltration Rate/Drawdown Time

In most cases, UIC wells are designed to completely drain ponded runoff within 48 to 72 hours after flow to the UIC well has stopped. If the UIC well is designed to meet a runoff treatment requirement, the long-term infiltration rate (see Appendix 7A) must be sufficient to accommodate the water quality design flow rate (see Chapter 8, Section 8.4.1 Design Volume and Flow).

Vertical Separation for Rule-Authorization Using the Presumptive Approach

WAC 173-218-090 requires that new Class V UIC wells used for stormwater management must not directly discharge into groundwater. A 5-foot separation between the bottom of the well and the top of the groundwater is required, unless a demonstrative approach confirms that a separation of 3 feet will meet the non-endangerment standard.

The required depth to groundwater/vertical separation between the base of the UIC well and the top of the groundwater table for rule-authorization using the presumptive approach depends on the treatment capacity of the unsaturated zone. Section 7C.16 and Section 7C.17 provide a method for determining the treatment requirements based on the treatment capacity of the vadose zone and the pollutant loading classification of the stormwater runoff directed to the UIC wells.

The minimum vertical separation is 5 feet between the base of a UIC well and the highest elevation between the seasonal high groundwater table, bedrock, hardpan, or other low-permeability layer.

Vertical Separation When 5-Foot Minimum Separation Cannot be Met

If vertical separation required for the presumptive approach cannot be met:

- Rule-authorization can be obtained using the demonstrative approach (see Section 7C.9), or
- A reduction in separation to as little as 3 feet can be considered under the presumptive approach provided:
    - The treatment requirements are otherwise met (see Section 7C.16 and Section 7C.17), and
    - The groundwater mounding analysis, the volumetric water holding capacity of the zone receiving the water, and the design of the overflow and/or bypass structures are judged by the design professional as adequate to prevent overtopping and meet the SSC specified in this section.

Inspection and Maintenance Access

The maximum depth of an infiltration BMP is 20 feet below the surrounding finished (developed) ground elevation, in order to provide for long-term inspection and maintenance access to the BMP.

7C.11 Operation and Maintenance of UIC Wells

The UIC rule requires that wells are operated and maintained to protect groundwater quality. Maintenance of UIC wells prevents clogging and contamination from materials that collect in the well over time. The following required preventive maintenance activities will help maintain UIC function:

- Treatment for solids removal or a catch basin with a down turned elbow upstream of discharge to the UIC well to promote the long-term infiltration capacity and reduce the need for maintaining the UIC wells, as well as reduce the long-term accumulation of contaminants in the vadose zone
- Annual inspections and regular maintenance to improve the long-term performance of the UIC wells
- Periodic removal of debris and sediment from the drywell to reduce or eliminate the buildup of materials that could inhibit infiltration
- Checking for structural damage and repair as needed

See Chapter 10 for recommended maintenance criteria.

7C.12 Prohibitions

UIC wells may not receive stormwater from the activities and conditions listed below:

- Any use that is specifically prohibited from discharge to UICs as indicated in Chapter 14.36 LMC
- Onsite vehicle fueling services
- Vehicle maintenance, repair, and service
- Commercial or fleet vehicle washing
- Airport/airplane deicing
- Storage of treated lumber
- Generation, storage, transfer, treatment, or disposal of hazardous wastes

- Handling of radioactive materials
- Solid waste handling facilities, including compost and biosolid facilities, except for those that recycle only glass, paper, plastic, or cardboard
- Concrete recycling facilities that generate, store, or handle crushed concrete
- Asphalt recycling facilities that generate, store, or handle crushed asphalt
- Industrial or commercial areas that have outdoor processing, handling, or storage of raw solid materials or finished products unless the facility has specific management plans for proper storage and spill prevention, control, and containment appropriate to the types of materials handled at the facility (see Chapter 9 for information on stormwater pollution prevention plans [SWPPPs] and source control)
- Contaminated sites when the stormwater would increase the mobility of the contaminants at the site. For example, a drywell could not be used upgradient of or over the contaminant plume at a leaking underground storage tank site. The stormwater could increase the movement of the contaminants.
- Process water from the production area of an animal feeding operation.
- Land use, activity, or infiltration determined to be a significant contributor of pollutants to waters of the State or a site release of hazardous substances from historical or current activities resulting in contamination of soil, groundwater, surface water, if the groundwater is in direct communication with surface water, or sediment, which is prohibited under the Model Toxics Control Act (Chapter 173-340 WAC) and Sediment Management Standards (Chapter 173-204 WAC).

Stormwater from areas subject to the activities listed above must be handled onsite with a closed-loop system or discharged to the sanitary sewer. Permits must be obtained either from the City of Lacey Wastewater Utility at (360) 491 5600, and/or the LOTT Clean Water Alliance at (360) 664 2333.

However, careful design of these project sites may allow UIC wells to handle some of the stormwater runoff that will be generated. Stormwater from any portions of the site or facility that do not come in contact with these activities (or the areas of the facility associated with these activities) are allowed to be discharged to a UIC well following the presumptive approach.

See WAC 173-218-040(5)(b) for a list of other prohibited UIC wells.

7C.13 Source Control and Runoff Treatment Requirements

The UIC rule bases source control and runoff treatment requirements on the types and quantities of pollutants expected from the proposed land use contributing storm runoff to the UIC well.

The rule presumes a UIC well meets the non-endangerment standard and is rule-authorized if the designer follows the guidelines in this section based on the following:

- Application of source control BMPs to control loading of pollutants that are difficult to remove from stormwater by filtration, settlement, or other treatment technologies, and

- Appropriate treatment of runoff to remove pollutants, which may be achieved by either or both:

  - Application of treatment to remove pollutants before discharging stormwater into the UIC well

  - Availability of appropriate vadose zone treatment capacity to remove the solid phase of pollutants in stormwater by filtration and adsorption (see Section 7C.16 and Section 7C.17).

7C.13.1 Source Control

Source control is necessary to protect groundwater from pathogens, pesticides, nitrates, road salts and other anti-icing and deicing chemicals, fuel additives, and many other pollutants in urban runoff, as well as accidental spills.

The operational and structural source control BMPs that are also required to meet the non-endangerment standard for various land uses are described in Chapter 9. Targeted education and outreach may also be a necessary source control measure.

Source control BMPs can significantly reduce clogging and pollutants, especially solids, and must be used at all project sites. Protect UIC wells during the construction phase to prevent sediment from entering the UIC well. Implement the BMPs in Chapter 5. Where there are no existing runoff treatment BMPs to practically address a pollutant issue and where filtration by the vadose zone cannot provide adequate removal of pollutants, owners are required to use source control BMPs to meet the non-endangerment standard. Otherwise, the discharge to the UIC well is prohibited (WAC 173-218-090(1)(c)(i)(D)). See Section 7C.12.

Wherever practicable, reduce the exposure of stormwater to these contaminants by one or more of the following:

- Careful attention to the product label application rates

- Targeted product use to avoid contamination of stormwater runoff
- Careful management of the storage and use of products
- Separation of areas where products are used from contributing areas that discharges to a UIC well
- Spill response planning.

Contact the City of Lacey Public Works Department, Water Resources Division to determine whether specific source control requirements apply to your project in addition to those methods described in this manual for the proposed land use.

7C.13.2 Runoff Treatment

The BMPs chosen for the site must remove or reduce the target pollutants to levels that will comply with State groundwater quality standards when the discharge reaches the groundwater table or first comes into contact with an aquifer (see Chapter 173-200 WAC). Each BMP is designed to reduce or eliminate certain pollutants. See other sections in Chapter 8 for specific runoff treatment BMP design criteria.

Removing solids from stormwater runoff before it is discharged to a UIC well helps preserve infiltration rates over the long term. UIC wells used for flow control are required to have solids removed prior to discharge. Treatment for solids removal (basic treatment) must be designed, constructed, operated, and maintained in accordance with this manual or an equivalent manual.

Designers may alternatively use the demonstrative approach (Section 7C.9) should they wish to install a BMP that is not included in this manual.

Some pollutants may require additional treatment beyond that provided by the approved BMPs described in other sections in Chapter 8. The text below discusses these pollutants.

Bacteria

Fecal coliform bacteria and other pathogens in stormwater come from many sources. Examples are manure fertilizers, pet waste, and animal feeding operations.

Runoff treatment BMPs are unreliable in removing fecal coliform bacteria and other pathogens from runoff. Because of this, UIC wells shall not receive direct stormwater discharges from areas or sites that generate high loadings of fecal coliform bacteria, such as animal feeding operations.

Alternatively, runoff from sites generating high loadings of bacteria and pathogens may be:

- Discharged to the sanitary sewer, permits must be obtained either from the City of Lacey Wastewater Utility at (360) 491 5600 and/or the LOTT Clean Water Alliance at (360) 664 2333; or
- Used for crop irrigation, as long as other applicable requirements are met; or
- Directed to a bioretention, biofiltration, or bioinfiltration BMP after the nutrient budget is addressed; or
- Diverted through stormwater treatment wetlands (see Chapter 8, Section 8.9) prior to discharge to a UIC well.

Municipal UIC well owners must implement appropriate source control, targeted education and outreach, and illicit discharge detection and elimination (IDDE) programs in areas served by their UIC wells to prevent pet wastes from contaminating stormwater and to control other sources of pathogens.

UIC wells in the vicinity of land application areas (i.e., along adjacent roadways) must be protected by appropriate buffers and berms to prevent manure-contaminated runoff from entering the UIC well. Best practices for setbacks, nutrient budgets, and timing of application must also be implemented.

Private UIC well owners must ensure that their UIC wells are appropriately protected from sources of bacterial contamination.

Soluble Pollutants, Pesticides, Fertilizer, and Nutrients

Many soluble pollutants that are commonly found in stormwater (including pesticides, fertilizers, road salts, and other chemical pollutants) are very difficult to remove from stormwater. Source controls applicable to the land use and activities at the site are required to reduce the contamination of stormwater from these chemicals.

Areas such as parks, playgrounds, golf courses, public ball fields, cemeteries, and urban landscape typically use pesticides and fertilizers for landscape management. Examples of other activities that generate high nutrient loads include commercial composting, commercial animal handling areas, nurseries, and land application areas.

Pesticides include a host of chemicals with varying chemical fate and transport characteristics. Some pesticides travel to groundwater more readily because they are more water soluble and less likely to “stick” or sorb to soil particles. These pesticides need treatment by a biological treatment method, such as a biofiltration swale or constructed wetland. UIC wells that receive stormwater with pesticides that use one of these biological treatment methods are rule-authorized when they are registered, providing this technical guidance is followed.

If UIC owners wish to use a different treatment method for pesticides, they may apply to Ecology for rule-authorization using the demonstrative approach outlined in Section 7C.9. Nonbiological treatment systems are ineffective at removing these pollutants from runoff. Instead, runoff from these types of landscaped areas should be directed to bioretention, biofiltration, or bioinfiltration BMPs or constructed wetlands prior to discharge to UIC wells. Stormwater with fertilizer or nutrients may be used to irrigate crops and/or landscaped areas in accordance with other applicable requirements.

For all UICs, the City encourages use of the following practices:

- Limited use of applied chemicals
- Site design to minimize runoff from the landscaped surface
- Development of a pesticide management plan.

For UICs within wellhead protection areas, the city will require the UIC owner to develop and implement an Integrated Pest Management (IPM) plan that addresses plant selection, irrigation, and maintenance practices for minimizing the need for pesticides and fertilizers, and for preventing the leaching of soluble fertilizers and other contaminants into groundwater. IPM Plans are expected to include the elements described in Thurston County's Integrated Pest Management Plan Guidance.

UIC wells in the vicinity of land application areas (i.e., along adjacent roadways) must be protected by appropriate buffers and berms to prevent manure-contaminated runoff from entering the UIC well. Best practices for setbacks, nutrient budgets, and timing of application must also be implemented.

Industrial Activities with Requirements to Monitor for Nitrate, Nitrite, Ammonia, or Phosphorus

The U.S. EPA lists industrial activities that have monitoring requirements for nitrate, nitrite, ammonia, or phosphorus. Runoff from sites where nitrate, nitrite, ammonia, or phosphorus come into contact with stormwater must be directed to one of the following:

- Bioretention, biofiltration, or bioinfiltration systems
- Constructed wetlands prior to discharge
- Sanitary sewer, permits must be obtained either from the City of Lacey Wastewater Utility at (360) 491 5600, or the LOTT Clean Water Alliance at (360) 664 2333
- Municipal drainage system that discharges to surface water, if allowed by the City of Lacey Public Works Department, Water Resources Division and following treatment for removal of solids.

Facilities may complete a no exposure certification as part of Ecology's UIC well registration process for exemption from these requirements. In order to qualify, no outdoor processing, handling, or storage of raw solid materials or finished products may take place at the facility. Industrial facilities that qualify for no-exposure certification may use the tables in Section 7C.17 to determine treatment requirements.

Commercial Site Roofs with Ventilation for Commercial Indoor Pollutants

Roof runoff from commercial businesses with ventilation systems specifically designed to remove commercial indoor pollutants must be evaluated on a case-by-case basis to identify the pollutants of concern and the appropriate treatment requirements.

In general, this runoff may be classified as a "medium" pollutant loading source (see Table 7C.3 in Section 7C.17), and the requirements of this section may be applied to discharges from these areas to UIC wells.

Commercial Site Outdoor Handling or Storage

Treatment for solids removal (basic treatment) is require at commercial sites with outdoor handling or storage of raw solid materials. Examples include gravel, sands, logs, salts, and compost.

Industrial Site Roofs

Roof runoff from industrial facilities must be evaluated on a case-by-case basis and should be treated according to the other BMP requirements for the facility.

Industrial Site Outdoor Handling or Storage

Owners at industrial sites where outdoor processing, handling, or storage of raw solid materials or finished products, including outdoor loading areas for these materials or products, takes place must provide solids removal (basic treatment). These are sites defined by the U.S. EPA (40 CFR 122.26 (b)(14)).

7C.14 Spills and Illicit Discharges

Appropriate spill control, prevention and response measures for various land uses are described in Chapter 9. The spill control requirements in Chapter 9 apply to all stormwater discharges to UIC wells. Any spills that pose a threat to groundwater quality should be reported to Ecology. Petroleum spills that enter a UIC well must be reported to Ecology.

7C.15 Deep UIC Wells

7C.15.1 Applicability

UIC wells with the following characteristics are considered deep UIC wells by the City and are subject to the deep UIC well requirements in this section:

- UIC wells that are constructed by drilling or excavation to extend through an upper confining layer and discharge into the underlying vadose zone. Examples include, but are not limited to:
  - Drywells where drilling extends through a surficial till layer into the vadose zone below.
  - Infiltration trenches, sometimes referred to as “pit drains” or “finger drains,” in the base of a pond, swale, bioretention facility, vault, or trench that penetrate an upper confining layer (i.e., penetrate till or other low permeability layer) into the vadose zone below.
- The upper confining layer being punctured is at least 5 feet thick and extends at least 10 feet below the ground surface.

7C.15.2 Limitations on the Use of Deep UIC Wells

The following requirements must be met in order to use a deep UIC well:

- Surface infiltration must be infeasible. Refer to Chapter 4, Section 4.2.
- Core Requirements #1 through 9 must be met.
- The demonstrative approach is required.
- Deep UIC wells are not allowed on sites with historic contamination. A Phase I Environmental Site Assessment (ESA) must be completed and a Phase II ESA is required if the Phase I ESA indicates potential contamination.
- Deep UIC wells are prohibited in some areas of the City as defined in the City’s Development Guidelines and Public Works Standards (DG&PWS), Chapter 6.025. This includes prohibition of introducing stormwater directly into the same aquifer as a drinking water supply well within the well’s 1-year time of travel (TOT) zone. The City may establish other restrictions on a case-by-case basis, including, but not limited to, prohibiting the use of deep UIC wells to manage stormwater from pollutant generating surfaces within the 5-year TOT zone of drinking water supply wells that have a higher susceptibility to contamination.

- Deep UIC wells may be no deeper than required to adequately discharge into the unsaturated infiltration receptor.

- Construction of a drilled deep UIC well can only be completed by a well driller licensed in Washington State. Excavations that penetrate an upper confining layer into the vadose zone below must be designed and overseen by a licensed hydrogeologist.

- The maximum depth of an infiltration BMP is 20 feet below the surrounding finished (developed) ground elevation. The 20 feet includes the full depth of the deep UIC well. The City of Lacey Public Works Department, Water Resources Division may impose limits on the total depth of deep UIC wells based on specific hydrogeologic conditions and other considerations.

7C.15.3 Site Suitability

The following site characteristics must be met for deep UIC well installation:

- A minimum 15-foot separation between the base of the deep UIC well and the surface of the seasonal high groundwater table.

- Stabilization of the site prior to the deep UIC wells going on line to prevent sediment entering the deep UIC wells.

7C.15.4 Required Notifications

The following notifications are required for deep UIC well installations:

- Drinking water supply purveyors must be notified when the proposed deep UIC well will be located in a WHPA, CARA, or a sole source aquifer.

    - During the design phase, the project proponent using a deep UIC well shall consult the WSDOH SWAP map to determine whether their site is within any WHPA.

    - The proponent shall provide notification to those water system owners that the proponent is working with the City for approval of a project that will utilize a deep UIC well within their WHPA.

    - The notification will include contact information at the City for more information about the project.

    - The proponent will provide copies of those notifications to the City.

    - The City can waive this requirement if the only affected water system is the City’s Drinking Water System.

7C.15.5 Submittal Requirements

Submittals to Ecology

Submittal of a State Waste Discharge Permit application to Ecology is required for any proposed deep UIC well in the City.

Submittals to the City

The following documentation is required to be submitted to the City **prior to start of groundwater monitoring** related to deep UIC wells:

- **Phase I ESA report (and Phase II ESA report if required)**
- **Hydrogeologic Characterization Plan** that includes the following:
  - **Groundwater Quality and Groundwater Level Monitoring Plan** which specifies the number of borings, drill methods, soil and groundwater sampling depths and parameters, and testing density throughout the site.
    - Groundwater quality monitoring is required, upstream and downstream of the development, including pre- and post-development monitoring and reporting.
    - At least 1 year of groundwater quality monitoring is required prior to construction.
      - A minimum of 3 monitoring wells are needed per proposed deep UIC well field; two downgradient and one upgradient. More wells may be required for large or complex sites.
      - Groundwater quality shall be monitored in the receptor aquifer (i.e., below the confining layer) and in the perched water-bearing zone above the confining layer (if a perched water-bearing zone is present on the site).
      - All wells must be sampled quarterly throughout the first year of groundwater quality monitoring and the time interval between sample events must be evenly-spaced.
      - Groundwater quality analysis must evaluate the following at a minimum:
        - Primary and secondary contaminants listed in WAC 173-200-040
        - Volatile organic compounds (VOC) (EPA Method 524.2)
        - Synthetic organic compounds (SOC) (EPA Method 525.2, 531.1, 515.3)

- Per- and Polyfluoroalkyl Substances (PFAS) (EPA Method 537.1)

  Analytes should be adjusted based on historic land use including findings of the Phase I and/or Phase II ESA.

- ♦ No site preparation allowed during the baseline groundwater monitoring period.

- ▪ At least 5 years of quarterly post-construction groundwater quality monitoring is required.

- ▪ Groundwater level monitoring requirements include:

  - ♦ Groundwater level monitoring wells shall have well screens be placed at or near the water table in the aquifer below the target vadose zone.
  - ♦ Groundwater level shall be monitored daily with pressure transducers or other equivalent data logging equipment.
  - ♦ Groundwater level monitoring duration and number of wells must match the groundwater quality monitoring requirements above, at a minimum.
  - ♦ Groundwater level must be monitored above and below any restrictive layer as well as seasonal variation. This includes monitoring the levels of perched aquifers if present on the site.

- o **Infiltration Testing Plan,** including design phase testing and construction phase testing to confirm that the design flow rate is met.

The following documentation is required to be included **in the appendices to the Drainage Control Plan** described in Chapter 3, Section 3.3.3:

- **Hydrogeologic Study** that details the following, to evaluate the potential for contamination of groundwater or other impacts on water resources:
  - o Consideration of potential changes to the aquifer.
  - o Hydrostratigraphy based on project-specific borings and data from other nearby wells. This should include a description of regional hydrogeology to provide context for site-specific conditions.
    - ▪ For each site geologic unit, describe the vertical and lateral extent, presence of stratification, and depositional environment indicators.
    - ▪ If local conditions differ from regional conditions, the hydrogeologic study must explain this difference.

    - Groundwater map(s) and hydrogeologic cross-sections must be provided along with results.
    - Typical maps include groundwater flow direction, site location relative to groundwater protection areas (GWPA) for group A and B wells in the search radius, and domestic wells within ~1/4 mile of the site.
- Relation of the proposed deep UIC well to the following:
    - Water supply wells and springs. Identify each water user source aquifer and the position relative to the deep UIC wells for impacts assessment.
    - GWPA such as a WHPA or CARA including the time of travel (TOT) zone and category of CARA in which the deep UIC well is proposed. Restrictions and requirements based on TOT zones are described above.
    - Any known contaminated sites verified through a Phase I ESA.
    - Nearby streams, lakes, wetlands, springs, shallow groundwater, or other surface water features.
- Results of hydrogeologic exploration, field testing, and analyses to determine potential changes to the aquifer and mounding effects.
    - Subsurface explorations to characterize groundwater occurrence and distribution.
        - Determine the thickness, lateral extent, stratigraphy of the unsaturated zone (i.e., the infiltration receptor horizon), and provide data for estimating the vadose zone treatment capacity.
        - At least one exploration should extend to the base of the aquifer or a minimum of 50 feet below the bottom of the UIC well, whichever is shallower.
    - Aquifer water level, fluctuation, recharge, and discharge.
    - Aquifer testing to estimate aquifer parameters (hydraulic conductivity, transmissivity, and storage) of the aquifer recharged by the UIC well.
    - Infiltration testing to estimate the hydraulic conductivity of the unsaturated zone (the infiltration receptor horizon).
    - Groundwater modeling to determine groundwater mounding impacts on deep UIC well performance, other infiltration stormwater BMPs or facilities, nearby surface water features, geologic hazards (slope stability), and potential cumulative impact in combination with other UICs.

Modeling should evaluate temporary storm-related groundwater mounding and permanently elevated groundwater (i.e., groundwater levels beneath UIC wells may become permanently elevated due to recharge; this is separate from temporary storm-related groundwater mounding). Groundwater modeling may include a combination of MODFLOW, MODRET or SEEP/W or equivalent.

- Slope stability modeling when groundwater mounding extends to geologic hazard areas. Analyze with appropriate slope stability analysis software. Include both static and seismic conditions.
- A summary of results from groundwater monitoring including groundwater level, groundwater quality, and the estimated seasonal high groundwater level.
- Describe whether precipitation was average, below average, or above average during the water year before and during groundwater monitoring.
- If monitoring is conducted during a below-average precipitation water year, the applicant shall discuss the increase in seasonal high groundwater level during a wetter year by correlation with long-term groundwater level monitoring data.

- Identification of the direction and rate of ground water flow.
- Evaluation of the treatment capacity of the vadose zone (see Section 7C.16 and Section 7C.17).
- If a deep UIC well is located within a GWPA, assessment of the vulnerability of the drinking water supply source as follows:
    - Evaluate whether the introduction of stormwater will affect the quality of the ground water at the water supply well.
        - Characterize water quality of stormwater to be infiltrated into the UIC well using water quality results from comparable land uses and proposed treatment.
        - Estimate ranges of contaminant loads to the UIC wells for average, above average, and below average precipitation years, in comparison to the background concentrations found during pre-construction monitoring.
        - Estimate time of travel from the UIC well to the water supply well.
    - Describe the following hydrogeologic factors that may influence the vulnerability of a groundwater supply source:

        - ♦ Depth of the drinking water well screened interval in relation to the deep UIC well infiltration depth.
        - ♦ Presence or lack of a confining layer between the land surface and the aquifer interval.
        - ♦ Presence or lack of a confining layer between the deep UIC well infiltration depth and the drinking water aquifer.
        - ♦ Type of material between the land surface and the aquifer, and between the bottom of the deep UIC well and the aquifer.
    - o A groundwater recharge budget should be prepared for water-bearing zones above the upper layer (e.g., above the till) to ensure the proposed development will not negatively affect surface water features.

- The **Maintenance and Source Control Manual** shall include the following:
    - o Description of runoff treatment BMPs.
    - o Description of any additional special runoff treatment needs and site operation requirements.
    - o Description of source control BMPs that will be implemented to minimize solids entering the deep UIC well and other risks of deep UIC contamination.
    - o Description of maintenance access for videotaping and cleaning.

- **Landscape Management Plan** (see Section 7C.13.1).
    - o The landscape management plan shall address using Integrated Pest Management (IPM) in order to minimize the potential for pesticides and fertilizers used on site to migrate to the UIC or shallow groundwater (See Chapter 14.36 LMC).

- **Contingency Plan** that includes the following:
    - o Identification of a party who has long term responsibility and liability for monitoring and maintenance of the deep UIC well and for addressing problems or replacing the deep UIC well if needed.
    - o Notification process related to tenant changes or changes in land use.
    - o Deep UIC well replacement plan including contingency plan for failure (i.e., additional property reserve or backup deep UIC well locations) and any necessary easements or land use restrictions to implement the contingency plan.

- Creation of a funding security mechanism.
- Specified responses to adverse post-development monitoring data.
- Spill reporting and response procedures.
- Procedures related to deep UIC well shut off.

7C.15.6 Design, Testing, and Construction Requirements

Treatment Requirements

For all discharges to deep UIC wells, the following level of treatment is required:

- Basic treatment for 100 percent of the runoff from non-pollutant generating surfaces to remove suspended sediments, and to prevent sediment entering the well structure and vadose zone.
- Enhanced treatment for 100 percent of the runoff from pollutant generating surfaces.

100 percent treatment shall be demonstrated by results of an approved continuous simulation model. If runoff from pollutant generating surfaces comingles with runoff from non-pollutant generating surfaces before treatment, enhanced treatment is required for 100 percent of the combined runoff.

General Well Design, Testing, and Construction

Well design depends on multiple factors including depth to the receptor horizon, physical properties of the receptor horizon, depth to groundwater, proposed method of runoff treatment prior to conveyance to the UIC, space available for well construction, and long-term operations and maintenance considerations. Other factors may also influence UIC well design based on project specific requirements. Deep UIC well design can be divided into three major categories: media backfilled wells, screened “water-well-style” wells, and infiltration trenches or pits that penetrate an upper confining layer into the vadose zone below. All deep UIC wells require sealing through the confining layer to prevent surface water and shallow subsurface flow from discharging into the deep UIC well.

Any test wells and production wells shall have full-time observation by a licensed geologist, hydrogeologist, or geotechnical engineer experienced in UIC well construction during well drilling to log the sediments and prepare a well construction log. The wells should be developed by cycling water through the well screen interval, and periodically removing fine sediment and sand produced during the well development process. The duration and quantity of inflow to achieve adequate well development will be dependent on results observed during the development process.

The UIC testing protocol generally consists of stepped-rate and constant-rate flow tests. Similar to shallow pilot infiltration tests, inflows are monitored with an in-line digital flow meter providing both instantaneous and total flow volumes. A hydrant or portable water storage tanks are used to provide a continuous supply of water during the inflow portion of the test. The flow rate, total volume, and stage height/water levels are recorded, and the duration of the test must be sufficient to confirm stabilization of water level in the well at specific flow rates.

The determination of an appropriate design infiltration rate for UIC wells is different than standard infiltration applications. Each UIC well is effectively a stand-alone infiltration BMP affected by well construction and well efficiency; therefore, the field test method should replicate full-scale performance. The design infiltration rate is typically 0.5 to 0.8 of the tested rate and is determined on a site-specific basis. The design infiltration rate should be factored based on the quality of the inflow water. Treated water may still contain significant suspended particulate matter.

Impermeable Layer Seal

- Seal any confining layers such as glacial till that are penetrated during drilling or excavation, to prevent aquifer interconnection if a perched aquifer or other saturated stratum is penetrated and to prevent fines from clogging the UIC well.

Surface Seal

- A surface seal shall also be included in the final completion of a deep UIC well:
    - For drilled excavations, the UIC well should be sealed consistent with water well requirements described in WAC 173-160, including sealing the annular space between the bore hole and the permanent casing. The seal shall be constructed to prevent interconnection of separate aquifers penetrated by the well, and shall provide casing stability.
    - For dug excavations, the applicant must demonstrate how the UIC well construction will avoid groundwater capture. Design elements may include specialized grading to direct shallow subsurface groundwater away from the excavation, low permeability backfill as cutoff for shallow subsurface flow, liners, or other measures.

Sand Filters

Clogging can reduce the long-term capacity of UIC wells. The frequency and nature of maintenance requirements for UIC well systems is dependent on system design. A sand filter (i.e., sand blanket) should be included for media backfilled UIC wells and infiltration basins. The sand media should be designed on a project specific basis to reduce clogging and preserve long term capacity of the deep UIC wells. An example specification for sand for sand filters is provided below.

Example Specification for Filter Sand

U.S. Sieve Number	Percent Passing
4	95-100
8	70-100
16	40-90
30	25-75
50	2-25
100	<2
200	<1

Filter Packs

A filter pack in the annular space between a cased UIC well and the formation can reduce the potential for the native formation to introduce fine sediment into the well screen or move vertically along the well screen. A filter pack should be included in the annular space between a cased UIC well and the formation. The filter pack should be designed based on project specific conditions, including anticipated flow rate, screen size (if used), and the formation gradation, using standard practice and well design manuals.

Shut off Valves

Shut off valves are required to provide protection from contaminant spills or to allow the deep UIC well to be taken offline if groundwater impacts or land use changes occur, or to allow for maintenance.

7C.16 Determining Runoff Treatment Requirements

For all stormwater discharges to UIC wells, some form of runoff treatment is required. Treatment may be provided by the vadose zone or by structural runoff treatment BMPs, and depends on the geologic conditions, the land use, and activities at the project site.

The tables in Section 7C.17 can be used by designers for the following:

- Sites using the presumptive approach.
- Industrial sites with no outdoor processing, storage, or handling of raw or finished products.
- Sites where onsite or nearby geologic and groundwater depth information is available. The tables can be used to evaluate whether the presumption that a stormwater discharge from a road, commercial site, or residential site to a UIC well meets the non-endangerment standard for solids, metals, oil, grease, and polycyclic aromatic hydrocarbons (PAHs).
- Used together, the tables in Section 7C.17 identify Ecology’s presumption about the extent to which the vadose zone provides sufficient treatment for a given

pollutant loading classification and whether additional treatment is necessary to meet the groundwater quality standards for these pollutants.

- Depending on conditions, treatment may be as simple as a catch basin with a downturned elbow, or as complex as an oil-water separator followed by basic and/or enhanced treatment. See Table 7C.4 in Section 7C.17 for treatment requirements as a function of pollutant loading classification and vadose zone treatment capacity.

The tables in Section 7C.17 are not allowed to be used by designers for the following:

- Sites with stormwater runoff from industrial activities, outdoor processing, storage, or handling of raw or finished products; or areas where stormwater runoff comes into contact with leachate or other prohibited discharges.

7C.16.1 Exceptions Based on Site-Specific or Local Studies

Exceptions to the tables in Section 7C.17 for UIC wells that are not classified as deep UIC wells (see Section 7C.15) may be made under any of the following circumstances:

- Local planning efforts have generated an alternative method that meets the non-endangerment standard based on local conditions. For example, the City may choose to allow changes in the pollutant loading categories in Table 7C.3 based on source control BMPs implemented at a site.

- More detailed site-specific data are gathered by the project proponent and approved by the City.

- The required thicknesses of the vadose zone treatment layer listed in Table 7C.2 may be as little as 3 feet for a high-capacity treatment matrix and 6 feet for a medium-capacity treatment matrix when all of the following requirements are met:

    - The UIC well satisfies the requirements in Section 7C.4, and the City approves the change in minimum thicknesses.

    - The pollutant loadings are insignificant or low.

    - Reliable onsite information is available.

    - Site-specific water level data justifies the minimal separation from the groundwater table in cases where the 3 feet of high-capacity treatment matrix provides the entire separation between the bottom of the structure and the seasonal high groundwater table.

    - Potential mounding of infiltrating stormwater above the groundwater table is likely. Additional separation or treatment may be required.

7C.16.2 Vadose Zone Treatment Capacity

In general, the vadose zone may provide adequate filtration, adsorption, and other pollutant reduction capacity to meet the non-endangerment standard for solids, metals, oil, grease, and PAHs. Designers may use the tables in Section 7C.17 to evaluate the use of the vadose zone for treatment and to determine treatment requirements to reduce concentrations of these pollutants prior to discharge to the UIC well.

Studies of stormwater pollutant concentrations in water through and below infiltration systems show mixed results in the effectiveness of vadose zone filtration in protecting groundwater quality (USEPA 1999, Pitt et al. 1999, Mason et al. 1999, and Appleyard 1993).

Designers can eliminate many of the problems documented in these studies by proper siting, design, maintenance, and use of the UIC well. Additional actions to offset problems are enhanced source control, spill prevention and response plans, and additional treatment prior to discharge to the UIC well, or prohibition of the discharge.

Studies of subsurface infiltration systems also indicate that filtered and adsorbed pollutants accumulate in the vadose zone at depths of less than a few feet below the UIC well at concentrations that may require soil cleanup activities upon decommissioning of a UIC well (Mikkelsen et al. 1996a, Mikkelsen et al. 1996b, and Appleyard 1993).

Because contaminated soil removal and disposal costs can be considerable, project proponents may wish to consider including pretreatment BMPs to remove solids from stormwater runoff and avoid potential cleanup requirements following long-term use of the UIC well.

7C.17 Classification of Vadose Zone Treatment Capacity

The treatment capacity of the vadose zone is classified as high, medium, low, or none. Ecology bases these classifications on minimum thickness and the characteristics of the geologic materials that make up the proposed treatment layer.

The tables include several different ways of describing the geologic materials: grain-size distribution, sand-to-fines ratio, well log lithology, geologic names, and infiltration rate, as defined in Table 7C.1.

Table 7C.1. Examples of Geologic Material Descriptions.

Geologic Material Description Method	Example
Grain size characteristics	Materials with median grain size < 0.125 mm
Sand-to-fines ratio	Having a sand to silt/clay ratio of < 1:1 and sand plus gravel < 50%
Well log lithology	Sandy or silty clay Silt Clayey or sandy silt Sandy loam or loamy sand Silt/clay with interbedded sand
Geologic name	This category includes geologic terms that indicate provenance, including glacial till, advance outwash, and recessional outwash.
Infiltration rate	Infiltration rate of ≥ 12 in/hr

in/hr = inches per hour

mm = millimeters

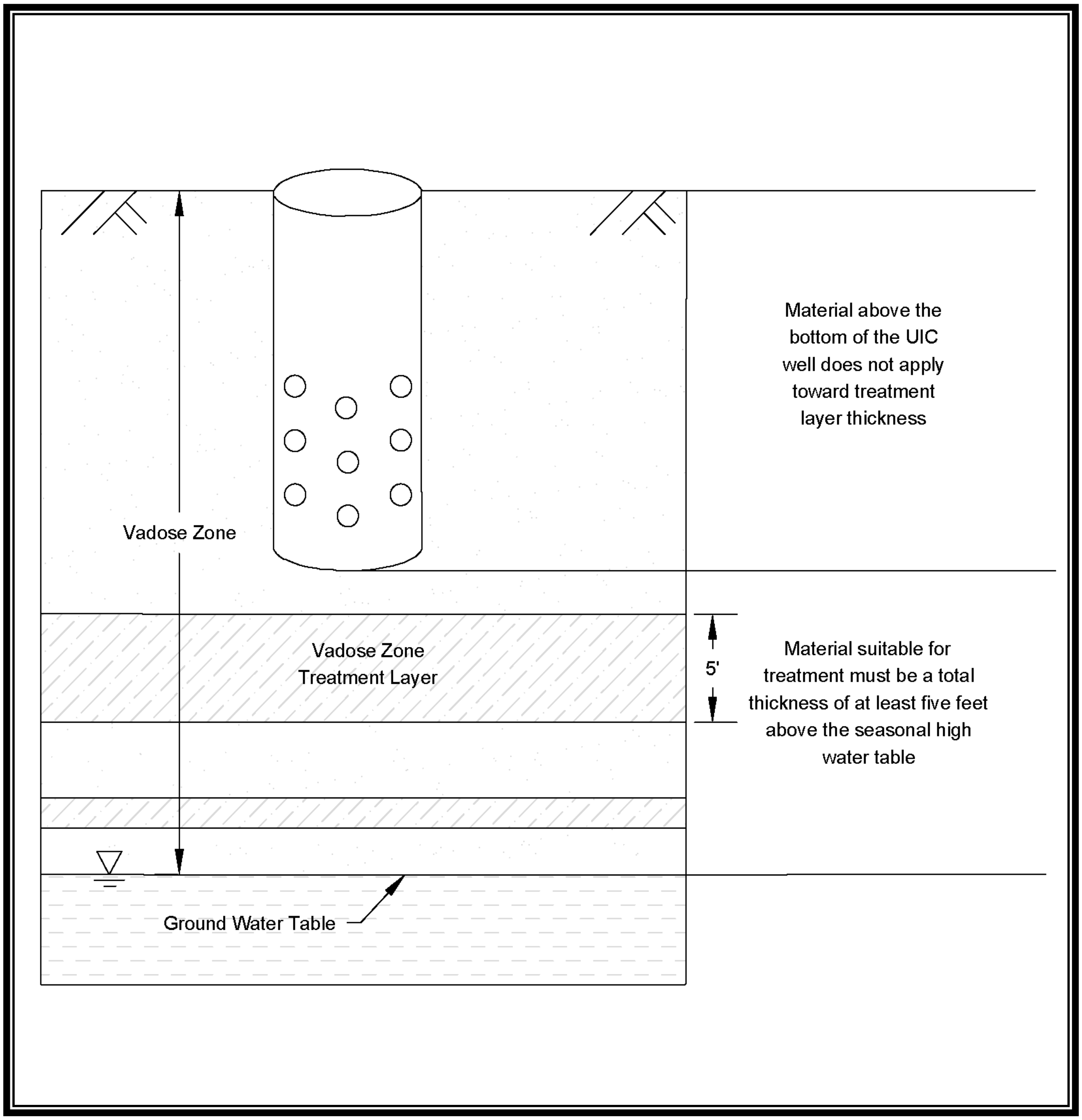
The ability of geologic materials to filter or adsorb pollutants such as solids, oils, and metals is related to grain size, the amount of organic matter, and the presence of clays, among other factors. Native organic matter improves adsorption and filtration (Ingloria et al. 1997) but is rarely found at depths below UIC wells.

Geologic materials classified as having a high treatment capacity are fine-grained with a greater capacity to filter discharges. These materials also tend to remove pollutants by chemical reactions such as cation exchange capacity (CEC) and sorption. These may be mixtures of materials where silt and clay fill the void spaces in the matrix of the coarser materials. More compaction results in better filtration. High-capacity treatment layers must total a minimum of 5 feet between the bottom of the UIC well and the seasonal high groundwater table to provide an adequate level of treatment (see Figure 7C.1).

Geologic materials classified as having a medium treatment capacity provide moderate to high filtration and have minor or no chemically reactive characteristics. Medium-capacity treatment layers must total a minimum of 10 feet to provide an adequate level of treatment.

Geologic materials that have a low treatment capacity provide some minimal filtration. Although the sand and gravel mixtures in this category may provide some filtration when the UIC well is initially installed, preferential flow paths develop that contribute to relatively rapid reduction in treatment capacity. Low-capacity treatment layers must total a minimum of 25 feet between the bottom of the UIC well and the seasonal high groundwater table to provide an adequate level of treatment.

Geologic materials that are classified as having no treatment capacity do not provide filtration to remove pollutants. Since this type of material does not have treatment capacity, basic treatment of stormwater (removal of solids) is always required prior to discharge to the UIC well, except for sites that are classified as having an insignificant pollutant load in Table 7C.3.



Source: Ecology

Figure 7C.1. Schematic Vadose Zone Treatment Layer Example.

7C.17.1 Classification of Vadose Zone Treatment Capacity

Site exploration or information from the site is required to obtain sufficient data to classify the treatment capacity of the vadose zone materials using Table 7C.2.

The treatment capacity classifications in Table 7C.2 apply to the vadose zone between the bottom of the UIC well and the top of the highest known seasonal groundwater table. Designers should use Table 7C.2 to assist in the determination of treatment requirements when using Table 7C.4. If vadose zone conditions are unknown, use “none” for treatment capacity. If thicknesses are less than the listed minimums, use “none” for treatment capacity or consider using the demonstrative approach (see Section 7C.9). Separation between the bottom of the UIC well and the top of the groundwater table is still required, see WAC 173-218-090(1)(b).

7C.17.2 Depth to Groundwater

The minimum required separation between the bottom of the UIC well and the highest seasonal groundwater table depends on the characteristics of the vadose zone, the potential for mounding of infiltrating stormwater above the groundwater table, and the degree of certainty of available data as to the seasonal high groundwater table elevation.

Knowledge of the seasonal high groundwater table is especially important for siting UIC wells in areas with seasonal high groundwater table < 15 feet below the bottom of the UIC well.

Significant mounding of infiltrating stormwater can occur above the groundwater table (Appleyard 1993) and UIC wells must not discharge stormwater directly into groundwater at any time. This applies even if the groundwater level is rising in response to the UIC discharge.

In most cases, one depth to water measurement, such as water level data associated with a single borehole log, is not sufficient to determine the depth/elevation of the seasonal high groundwater table. This is especially true if drilling was conducted outside of the period of seasonal high groundwater levels or following a period of lower than normal precipitation. Seasonal high groundwater tables in shallow aquifers generally occur during late winter through mid-spring in most of Washington State. Moderate depth aquifers or aquifers beneath a low permeability confining layer may reach seasonal high elevations during June, July, or August. In heavily irrigated areas, the seasonal high groundwater table elevation may occur in late summer. The elevation of the seasonal high groundwater table is best determined through installation and periodic monitoring of one or more groundwater monitoring wells at the infiltration BMP location.

At sites where the fluctuation of the seasonal groundwater table is large (several feet) or unknown, designers should err on the side of caution. As described above and reinforced here, UIC wells must not discharge stormwater directly into groundwater.

Table 7C.2. Vadose Zone Treatment Capacity.

Treatment Capacity Classification and Required Minimum Thickness	Description of Vadose Zone Layer[c,d]
HIGH A minimum thickness of 5 feet	Meets all of the following characteristics: • Materials with median grain size < 0.125 mm • Having a sand to silt/clay ratio of < 1:1 and sand plus gravel < 50% • Field-tested saturated hydraulic conductivity below 2.4 in/hr at the bottom elevation of the proposed BMP • Materials with CEC of ≥ 5 milliequivalents CEC/100 g dry soils, and a minimum of 1% organic content, ≥ 18-inch minimum thickness • Typical geotechnical descriptive words for appropriate soils: • Lean, fat, or elastic clay • Sandy or silty clay • Silt • Clayey or sandy silt • Sandy loam or loamy sand • Silt/clay with interbedded sand • Well-compacted, poorly sorted materials This category generally includes till, hardpan, caliche, and loess.
MEDIUM A minimum thickness of 10 feet	Meets all of the following characteristics: • Materials with average grain size 0.125 to 4 mm • Having a sand to silt/clay ratio from 1:1 and 9:1 and percent sand > percent gravel • Field-tested saturated hydraulic conductivity between 2.4 in/hr and 6 in/hr at the bottom elevation of the proposed BMP • Materials between 2 and 5 milliequivalents CEC/100 g dry soils, and a minimum of 0.5% to 1% organic content, • Typical geotechnical descriptive words for appropriate soils: • Fine, medium, or coarse sand • Sand with interbedded clay and/or silt • Poorly compacted, poorly sorted materials This category includes some alluvium and outwash deposits.

Table 7C.2 (continued). Vadose Zone Treatment Capacity. (continued)

Treatment Capacity Classification and Required Minimum Thickness	Description of Vadose Zone Layer[c,d]
LOW A minimum thickness of 25 feet	Meets all of the following characteristics: • Materials with median grain size > 4 mm to 64 mm • Having a sand to silt/clay ratio > 9:1 and percent sand less than percent gravel • Field-tested saturated hydraulic conductivity between 6 in/hr and 12 in/hr at the bottom elevation of the proposed BMP • Materials with CEC of ≤ 2 milliequivalents CEC/100 g dry soils and a minimum of < 0.5% organic content • Typical geotechnical descriptive words for appropriate soils: • Poorly sorted, silty, or muddy gravel • Sandy gravel, gravelly sand, or sand and gravel This category includes some alluvium and outwash deposits.
NONE Minimum thickness not applicable	Meets all of the following characteristics: • Vadose zone conditions are unknown; or • Vadose zone conditions are known and are characterized in any of the following ways: • Sedimentary materials with median grain size > 64 mm • Total fines (sand and mud) < 5% • Field-tested saturated hydraulic conductivity > 12 in/hr at the bottom elevation of the proposed BMP • Materials with no measurable CEC or organic content • Typical geotechnical descriptive words for appropriate soils: • Well-sorted or clean gravel • Boulders and/or cobbles • Fractured rock This category generally includes vadose zones with conditions that are unknown or vadose zones that are known to be composed of fractured basalt, other fractured bedrock, and cavernous limestone.

[a] This table is applicable to designers intending to use the presumptive approach to identify the necessary level of stormwater treatment prior to discharge to a UIC well. Designers for industrial sites with no outdoor processing, storage, or handling of raw or finished products may also use these tables.

[b] This table is not applicable to stormwater runoff from industrial activities, outdoor processing, storage, or handling of raw or finished products; or areas where stormwater runoff comes into contact with leachate or other prohibited discharges.

[c] If vadose zone conditions are unknown or if the vadose zone thicknesses are less than those listed, use "none" for the treatment capacity.

[d] Separation between the bottom of the UIC well and the top of the groundwater table is required, see WAC 173-218-090(1)(b).

Table 7C.3. Pollutant Loading Classifications for Solids, Metals, and Oil in Stormwater Runoff Directed to UIC Wells.

Classification	Areas Contributing Runoff to the UIC Well
Insignificant	• Impervious surfaces not subject to motorized vehicle traffic or application of sand or deicing chemicals • Unmaintained open space

Low	• Parking areas with < 40 total trip ends per 1,000 square feet (sf) of gross building area or < 100 total trip ends (if you exceed either threshold, move to the Medium Classification)
	• Other land uses with similar traffic/use characteristics (e.g., most residential parking and employee-only parking areas for small office parks or other commercial buildings)
	• **Inside Urban Growth Management Areas**
	  ○ Fully controlled and partially controlled limited access highways with ADT < 15,000
	  ○ Other roads with ADT < 7,500 vehicles
	• Outside Urban Growth Management Areas
	  ○ All roads with ADT < 15,000 vehicles

Medium	• Parking areas with between 40 and 100 trip ends per 1,000 sf of gross building area or between 100 and 300 total trip ends (if you exceed either threshold, move to the High Classification)
	• Primary access points for high-density residential apartments
	• Intersections controlled by traffic signals that do not meet the definition of a high-density intersection (i.e., 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)
	• Transit center bus stops
	• **Inside Urban Growth Management Areas**
	  ○ Fully controlled and partially controlled limited access highways with ADT between 15,000 and 30,000 vehicles
	  ○ Other roads with ADT between 7,500 and 30,000 vehicles
	• Outside Urban Growth Management Areas
	  ○ All roads with ADT between 15,000 and 30,000 vehicles

High	• High-use sites ○ Includes roads with ADT > 30,000 vehicles • On-street parking areas of municipal streets in commercial and industrial areas • Highway rest areas • Other land uses with similar traffic/use characteristics (e.g., commercial buildings with a frequent turnover of visitors, such as grocery stores, shopping malls, restaurants, drive-through services, etc.)

Notes:

[a] This table is applicable to designers intending to use the presumptive approach to identify the necessary level of treatment upstream of a UIC well. Designers for industrial sites with no outdoor processing, storage, or handling of raw or finished products may also use these tables.

[b] This table is not applicable to stormwater runoff from industrial activities, outdoor processing, storage, or handling of raw or finished products; or areas where stormwater runoff comes into contact with leachate or other prohibited discharges.

Use the treatment capacity classification from Table 7C.2 and the pollutant loading classification from Table 7C.3 to determine the appropriate level of treatment for solids, oil, and metals in Table 7C.4.

Designers may use UIC wells to provide flow control of excess stormwater runoff for flows greater than the water quality design storm where pollutant concentrations that reach groundwater will meet Washington State groundwater quality standards; or where stormwater is adequately treated prior to discharge.

Table 7C.4. Treatment Required for Solids, Oil, and Metals.

Pollutant Loading	Treatment Capacity			
	High	Medium	Low	None
Insignificant	Two-stage drywell[a]	Two-stage drywell[a]	Two-stage drywell[a]	Two-stage drywell[a]
Low	Two-stage drywell[a]	Pretreatment[b]	Pretreatment[b]	Remove solids[c]
Medium	Pretreatment[b]	Remove solids[c]	Remove solids[c]	Remove solids[c]
High	Remove oil[d]	Remove oil[d]	Remove oil and solids[c,d]	Remove oil and solids[c,d]

Notes:

a A two-stage drywell has a catch basin or other presettling device that traps small quantities of oils and solids. Regularly inspect and maintain the catch basin or other presettling device.

b Pretreatment removes solids, but at a level less than basic treatment. Ecology's definition for pre- treatment is 50% removal and typically installed upstream of a UIC well.

c Treatment to remove solids means basic treatment. Removal of solids removes a large portion of the total metals in most stormwater runoff. Any special treatment requirements in this chapter still apply. Owners may use appropriate source control BMPs for low-pollutant-loading sites, in lieu of structural treatment BMPs.

d Treatment to remove oil is to be accomplished by applying one of the oil control BMPs identified in this manual. See Chapter 8, Section 8.10.6 for API (Baffle type) Separator and Coalescing Plate (CP) Separator.

At high-density intersections and at commercial or industrial sites subject to an expected average daily traffic (ADT) count of 100 vehicles/1,000 sf gross building area, sufficient quantities of oil may be generated to justify operation of a separator BMP.

At other high-use sites, project proponents may select a basic treatment BMP that also provides adsorptive capacity, such as a biofiltration or bioinfiltration swale, a filter, or other adsorptive technology, in lieu of a separator BMP. A catch basin with a turned down elbow is not adequate for oil control in this case.

The requirement to apply a basic treatment BMP with adsorptive characteristics also applies to commercial parking and to streets with ADT > 7,500.

7C.18 Site Suitability Criteria (SSC)

This section provides criteria that must be considered for siting infiltration BMPs. When a site investigation reveals that any of the applicable site suitability criteria cannot be met, appropriate mitigation measures must be implemented so that the infiltration BMP will not pose a threat to safety, health, and the environment.

For site selection and design decisions, a geotechnical and hydrogeologic report shall be prepared by a licensed engineer in the state of Washington with geotechnical and hydrogeologic experience, or a licensed geologist, hydrogeologist, or engineering geologist. The designer 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 local regulations, uniform building code requirements, or other state regulations.

These setback criteria are provided as guidance:

- Stormwater infiltration BMPs should be set back at least 100 feet from drinking water wells, septic tanks or drainfields, and at least 200 feet from springs used for public drinking water supplies. Infiltration BMPs upgradient of drinking water supplies and within 1-, 5-, and 10-year time of travel zones must comply with WSDOH requirements (WSDOH 2010). Infiltration BMPs that qualify as UIC wells must comply with Chapter 173-218 WAC and the guidance in this appendix.

- Additional setbacks must be considered if roadway deicers or herbicides are likely to be present in the influent to the infiltration BMP.

- From building foundations: ≥ 20 feet downslope and ≥ 100 feet upslope

- From Native Growth Protection Easement (NGPE): ≥ 20 feet

- From the top of slopes > 15 percent: ≥ 50 feet.

- Evaluate onsite and offsite 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 Groundwater Protection Areas

A site is not suitable for an infiltration BMP if the infiltration BMP will cause a violation of Ecology's Groundwater Quality Standards (Chapter 173-200 WAC). See SSC-3 High Vehicle Traffic Areas through SSC-6 Soil Physical and Chemical Suitability for Treatment, and SSC-8 Cold Climate and Impact of Roadway Deicers for measures to protect groundwater quality. City staff and local ordinances should be consulted for applicable pretreatment requirements if the project site is located in an aquifer sensitive area, sole source aquifer, wellhead protection area, or critical aquifer recharge area.

SSC-3 High Vehicle Traffic Areas

An infiltration BMP may be considered for runoff from areas that require an oil control BMP per Chapter 8. For such applications, provide the oil control BMP upstream of the infiltration BMP to ensure that groundwater quality standards will not be violated and that the infiltration BMP is not adversely affected.

SSC-4 Soil Infiltration Rate/Drawdown Time

Infiltration Rates: measured (initial) and design (long-term)

For infiltration BMPs used for runoff treatment, the measured (initial) soil infiltration rate shall be 9 in/hr or less (For permeable pavements, this rate can be 12 in/hr or less). Design (long-term) infiltration rates up to 3.0 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 Soil Physical and Chemical Suitability for Treatment to adequately control the target pollutants. Project sites with infiltration rates lower than those identified in the infeasibility criteria may be used for infiltration of stormwater if the City approves the design.

The design infiltration rate should also be used for maximum drawdown time and routing calculations.

Drawdown Time

For infiltration BMPs designed strictly for flow control, there isn’t a maximum drawdown time.

For infiltration BMPs designed to provide runoff treatment, document that the water quality design volume (as described in Chapter 8, Section 8.4.1) can infiltrate through the infiltration BMP surface within 48 hours. This can be calculated by multiplying the horizontal projection of the infiltration BMP mid-depth dimensions by the estimated 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 infiltration BMP size. If the design fails the check procedure, redesign the infiltration BMP.

SSC-5 Depth to Bedrock, Water Table, or Impermeable Layer

The base of infiltration basins or infiltration trenches 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 groundwater 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 other site suitability criteria specified in this section.

SSC-6 Soil Physical and Chemical Suitability for Treatment

This SSC applies to infiltration BMPs that intend to use native soil to provide runoff treatment. If the native soils do not meet the criteria below, runoff treatment must be prior to infiltration either by a layer within the infiltration BMP (such is the case for Bioretention), a runoff treatment BMP upstream of the infiltration BMP, or a layer of engineered soil that meets the criteria below. Refer to Chapter 8 for guidance to determine the appropriate level of runoff treatment, based on land use and project type, that is necessary to precede the infiltration BMP.

Consider the soil texture and design infiltration rates 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 1986). 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 (Buckman and Brady 1969). 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 City.

- Depth of soil used for infiltration runoff treatment must be a minimum of 18 inches. Depth of soil used for infiltration runoff treatment below permeable pavement that is a pollution-generating hard surface may be reduced to one foot if the permeable pavement does not accept runon 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. A minimum of 1.0 percent organic content is necessary.

- Waste fill materials shall not be used as infiltration soil media, nor shall such media be placed over uncontrolled or non-engineered fill soils.

Engineered soils may be used to meet these design criteria. Field performance evaluation(s), using protocols cited in this manual, would be needed to determine feasibility and acceptability by the City.

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

Consider the potential impact of roadway deicers on potable water wells in the siting determination. Implement mitigation measures if the infiltration of roadway deicers could cause a violation of groundwater quality standards.

7C.19 Definitions

Groundwater Protection Area

The area surrounding a drinking water source evaluated as part of SSC-2 Groundwater Protection Areas that includes the wellhead protection area and may also include aquifer sensitive areas, sole source aquifers, groundwater management areas, or critical aquifer recharge areas.

Sanitary Control Area

The inner circle of a wellhead protection area maintained around a drinking water source to minimize direct contamination at the wellhead and reduce the possibility of surface flows reaching the wellhead and traveling down the casing (WAC 246-290-135). For potable groundwater wells, the sanitary control area is defined as the 100-foot radius around the well.

Susceptibility

The ease with which contaminants can move from the land surface to the aquifer, based solely on the types of surface and subsurface materials in the area. Susceptibility usually defines the rate at which a contaminant will reach an aquifer unimpeded by chemical interactions with the vadose zone media.

Susceptible Drinking Water Source

Sources rated highly susceptible by WSDOH and any drinking water source where a deep injection well will be placed within a groundwater protection area.

Vulnerability

Vulnerability is a water source's potential for contamination. Two factors influence vulnerability:

Physical susceptibility to contaminant infiltration. Susceptibility depends on conditions that affect the movement of contaminants from the land surface into a water supply. This includes the depth of the well, its construction, the geology of the area, the pumping rate, the source(s) of groundwater recharge, and the aquifer material.

The source's risk of exposure to contaminants. The risk of exposure is measured by determining whether contaminants were used in the water supply area. However, each type of contaminant may behave differently in the environment, making it difficult to predict groundwater pollution from surface exposure accurately. For this reason, susceptibility is the key factor used in determining vulnerability. See Washington *State Wellhead Protection Program Guidance Document* (WSDOH 2010).

Wellhead Protection Area

The area surrounding a drinking water source that is focused on protection from potential contamination that typically includes four or five zones: a sanitary control area, 1-, 5-, and 10-year time-of-travel capture zones, and a management zone (if warranted) (WAC 246-290-130, WAC 246-290-135, City of Lacey Wellhead Protection Plan).

The maps provided in Appendix 8B (as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>) identify wellhead protection areas and critical aquifer recharge areas in the City.

7C.20 References

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Chapter 8 – Runoff Treatment BMPs

Table of Contents

Tables

Figures

Chapter 8 – Runoff Treatment BMPs

8.1 Introduction

8.1.1 Purpose of this Chapter

This chapter focuses on best management practices (BMPs) for the treatment of runoff to remove sediment and other pollutants at developed sites. These BMPs are required to ensure that development or redevelopment does not impair waters of the state. These controls are also to protect wetlands, riparian corridors, and groundwaters to the maximum extent practicable.

The purpose of this chapter is to provide guidance for selection, design, and maintenance of permanent runoff treatment BMPs.

BMPs with respect to controlling stormwater flows and control of pollutant sources are presented in Chapters 7 and 9, respectively.

8.1.2 Content and Organization of this Chapter

Chapter 8 of the SDM contains 11 sections:

- **Section 8.1** serves as an introduction and summarizes available options for treatment of stormwater.
- **Section 8.2** outlines a step-by-step process for selecting treatment BMPs for new development and redevelopment projects.
- **Section 8.3** presents runoff treatment BMP options that are used in applying the step-by-step process presented in Section 8.2. These options cover different runoff treatment needs that are associated with different sites.
- **Section 8.4** discusses general requirements for runoff treatment BMPs.
- **Sections 8.5 through 8.10** provide detailed information regarding specific types of runoff treatment.
- **Section 8.11** discusses special considerations for manufactured treatment devices.
- **Appendix 8A** provides geotextile specifications for stormwater BMPs.
- **Appendix 8B** provides the wellhead protection and critical aquifer recharge area maps.

8.1.3 How To Use this Chapter

The reader should consult this chapter to select specific BMPs for runoff treatment for the Stormwater Site Plans. After the core requirements have been identified from Chapter 2, this chapter can be used to select specific treatment BMPs for permanent use at developed sites, and as an aid in designing and constructing these BMPs.

8.1.4 Runoff Treatment BMPs

General Considerations

Runoff treatment BMPs 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 phosphorus); 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.

Operations and Maintenance

Maintenance is required for all types of runoff treatment BMPs. See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Treatment Methods

Methods used for runoff treatment BMPs and common terms used in runoff treatment are discussed below:

- Wet pools. Wet pools provide runoff treatment by allowing settling of particulates during quiescent conditions (sedimentation), by biological uptake, and by vegetative filtration. Wet pool BMPs include wet ponds, wet vaults, and constructed stormwater wetlands. Wet pools may be single-purpose BMPs, providing only runoff treatment, or they may be combined with a detention pond or vault to also provide flow control. If combined, the wet pool BMP can often be stacked under the detention BMP with little to no further loss of development area.

- Biofiltration. Biofiltration BMPs use 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 sedimentation, filtration, infiltration, settling, and/or plant uptake. These effects are aided by the reduction of the velocity of stormwater as it passes through the biofiltration BMP. Biofiltration BMPs 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 separator BMPs remove oil and other water-insoluble hydrocarbons, and settleable solids from stormwater runoff. There are two general types of oil-water 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 bays separated by baffles. The efficiency of these separators is dependent on detention time in the center bay and on droplet size. Coalescing plate separators use a series of parallel plates in the separator bay, which improve separation efficiency by providing more surface area. Oil-water separators must be located off-line from the primary conveyance/detention system, bypassing flows greater than the water quality design flow rate. Other BMPs that may be used for removal of oil include manufactured treatment devices (see definition below), and linear sand filters. Oil-water separator BMPs should be placed upstream of other runoff treatment BMPs and as close to the source of oil generation as possible. **Note that the City will not accept ownership of some types of oil-water separator BMPs without prior approval.** See Sections 8.2 and 8.3 for additional information.

- Pretreatment. Presettling basins are often used to remove suspended solids prior to discharge into other runoff treatment BMPs. Basic treatment BMPs, listed in Section 8.2, Figure 8.1, Step 7, can also be used to provide pretreatment. Pretreatment often must be provided for filtration and infiltration BMPs to protect them from clogging or to protect groundwater. Appropriate pretreatment devices include a presettling basin, wet pond/vault, biofiltration, constructed wetland, or oil-water separator. A number of patented technologies have received General and Conditional Use Level Designations for Pretreatment through Ecology's Technology Assessment Protocol – Ecology (TAPE) program. A listing and descriptions are available at Ecology's Emerging Stormwater Treatment Technologies web page <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>. Only those technologies that have received General Use Level Designation (GULD) may be used to meet the requirements of this manual. Prior approval is required for GULD BMPs that are to be maintained by the City.

- Infiltration. Infiltration refers to the use of the filtration, adsorption, and biological 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, groundwater recharge, and flood control. One condition that can limit the use of infiltration is the potential adverse impact on groundwater quality. Some soils may provide adequate runoff treatment of stormwater, though many soils will not, and therefore pose a risk to groundwater if used for stormwater infiltration. To be used for runoff treatment, generally soils must include sufficient organic content and sorption capacity to remove pollutants. 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. See Chapter 6, Section 6.3 for specific soil requirements for runoff treatment using infiltration. The use of coarser soils to provide flow control for runoff from pollution generating surfaces must be preceded by treatment to protect groundwater quality. Thus, there will be instances when soils are suitable for treatment but not flow control, and vice versa. In addition, note that infiltration is regulated by Ecology and the UIC program (WAC 173-218). Additional information on UIC and how it applies to infiltration and stormwater management is included in Chapter 7, Section 7.3.

- Filtration. Another 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 are commonly configured as basins, trenches, vaults, or proprietary cartridge filtration systems. Several sand filtration BMPs are discussed in Section 8.7. A number of "manufactured treatment devices" which provide filtration have completed or are in the process of being assessed through the "manufactured treatment devices" process described in the following bullet. **Note that the City will not accept ownership of proprietary media filtration BMPs without prior approval.**

- Manufactured Treatment Devices. Manufactured treatment devices are new stormwater treatment technologies that are continually being added to the stormwater treatment marketplace. These devices include both permanent and construction site treatment technologies.

  Ecology established the TAPE program to evaluate the capabilities of manufactured treatment devices. Manufactured treatment devices that have been evaluated by this program are designated with a level of use designation under specified conditions. Their use is restricted in accordance with their evaluation as explained in Section 8.11. The recommendations for use of individual manufactured treatment devices may be updated as Ecology collects more data on their performance. Updated recommendations on their use are posted to Ecology's Emerging Stormwater Treatment Technologies web page (<https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>). Manufactured treatment devices can also be considered for retrofit situations where TAPE approval is not required.

- On-line Systems. Most treatment BMPs can be designed as on-line systems with flows above the water quality design flow rate or volume simply passing through the BMP with lesser or no pollutant removal efficiency. An example of an on-line system is a wet pool that maintains a permanent pool of water for runoff treatment purposes. However, it is sometimes desirable or necessary to restrict flows to treatment BMPs and bypass excess flows around them. These are called off-line systems.

- Design Flow. For information on determining the water quality design flow rate and/or volume for sizing runoff treatment BMPs, refer to Section 8.4.

8.2 Runoff Treatment BMP Selection Process

This section describes a step-by-step process for selecting the type of treatment BMPs that will apply to individual projects (or TDA within the project) if directed by Chapter 2, Section 2.1.2, Core Requirement #6, Core Requirement #8, and/or if the project is using an infiltration BMP per Chapter 7, Section 7.2.

This section may also be referred to as directed by Appendix 7C to determine acceptable runoff treatment BMPs prior to UIC wells.

Physical features of sites that are applicable to treatment BMP selection are also discussed. Refer to Section 8.3 for additional detail on the four treatment types—oil control treatment, phosphorus treatment, enhanced treatment, and basic treatment.

Section 8.11 includes links to options for manufactured treatment devices that have a Use Level Designation for pretreatment, oil, phosphorus, enhanced, or basic treatment. Only manufactured treatment devices with a GULD can be used to meet the requirements of this manual.

While this section provides guidance to the applicant or project engineer regarding the selection of treatment BMPs, BMP selection remains the responsibility of the project engineer.

8.2.1 Selection Process for Treatment BMPs

Refer to Figure 8.1. Use the step-by-step process outlined below to determine the type of runoff treatment BMPs applicable to the project.

Step 1: Determine the Receiving Waters and Pollutants of Concern Based on Off-site Analysis

An off-site analysis is necessary in order to obtain a more complete determination of the potential impacts of a stormwater discharge. In conjunction with the off-site analysis, the project applicant must also determine the natural receiving waters for the stormwater drainage from the project site (groundwater, wetland, lake, stream, and/or saltwater). This is necessary to determine the applicable runoff treatment option, as well as whether any additional runoff treatment requirements apply (see Step 6 and Section 8.3.5). **The identification of the receiving waters must be completed in order to determine the site-specific runoff treatment requirements and should be verified by the City.** If the discharge is to the municipal stormwater drainage system, the receiving water(s) for the drainage system must be determined.

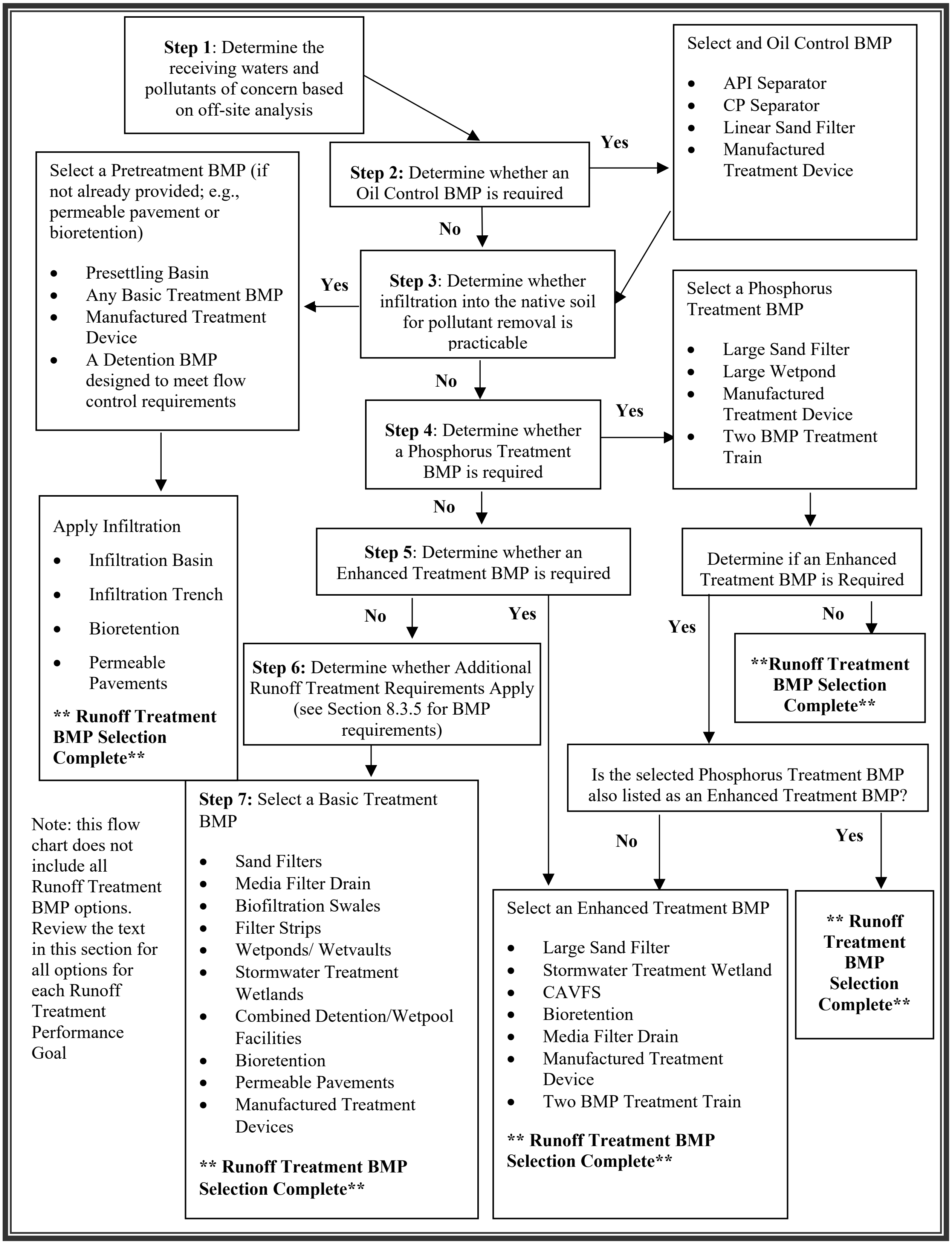


Figure 8.1. Runoff Treatment BMP Selection Flow Chart.

The following factors must be considered when determining the appropriateness of a runoff treatment BMP:

- Whether the receiving water is listed under Sections 304(1)(1)(A)(I), 304(1)(1)(A)(II), or 304(1)(1)(B)(1) of the Clean Water Act.

- Whether the receiving water is listed in Washington State's Non-Point Source Assessment required by Section 319(a) of the Clean Water Act.

- Whether any type of water quality management plans and/or local ordinances or regulations have established specific requirements for that (those) receiving waters. See also Step 6 below and Section 8.3.5. These requirements should be verified by the City. Examples of plans to be aware of include:

  - **Watershed or Basin Plans** can be developed to cover a wide variety of geographic scales (e.g., Water Resource Inventory Areas [WRIAs], or subbasins of only a few square miles), and can be focused solely on establishing stormwater requirements (e.g., 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** establish a TMDL of a pollutant or pollutants in a specific receiving water or basin, and identify actions necessary to remain below that maximum loading. The plans may identify discharge limitations or management limitations (e.g., use of specific runoff treatment BMPs) for stormwater discharges from new and redevelopment projects, or monitoring requirements for stormwater discharges. See also Chapter 2, Section 2.3.2, and Step 6 below.

  - **Groundwater Management Areas (Wellhead Protection and Critical Aquifer Recharge)**: To protect groundwater quality and/or quantity, these areas typically require specific actions related to stormwater discharges. See Step 5 below, Section 8.3.4 below, and Chapter 4. The maps provided in Appendix 8B (as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>) identify wellhead protection areas and critical aquifer recharge areas in the City.

  - **Lake Management 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. This analysis will help determine whether basic, enhanced, or phosphorus treatment requirements apply to the project. Project proponents will make those decisions in the steps below.

Step 2: Determine Whether an Oil Control BMP Is Required

The use of oil control BMPs is dependent upon the specific land use proposed for development.

Where Applied: Oil control (Section 8.3.2) applies to projects that have "high-use sites" or have NPDES permits that require application of oil control. 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 design year average daily traffic count equal to or greater than 100 vehicles per 1,000 square feet of gross building area.

  Note: Gasoline stations (with or without convenience stores), fast food restaurants, and drive-through businesses will typically require oil control.

- 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.

  Note: The petroleum storage and transfer criterion are intended to address regular transfer operations such as gasoline service stations, bus fueling stations, motor pool fueling stations, and equipment rental BMPs that provide on-site fueling.

- 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.).

  Note: In general, all-day parking areas are not intended to be defined as high-use sites, and may not require an oil control BMP.

- A road intersection with a design year average daily traffic 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. See: <www.ite.org/>.

  Note: The design year average daily traffic is defined as the planned traffic 5 years after the road is scheduled to be built. The traffic count can be estimated using information from "Trip Generation," published by the Institute of Transportation Engineers (ITE 2012), or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

The City may also require oil control BMPs to be used on other sites that generate high concentrations of oil per the 2019 Ecology Manual.

If oil control is required for the site, refer to the general requirements in Section 8.4. These requirements may affect the design and placement of BMPs on the site (e.g., flow splitting). Refer to the list of oil control BMP options in Section 8.3.2; then see Section 8.10 for guidance on the proper selection of options and design details.

If an Oil Control BMP is required, select and apply an appropriate Oil Control BMP from the options in Section 8.3.2. After selecting an oil control BMP, proceed to Step 3.

If an oil control BMP is not required, proceed directly to Step 3.

Step 3: Determine Whether Infiltration into the Native Soil for Pollutant Removal Is Practicable

Review the infiltration design criteria in Section 8.6. Infiltration can be effective at treating stormwater runoff, but soil properties must be appropriate to achieve effective treatment while not adversely impacting groundwater resources. The location and depth to bedrock, the water table, or impermeable layers (such as glacial till), and the proximity to drinking water wells, aquifers, building foundations, septic tank drainfields, and unstable or steep slopes can preclude the use of infiltration.

Most infiltration BMPs should be preceded by a pretreatment BMP to reduce the occurrence of plugging. Some infiltration BMPs have pretreatment integrated into the BMP, such as bioretention and permeable pavements, and therefore it is not necessary to provide additional pretreatment prior to infiltration. Any basic treatment BMPs, as well as detention ponds, vaults, or tanks designed to meet flow control requirements, can also be used for pretreatment. If an oil-water separator is necessary for oil control, it can also function as the presettling 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 cleanout is recommended.

If infiltration is planned, users must refer to the general requirements in Sections 8.4 and 8.6. Those requirements can affect the design and placement of BMPs on your site. If infiltration is within the 1-year time of travel zone for a wellhead protection area or within a Category I critical aquifer recharge area (see area maps in Appendix 8B as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>), or within one-quarter mile of a water body designated for aquatic life use or that has an existing aquatic life use, refer to Step 5 below to determine if part or the entire site is subject to enhanced treatment (Section 8.3.4). If enhanced treatment does apply, read the note under "Infiltration with appropriate pretreatment" to identify special pretreatment needs. If your infiltration site discharges to a water body that is not subject to enhanced treatment requirements, refer to phosphorus treatment (Section 8.3.3) for special pretreatment needs.

Note: Infiltration for flow control as outlined in Chapter 7, Sections 7.2 and 7.4, is allowable and generally is the preferred method of flow control. However, the infiltration BMP (except for bioretention and permeable pavements) must be preceded by a basic treatment BMP (or an enhanced treatment or a phosphorus treatment BMP, in accordance with the previous paragraph).

If infiltration is practicable, select and apply a pretreatment BMP and an infiltration BMP.

If infiltration is not practicable, proceed to Step 4.

Step 4: Determine Whether a Phosphorus Treatment BMP is Required

The requirement to provide phosphorus control is determined by the City, Ecology, or the U.S. EPA. The plans, ordinances, and regulations identified in Step 1 are a good reference to help determine if the subject site is in an area where phosphorus control is required.

Phosphorus control is required for all discharges to fresh water bodies (including wetlands) or conveyance systems tributary to fresh water bodies (subject to Core Requirement #6) in the City. This includes projects that use infiltration and the infiltration site is within one-quarter mile of a fresh water body. When phosphorus control is required, select and apply a phosphorus treatment BMP from the list of phosphorus treatment options in Section 8.3.3. Select a BMP after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

After selecting a phosphorus treatment BMP, refer to the general requirements in Section 8.4. This guidance may affect the design and placement of BMPs on the site.

Note: Project sites subject to the phosphorus treatment requirement could also be subject to enhanced treatment (see Step 5) or additional area-specific requirements (see Step 6). In that event, apply a BMP or a treatment train that is listed for all of the applicable requirements. Note that large sand filters, media filter drains, two BMP treatment trains, bioretention without imported compost materials, and a range of manufactured treatment devices are approved for both enhanced treatment and phosphorus treatment.

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

Step 5: Determine Whether an Enhanced Treatment BMP Is Required

Enhanced treatment for reduction in dissolved metals is required for two categories of project types:

1. Enhanced treatment is required for all pollution-generating surfaces subject to Core Requirement #6 if the project site proposes infiltration within the 1-year time of travel zone for a wellhead protection area or within a Category I critical aquifer recharge area (see area maps in Appendix 8B as well as on the City's web site at <https://cityoflacey.org/resource_library/stormwater-utility/>).

2. Enhanced treatment is required for all pollution-generating surfaces that propose infiltrating to deep UIC wells. Refer to Appendix 7C, Section 7C.15.

3. Enhanced treatment is also required for the following project sites that:

    a. Discharge directly to fresh waters or conveyance systems tributary to fresh waters designated for aquatic use or that have an existing aquatic life use;

    b. Propose infiltration within one-quarter mile of a fresh water designated for aquatic life use or that has an existing aquatic life use; or

Project sites where Enhanced Treatment BMPs may be required based on the above project categories are:

- Industrial project sites
- Commercial project sites
- Multifamily residential project sites
- High average annual daily traffic (AADT) roads as follows:
    - Fully controlled and partially controlled limited access highways with AADT counts of 15,000 or more
    - All other roads with AADT of 7,500 or greater.

  Note: The design year average daily traffic is defined as the planned traffic 5 years after the road is scheduled to be built.

For TDAs with a mix of land use types, enhanced treatment BMPs are required when the runoff from the areas subject to the enhanced treatment requirement comprises 50 percent or more of the total runoff within the TDA.

If the project must apply enhanced treatment, select and apply an appropriate enhanced treatment BMP. Refer to enhanced treatment BMP options in Section 8.3.4. Select a BMP after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

After selecting an enhanced treatment BMP, refer to the general requirements in Section 8.4. This guidance may affect the design and placement of BMPs on the site.

Note: Project sites subject to the enhanced treatment requirement could also be subject to the phosphorus removal requirement if located in an area designated for phosphorus control (see Step 4), or additional area-specific requirements if applicable (see Step 6). In that event, apply a BMP or a treatment train that is listed for all of the applicable requirements. Note that large sand filters, media filter drains, two BMP treatment trains, bioretention without imported compost materials, and a range of manufactured treatment devices are approved for both enhanced treatment and phosphorus treatment.

If enhanced treatment does not apply to the site, proceed to Step 6.

Step 6: Determine if Additional Runoff Treatment Requirements Apply

Additional/specific runoff treatment requirements also apply to development projects located within basins with known water quality problems. A water quality problem, for the purposes of this manual, is defined as a stream reach, lake, or other water body of the state that is either: 1) currently designated in the state's Water Quality Assessment 303(d)/305(b) Integrated Report as a Category 2, 4, or 5 waterbody due to exceedance or concern for exceedance of the state's numeric action standard for any pollutants of concern (fecal coliform bacteria, dissolved oxygen, or temperature, as noted below); or 2) is currently designated by the City or Thurston County as a problem based on credible data indicating exceedance or concern for exceedance of the state's numeric action standard.

The goal of this manual is to prevent creation or significant aggravation of such problems to the maximum extent practicable. While the runoff treatment options in this chapter and the source control BMPs required in Chapter 9 serve to minimize the creation and aggravation of many types of downstream water quality problems, there are some problems that are either not addressed by these requirements (e.g., temperature issues) or warrant additional measures/considerations to minimize the proposed project's impacts to the maximum extent practicable. In particular, there are currently three types of downstream water quality problems for which the City has determined that additional attention needs to be given to preventing or minimizing increases in the pollutants of concern discharging from the site. These problems are associated with the following water quality parameters:

- Bacteria
- Dissolved Oxygen
- Temperature

The water quality mitigation requirements outlined in Section 8.3.5 must be met as applicable if a proposed project requires runoff treatment per Core Requirement #6, and if the project **surface discharges** to water quality problem areas within one-half mile downstream. This distance is calculated along the travel path of the discharged water, not as a direct line on a map. If a project is located within one-half mile upstream of a water quality problem area, but uses an infiltration treatment BMP to meet applicable treatment requirements, no additional water quality mitigation is required. A longer distance may be considered a direct discharge if there is hydraulic connectivity (i.e., depending on conveyance type/situation).

Note: Project sites subject to these additional area-specific requirements could also be subject to a phosphorus treatment (see Step 4) if located in an area designated for phosphorus control, or the enhanced treatment requirement (see Step 5). In that event, apply a BMP or a treatment train that is listed for all of the applicable requirements. Note that large sand filters, media filter drains, two BMP treatment trains, bioretention without imported compost materials, and a range of manufactured treatment devices are approved for both enhanced treatment and phosphorus treatment.

If additional area-specific water quality requirements do not apply to the site, proceed to Step 7.

Step 7: Select a Basic Treatment BMP

Areas that must provide phosphorus treatment BMPs or enhanced treatment BMPs do NOT have to provide additional basic treatment BMPs to meet the basic treatment performance goal.

If phosphorus treatment BMPs or enhanced treatment BMPs are not provided, basic treatment BMPs are required before discharging runoff off site through either infiltration or surface flow.

For TDAs with a mix of land use types, basic treatment BMPs are required when the runoff from the areas subject to the basic treatment requirement comprises 50 percent or more of the total runoff from the TDA.

Refer to basic treatment in Section 8.3.6. Select a BMP after reviewing the applicability and limitations, site suitability, and design criteria of each for compatibility with the site.

After selecting a basic treatment BMP, refer to the general requirements in Section 8.4. This guidance may affect the design and placement of BMPs on the site.

You have completed the runoff treatment BMP selection process.

8.2.2 Other Runoff Treatment BMP Selection Factors

The selection of a runoff treatment BMP should be based on site physical factors and pollutants of concern. The requirements for use of enhanced treatment or phosphorus treatment represent BMP selection based on pollutants of concern. Even if the site is not subject to those requirements, try to choose a BMP that is likely to remove the types of pollutants generated on the site. Integration of runoff treatment BMPs with flow control and spill containment measures should also be considered. The types of site physical factors that influence BMP selection are summarized below. Additional BMP-specific requirements are listed under the design sections for each BMP.

Soil Type

The permeability of the soil underlying a runoff treatment BMP has a profound influence on its effectiveness. This is particularly true for infiltration BMPs. Discharge of pollution-generating surfaces into a drywell, after pretreatment for solids reduction, can be acceptable if the soil conditions provide sufficient runoff treatment capacity. Drywells into gravelly soils are not likely to have sufficient treatment capability and must be preceded by at least a basic treatment BMP. See Section 8.6.3 for details.

Likewise, wet pond BMPs 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 BMP is typically required.

Other Physical Factors

Slope and Topography: Steep slopes restrict the use of several BMPs. For example, biofiltration swales are usually situated on sites with slopes of less than 6 percent, although greater slopes can be considered. Infiltration BMPs also have restrictions related to adjacent slope angle (see Chapter 7, Section 7.2.2).

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 seasonally-high or perched groundwater extends to within 5 feet from the bottom of an infiltration BMP, the site may not be suitable for infiltration (see Chapter 7, Section 7.2.2).

Depth to Bedrock/Glacial Till: The downward exfiltration of stormwater is also impeded if a bedrock or till layer lies too close to the surface. If the restrictive layer lies within 5 feet from the bottom of the infiltration BMP, the site may not be suitable for infiltration (see Chapter 7, Section 7.2.2). 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 problem if the BMP is located too close to a building foundation. Another risk is groundwater pollution; hence the requirement to site infiltration systems a specified distance away from drinking water wells (see Chapter 7, Section 7.2.2).

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.

8.3 Runoff Treatment BMP Options

This section identifies choices that comprise the runoff treatment BMP options referred to in Section 8.2. The BMP options in this section are discussed in the order of the decision process shown in Figure 8.1 and are as follows:

- Oil control, Section 8.3.2
- Phosphorus treatment, Section 8.3.3
- Enhanced treatment, Section 8.3.4
- Additional area-specific runoff treatment requirements, Section 8.3.5
- Basic treatment, Section 8.3.6

See also Section 8.11 for information on manufactured treatment devices that have a GULD that may be used for pretreatment, oil, phosphorus, enhanced, or basic treatment.

8.3.1 Guide to Applying BMP Options

Read the step-by-step selection process for runoff treatment BMPs in Section 8.2.

Determine which BMPs apply to the discharge situation. This will require knowledge of the receiving water(s) that the project site ultimately discharges to, and 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 control, choose one of the options presented in Section 8.3.2. Detailed designs for oil control BMPs are given in subsequent sections.

Note: One of the other three runoff treatment options will also need to be applied along with oil control.

Find the runoff treatment type(s) that applies to the project—basic, enhanced, and/or phosphorus.

A project site may be subject to both the enhanced treatment requirement and the phosphorus treatment requirement. In that event, select a BMP or a treatment train that is listed for both runoff treatment types.

Note: If flow control requirements apply, it may be more economical to use the combined detention/wet pool BMPs. Detailed BMP design criteria for all the possible options are provided in subsequent sections in this chapter.

Read Section 8.4 concerning general BMP requirements.

This guidance applies to all BMPs and may affect the design and placement of BMPs on the site.

8.3.2 Oil Control BMP Options

Note: Where oil control is applicable, it is in addition to BMPs required by one of the other runoff treatment types.

Application on the Project Site: Oil control BMPs are to be placed upstream of other BMPs, 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 oil control requirements. If common parking for multiple businesses is provided, oil control BMPs shall be applied to the number of parking stalls required for the business that requires oil control. However, if the runoff contributing to the oil control BMP includes runoff from other areas, the oil control BMP must be sized to treat all water passing through it.

Roadway intersections that trigger the above thresholds shall provide oil control for 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 area treated 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, oil control may be limited to any two of the collection areas.

Performance Goal: BMP choices for oil control 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 milligrams per liter (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. If the concentration of gasoline is of interest, the method for NWTPH-Gx should be used to analyze grab samples.

BMP Options: Oil control options include BMPs that are small, treat runoff from a limited area, and require frequent maintenance. The options also include BMPs that treat runoff from larger areas and generally have less frequent maintenance needs. **Note that the City will not accept ownership of some types of oil control BMPs without prior approval.**

- **API-Type Oil-water Separator** (see Section 8.10). Requires prior approval for City ownership.

- **Coalescing Plate Oil-water Separator** (see Section 8.10). Requires prior approval for City ownership.

- **Manufactured Treatment Devices** (see Section 8.11).

  Note: As manufactured treatment devices are approved by Ecology for meeting oil control requirements, these may be added to the City's approved list of acceptable BMPs. Additional BMPs will be accepted by the City on a case-by-case basis, after GULD approval by Ecology.

- **Linear Sand Filter** (see Section 8.7).
- **Note:** Linear sand filters may also be used to meet basic, enhanced, or phosphorus treatment. If used to satisfy one of those runoff treatment requirements, the same BMP shall not also be used to satisfy the oil control requirement unless increased maintenance (quarterly cleaning) is assured. This increase in maintenance is to prevent clogging of the filter by oil so that it will function for suspended solids and phosphorus removal, as well.
- **Oil Control Booms** (see Section 8.10, and the 2019 Washington State Department of Transportation [WSDOT] Highway Runoff Manual [HRM]).

8.3.3 Phosphorus Treatment BMP Options

Performance Goal: The phosphorus treatment BMP options are intended to achieve a goal of 50 percent total phosphorus removal for a range of influent concentrations of 0.1 to 0.5 mg/L total phosphorus. In addition, the phosphorus treatment BMPs are also intended to achieve the basic treatment performance goal. The performance goal applies to the water quality design volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the BMP (creating an off-line runoff treatment BMP) or can be passed through the BMP (creating an on-line runoff treatment BMP) provided a net pollutant reduction is maintained. The design and operation of runoff treatment BMPs that engage a bypass at flow rates higher than the water quality design flow rate is encouraged. 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 wet pool BMPs are always designed to be on-line.

Options: Any one of the following options may be chosen to satisfy the phosphorus treatment requirement:

- **Infiltration with Appropriate Pretreatment** – see Section 8.5 and 8.6. (Note that this option is only necessary for projects where stormwater is infiltrated within one-quarter mile of a fresh water body. Otherwise, phosphorus treatment is not required for infiltrating sites.)
    - Infiltration through soils meeting the minimum site suitability criteria for infiltration treatment (see Section 8.6). Note that a presettling basin or a basic treatment BMP is needed for pretreatment (see Section 8.5).
    - If the soils do not meet the soil suitability criteria **and** the infiltration site is within one-quarter mile of a fresh water body, treatment must be provided by one of the other treatment BMP options listed below.
- **Large Sand Filter** – see Section 8.7.
- **Large Wet Pond** – see Section 8.9.

- **Media Filter Drain** – see Section 8.7.

- **Bioretention** (only when constructed with a high performance bioretention soil mix). See Chapter 7, Section 7.4.4 for bioretention design requirements. Refer to the latest guidance on using high performance soil mixes, available on Ecology's website at: https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html

- **Manufactured Treatment Devices approved for phosphorus removal** – As manufactured treatment devices are approved by Ecology for meeting phosphorus treatment requirements, these may be added to the City's approved list of acceptable BMPs. Additional BMPs may be accepted by the City on a case-by-case basis, after GULD approval by Ecology.

- **Two-BMP Treatment Trains** – see Table 8.1.

Table 8.1. Treatment Trains for Phosphorus Removal.

First Basic Treatment BMP	Second Treatment BMP
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault
Vegetated Filter Strip	Linear Sand Filter (no presettling needed)
Linear Sand Filter	Vegetated Filter Strip
Basic Wet Pond	Basic Sand Filter or Sand Filter Vault
Wet Vault	Basic Sand Filter or Sand Filter Vault
Stormwater Treatment Wetland	Basic Sand Filter or Sand Filter Vault
Combined Detention and Wet Pool	Basic Sand Filter or Sand Filter Vault

8.3.4 Enhanced Treatment BMP Options

Performance Goal: The enhanced treatment BMP options are intended to provide a higher rate of removal of dissolved metals than basic treatment BMPs. The choices are intended to achieve the basic treatment performance goal. Based on a review of dissolved metals removal of basic treatment options, a "higher rate of removal" is currently defined at greater than 30 percent dissolved copper removal and greater than 60 percent dissolved zinc removal. The performance goal assumes that the BMP is treating stormwater with dissolved copper typically ranging from 0.005 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 volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the BMP (off-line treatment BMPs) or can be passed through the BMP (on-line treatment BMPs) provided a net pollutant reduction is maintained. The design and operation of treatment BMPs that engage a bypass at flow rates higher than the water quality design flow rate is encouraged as long as the reduction in dissolved metals loading exceeds that achieved with initiating bypass at the water quality design flow rate.

Options: Any one of the following options may be chosen to satisfy the enhanced treatment requirement:

- **Infiltration with Appropriate Pretreatment** – see Section 8.5 and 8.6.
    - Infiltration through soils meeting the minimum site suitability criteria for infiltration treatment (see Section 8.6). Note that a presettling basin or a basic treatment BMP is needed for pretreatment (see Section 8.5).
    - If the soils do not meet the soil suitability criteria, treatment must be provided by one of the other runoff treatment BMP options listed below.
- **Large Sand Filter** – see Section 8.7.
- **Stormwater Treatment Wetland** – see Section 8.9.
- **Compost-amended Vegetated Filter Strip (CAVFS)** – see Section 8.6.
- **Two BMP Treatment Trains** – see Table 8.2.

  Note: Secondary treatment BMPs may include manufactured treatment devices (Section 8.11) where appropriate and approved by the City.

Table 8.2. Treatment Trains for Dissolved Metals Removal.

First Basic Treatment BMP	Second Treatment BMP
Biofiltration Swale	Basic Sand Filter or Sand Filter Vault or
Vegetated Filter Strip	Linear Sand Filter with no presettling cell needed
Linear Sand Filter	Vegetated Filter Strip
Basic Wet Pond	Basic Sand Filter or Sand Filter Vault
Wet Vault	Basic Sand Filter or Sand Filter Vault
Basic Combined Detention/Wet Pool	Basic Sand Filter or Sand Filter Vault

- **Bioretention** – see Chapter 7, Section 7.4.4.

  Note: Stormwater runoff that infiltrates through the bioretention soil mix specified in Chapter 7 will receive enhanced treatment. If the site is also subject to phosphorus treatment requirements, bioretention must be constructed **without** imported composted materials (i.e., the underlying soils must meet the requirements for treatment in Section 8.6.3). Where bioretention/is intended to fully meet treatment requirements for its drainage area, it must be designed, using an approved continuous runoff model, to pass at least 91 percent of the influent runoff file through the bioretention soil mix.
- **Media Filter Drain** – See Section 8.7.

- **Manufactured Treatment Devices** – see Section 8.11 – As manufactured treatment devices are approved by Ecology for meeting enhanced treatment requirements, these may be added to the City's approved list of acceptable enhanced treatment BMPs. Additional BMPs may be accepted by the City on a case-by-case basis, after GULD approval by Ecology.

8.3.5 Additional Runoff Treatment Requirements

Performance Goal: The performance goal for the runoff treatment requirements outlined in this section vary depending on the pollutant of concern. See additional details below.

Bacteria Problem

1. The following runoff treatment BMPs, in order of preference, shall be used to meet the area–specific runoff treatment requirements if infiltration is not feasible:

   a. Sand filter (**Note:** if the site also requires phosphorus treatment or enhanced treatment, the sand filter must be a large sand filter per phosphorus and enhanced treatment.)

   b. Stormwater treatment wetland (**Note**: if the site also requires phosphorus treatment, the stormwater treatment wetland must be followed by a basic sand filter or sand filter vault per phosphorus treatment. If the site is also subject to temperature problems [see "Temperature Problem" heading below], refer to the wetland criteria described under temperature problems below.)

   c. Wet pond (**Note:** if the site also requires phosphorus treatment or enhanced treatment, the wet pond must be followed by a basic sand filter, a sand filter vault, or an Ecology-approved manufactured treatment device.)

   d. Other runoff treatment BMP only if combined with an Ecology-approved manufactured treatment device (refer to Section 8.11) that provides equivalent removal of bacteria

2. If the proposed project is a residential subdivision, then signage shall be provided in the subdivision's public areas (i.e., recreation/open space areas and right-of-way) requesting that pet waste be picked up in order to protect downstream water quality. The extent and location of this signage shall be reviewed and subject to approval by the City.

3. If the proposed project is a multifamily development with a recreation/open area or is a park improvement, then signage shall be provided requesting that pet waste be picked up in order to protect downstream water quality. A pet waste bag station and trash receptacle shall be provided near the signage. The extent and location of this signage and stationing shall be reviewed and subject to approval by the City.

Dissolved Oxygen (DO) Problem

1. A runoff treatment BMP option for phosphorus treatment shall be a component of the required treatment system (**Note:** if the site also requires enhanced treatment, choose a BMP option that also provides enhanced treatment).

2. If the proposed project includes a wet pond or wet vault, then the wet pool depth shall not exceed 6 feet, and the outflow system shall include a measure designed to promote aeration of the BMP's discharges for 2-year runoff events and smaller. (Note that wet vaults are only allowed if used as part of a two BMP treatment train, per Section 8.3.3.) One way to do this is to create a drop in flow elevation within a manhole by placing the outlet invert of the incoming pipe a minimum of 12 inches above the 2-year headwater elevation of the outgoing pipe. Alternatively, if the outflow system discharges to an open channel, the same drop in flow elevation could be achieved by placing the outlet invert a minimum of 12 inches above the 2-year tailwater elevation created by the channel. Other equivalent approaches may be used as approved by the City.

3. If the proposed project includes a wet vault, then the required ventilation area specified in Chapter 8 shall be doubled.

Temperature Problem

1. Use of a wet pond or wetland is prohibited unless it will be at least 50 percent shaded at midday in the summer or its discharges will flow through 200 feet or more of open channel that is at least 50 percent shaded at midday in the summer. The City must review and approve the extent and location of this shading. In addition, the outlet structure of the wet pond or wetland must include a bottom water release system that draws water from within 1 foot of the bottom of the permanent pool area near the outlet structure. Because bottom waters may have a low dissolved oxygen, aeration of the effluent water is required as described for the dissolved oxygen runoff treatment BMPs above.

2. If the proposed project includes open drainage features, then vegetation or other means shall be used where practicable to maximize shading of the drainage features, except biofiltration swales and vegetated filter strips. The extent and location of this shading shall be reviewed and approved by the City.

Summary of Additional Requirements

Table 8.3 summarizes the additional runoff treatment requirements associated with water quality problems known at the time this manual was developed.

Table 8.3. Summary of Additional Runoff Treatment Requirements.	
Problem Type	**Runoff Treatment Requirements**
Bacteria	• Use the following BMPs (in order of preference): sand filter, stormwater wetland, wet pond, or other treatment options if combined with an Ecology-approved manufactured treatment device that provides equivalent removal of fecal coliform bacteria. • If project is located in a residential subdivision, multifamily development with a recreation/open area, or is a park improvement, provide signage that pet waste be picked up, as well as a bag station and trash receptacle.
Dissolved Oxygen	• Use a phosphorus treatment BMP. • If a wet pond is used, the wet pool depth shall not exceed 6 feet, AND the outflow system shall include a measure designed to promote aeration of the BMP's discharges for 2-year runoff events and smaller • If a wet vault is used, required ventilation area shall be doubled
Temperature	• Use of a wet pond or wetland is prohibited unless it will be at least 50% shaded at midday in the summer or its discharges will flow through 200 feet or more of open channel that is at least 50% shaded at midday in the summer. In addition, a bottom water outlet structure with appropriate aeration must be employed. • If the proposed project includes open drainage features: • Vegetation or other means shall be used where practicable to maximize shading of the drainage features, except biofiltration swales and vegetated filter strips. • Flow control BMPs shall be applied the same way they would be applied if the project was located within a critical aquifer recharge area.

8.3.6 Basic Treatment BMP Options

Performance Goal: Basic treatment BMP options are intended to achieve 80 percent removal of TSS 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 BMPs are intended to achieve an effluent goal of 20 mg/L TSS.

The performance goal applies to the water quality design volume or flow rate, whichever is applicable. The incremental portion of runoff in excess of the water quality design flow rate or volume can be routed around the BMP (off-line treatment BMPs) or can be passed through the BMP (on-line treatment BMPs) provided a net TSS reduction is maintained.

Options: Any one of the following options may be chosen to satisfy the basic treatment requirement:

- **Infiltration** – see Section 8.6.
- **Sand Filters** – see Section 8.7.
- **Biofiltration Swales** – see Section 8.8.
- **Vegetated Filter Strips** – see Section 8.8.

- **CAVFS** – see Section 8.6.
- **Basic Wet Pond** – see Section 8.9.
- **Wet Vault** – see Section 8.9.

  Note: A wet vault may be used for commercial, industrial, or road projects if there are space limitations. Ecology and the City discourage the use of wet vaults for residential projects. Combined detention/wet vaults are allowed; see Section 8.9.3.

- **Stormwater Treatment Wetland** – see Section 8.9.
- **Combined Detention and Wet Pool Facilities** – see Section 8.9.3.
- **Bioretention Cells, Swales, and Planter Boxes** – see Chapter 7, Section 7.4.4.

  Note: Where bioretention is intended to fully meet treatment requirements for its drainage area, it must be designed, using an approved continuous runoff model, to pass at least 91 percent of the influent runoff file through the imported soil mix.

- **Media Filter Drain** – see Section 8.7.
- **Permeable Pavements** – see Chapter 7, Section 7.4.6.
- **Manufactured Treatment Devices** – see Section 8.11 – As manufactured treatment devices are approved by Ecology for meeting enhanced treatment requirements, these may be added to the City of Lacey's approved list of acceptable basic treatment BMPs. Additional BMPs may be accepted by the City of Lacey on a case-by-case basis, after GULD approval by Ecology.

8.4 General Requirements for Runoff Treatment BMPs

This section addresses general requirements for runoff treatment BMPs. Requirements discussed in this section include water quality design volumes and flows, sequencing of BMPs, liners, and hydraulic structures for splitting or dispersing flows. Additional requirements for individual BMPs are discussed in subsequent sections.

8.4.1 Runoff Treatment BMP Sizing

Size runoff treatment BMPs 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 (Chapter 2, Section 2.1.2) or the runoff treatment threshold decisions of Core Requirement #6 (Chapter 2, Section 2.2.6). Runoff treatment BMPs are sized by using either a volume (the water quality design volume) or a flow rate (the water quality design flow rate), depending on the runoff treatment BMP selected. Refer to the selected runoff treatment BMP to determine whether the BMP is sized based on a volume or a flow rate.

See below for details about the water quality design volume and the water quality design flow rate used to size runoff treatment BMPs.

Water Quality Design Volume

Using an approved continuous simulation model (e.g., the Western Washington Hydrology Model [WWHM]), the water quality design volume shall be the simulated daily volume that represents the upper limit of the range of daily volumes that accounts for 91 percent of the entire runoff volume over a multi-decade period of record.

Water Quality Design Flow Rate

Downstream of Detention BMPs: The water quality design flow rate shall be the full 2-year release rate from the detention BMP.

An approved continuous runoff model should identify the 2-year rate discharged by a detention BMP that is designed to meet the flow duration standard.

Preceding Detention BMPs or When Detention BMPs Are Not Required: The water quality design flow rate shall be the flow rate at or below which 91 percent of the total runoff volume, as estimated by an approved continuous simulation model, will be treated.

Design criteria for runoff treatment BMPs are assigned to achieve the applicable performance goal at the water quality design flow rate (e.g., basic treatment, enhanced treatment). At a minimum, 91 percent of the total runoff volume, as estimated by an approved continuous simulation model, must pass through runoff treatment BMP(s) at or below the approved hydraulic loading rate for the BMP(s).

- Off-line runoff treatment BMPs: For runoff treatment BMPs not preceded by an equalization or storage basin, and when runoff flow rates exceed the water quality design flow rate, the runoff treatment BMP must continue to receive and treat the water quality design flow rate to the applicable runoff treatment performance goal. Only the higher incremental portion of flow rates are bypassed around a runoff treatment BMP.

  Runoff treatment BMPs 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.

  Flow splitters can also be used to direct flows higher than the off-line water quality design flow rate to the runoff treatment BMP. These designs will act similarly to an on-line runoff treatment BMP, where flows higher than the off-line water quality design flow rate will not achieve the full performance goal, but will achieve some level of pollutant removal. If this option is selected, an increased maintenance frequency may be needed to accommodate the increase in pollutant accumulation within the BMP.

- On-line runoff treatment BMPs: Some BMP designs do not make use of a flow splitter and receive all of the stormwater runoff from the contributing basin. On-line runoff treatment BMPs must be designed using the on-line water quality design flow rate (as determined by an approved continuous runoff model). On-line runoff treatment BMPs treat flows up to the on-line water quality design flow rate to meet the performance goal and flows higher than the on-line water quality design flow rate pass through the BMP at a lower percent removal.

Flows Requiring Treatment

Runoff from pollution-generating hard or pervious surfaces must be treated. Pollution-generating hard surfaces (PGHS) are those hard surfaces considered to be a significant source of pollutants in stormwater runoff. PGHS include 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 Chapter 1 of this manual provides additional definitions and clarification of these terms.

PGHS, PGIS, and PGPS include those surfaces that receive direct rainfall, or run-on or blow-in of rainfall, and are subject to: vehicular use; industrial activities; or storage of erodible or leachable materials, wastes, or chemicals. Erodible or leachable materials, wastes, or chemicals are those substances that, 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 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, restricted access fire lanes, and infrequently used maintenance access roads.

PGPS are any pervious surface that receives direct rainfall, or run-on, or blow-in of rainfall and are subject to vehicular use; industrial activities (as further defined in the glossary); storage of erodible or leachable materials, wastes, or chemicals; the use of pesticides and fertilizers; or loss of soil. Typical PGPS include permeable pavements subject to vehicular use, lawns, and landscaped areas, including golf courses, parks, cemeteries, and sports fields (both natural and artificial turf).

Summary of Areas Needing Runoff Treatment

- All runoff from pollution-generating hard surfaces is to be treated through the runoff treatment BMPs specified in Section 8.2 and Section 8.3.

- Lawns and landscaped areas specified are pervious but also generate runoff into street drainage systems. In those cases, the runoff from the pervious areas must be estimated and added to the runoff from hard surface areas to size treatment BMPs.

- 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 runoff treatment, provided it meets the requirements outlined in Chapter 7, Section 7.4.2 for dispersion.

- Drainage from 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.

- Runoff from non-pollution-generating roofs is still subject to flow control per Core Requirement #7. The non-pollution-generating roof runoff that is directed to an infiltration trench or drywell must first pass through a catch basin as described under Downspout Infiltration Systems (see Chapter 7, Section 7.4.10). Note that metal roofs are considered pollution-generating unless they are coated with an inert non-leachable material. Roofs that are subject to venting of significant amounts of manufacturing, commercial, or other indoor pollutants are 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 groundwater, wetlands, and streams (see Chapter 7, Section 7.4.2 for flow dispersion requirements).

- 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 BMP. Once runoff from non-pollution generating areas is mixed with runoff from pollution-generating areas, it cannot be separated before treatment.

8.4.2 Sequence of BMPs

Enhanced treatment and phosphorus treatment, described in Section 8.3, include treatment options in which more than one type of treatment BMP is used. In those options, the sequence of BMPs is prescribed. This is because the specific pollutant removal role of the second or third BMP in a treatment often assumes that significant solids' settling has already occurred. For example, phosphorus treatment using a two-BMP treatment relies on the second BMP (sand filter) to remove a finer fraction of solids than those removed by the first BMP.

There is also the question of whether runoff treatment BMPs should be placed upstream or downstream of detention BMPs that are needed for flow control purposes. In general, all treatment BMPs may be installed upstream of detention BMPs, although presettling basins are needed for sand filter and sand infiltration systems. However, not all treatment BMPs can function effectively if located downstream of detention BMPs. Those BMPs that treat unconcentrated flows, such as vegetated filter strips, are usually not practical downstream of detention BMPs. Other types of treatment BMPs present special problems that must be considered before placement downstream is advisable.

For instance, prolonged flows discharged by a detention BMP that is designed to meet the flow duration standard of Core Requirement #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 biofiltration swale 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 BMP that is less sensitive to prolonged flows.

Oil control BMPs for runoff treatment must be located upstream of treatment and detention BMPs and as close to the source of oil-generating activity as possible.

Table 8.4 summarizes placement considerations of treatment BMPs in relation to detention.

Table 8.4. Runoff Treatment BMP Placement in Relation to Detention.

Runoff Treatment BMP	Preceding Detention	Following Detention
Basic biofiltration swale (Section 8.8)	OK	OK. Prolonged flows may reduce grass survival. Consider wet biofiltration swale.
Wet biofiltration swale (Section 8.8)	OK	OK
Vegetated filter strip (Section 8.8)	OK	No—must be installed before flows concentrate.
Basic or large wet pond (Section 8.9)	OK	OK—less water level fluctuation in ponds downstream of detention may improve aesthetic qualities and performance.
Basic or large combined detention and wet pond (Section 8.9)	Not applicable	Not applicable
Wet vault (Section 8.9)	OK	OK

Table 8.4 (continued). Runoff Treatment BMP Placement in Relation to Detention.		
Runoff Treatment BMP	**Preceding Detention**	**Following Detention**
Basic or large sand filter basin or sand filter vault (Section 8.7)	OK, but presettling and control of floatables needed	OK—sand filters downstream of detention BMPs may require field adjustments if prolonged flows cause sand saturation and interfere with phosphorus removal.
Stormwater treatment wetland/pond (Section 8.9)	OK	OK—less water level fluctuation and better plant diversity are possible if the stormwater wetland is located downstream of the detention BMP.

8.4.3 BMP Liners

Liners are intended to reduce the likelihood that pollutants in stormwater will reach groundwater when runoff treatment BMPs are constructed. In addition to groundwater protection considerations, some BMP types require permanent water for proper functioning. An example is the first cell of a wet pond.

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, 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. These types of liners are used for industrial or commercial sites with a potential for high pollutant loading in the stormwater runoff. Low permeability liners may be fashioned from geomembrane or concrete. See below for more specific design criteria for treatment liners and low permeability liners.

General Design Criteria

- Table 8.5 shows the type of liner required for use with various runoff treatment BMPs. Other liner configurations may be used with prior approval from the City.

Table 8.5. Lining Types Required for Runoff Treatment BMPs.		
Runoff Treatment BMP	**Area to be Lined**	**Type of Liner Required**
Presettling basin	Bottom and sides	Low permeability liner or treatment liner[a]
Wet pond	First cell: bottom and sides to water quality design water surface	Low permeability liner or treatment liner[a]
	Second cell: bottom and sides to water quality design water surface	Treatment liner
Combined detention/runoff treatment BMP	First cell: bottom and sides to water quality design water surface	Low permeability liner or treatment liner[a]
	Second cell: bottom and sides to water quality design water surface	Treatment liner
Stormwater wetland	Bottom and sides, both cells	Low permeability liner[a]

Table 8.5 (continued). Lining Types Required for Runoff Treatment BMPs.

Runoff Treatment BMP	Area to be Lined	Type of Liner Required
Basic and large sand filter 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[a]
Media filter (in vault)	Not applicable	No liner needed
Wet vault	Not applicable	No liner needed

[a] If the BMP will intercept the seasonal high groundwater table, a treatment liner may be recommended.

- Liners shall be evenly placed over the bottom and/or sides of the treatment area of the BMP as indicated in Table 8.5. Areas above the treatment volumes that are required to pass flows greater than the runoff 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:

  - Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. In these instances, use of a low permeability liner shall be evaluated and recommended by a geotechnical engineer.

  - Where grass must be planted over a low permeability liner per the BMP design, a minimum of 6 inches of good topsoil or compost-amended native soil must be placed over the liner in the area to be planted. Twelve inches of cover is preferred (see additional requirements for geomembrane liners).

- If a treatment liner will be below the seasonal high water level, the pollutant removal performance of the liner and BMP must be evaluated by a geotechnical or groundwater specialist and found to be as protective as if the liner and BMP were above the level of the groundwater.

Treatment Liner Design Criteria

This section presents the design criteria for treatment liners.

- A 2-foot thick layer of soil with a minimum organic content of 1 percent 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 BMP.

- To demonstrate that in-place soils meet the above criteria, one sample per 1,000 square feet of BMP area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer (usually 2 to 6 feet below the expected BMP 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 should 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.

  Ecology approved continuous simulation models must be run using the “No Infiltration” option through the sidewalls if one sidewall is impervious. Refer to Chapter 6, Section 6.2 for more information about Ecology approved continuous simulation models.

- Organic content shall be measured on a dry weight basis using ASTM D2974.

- CEC shall be tested using U.S. 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 City.

Low Permeability Liner Design Criteria

This section presents the design criteria for the two low permeability liner options: geomembrane liners and concrete liners.

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.

- The geomembrane fabric shall be protected from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane determined to have a high survivability per the Standard Specifications for Road, Bridge, and Municipal Construction (WSDOT Standard Specifications) as amended, specifically Section 9-33 Construction Geotextile (2021 or the latest version as amended). Equivalent methods for protection of the geomembrane liner will be considered. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing, and abrasion.

- Geomembranes shall be bedded according to the manufacturer’s recommendations.

- Liners must be covered with 12 inches of top dressing forming the bottom and sides of the water quality BMP, except for linear 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 BMP.

- 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

- Concrete liners may also be used for sedimentation chambers and for sedimentation and filtration basins less than 1,000 square feet in area. Concrete shall be 5-inch-thick Class 3000 or better and shall be reinforced by steel wire mesh. The steel wire mesh shall be six (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 shall have a minimum 6-inch compacted aggregate base consisting of coarse sand and river stone, crushed stone or equivalent with diameter of 0.75 to 1 inch. Where visible, the concrete shall be inspected annually and all cracks shall be sealed.

- Portland cement liners are allowed irrespective of BMP 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 BMP 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. 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.

8.5 Pretreatment

8.5.1 Purpose

This section presents the methods that may be used to provide pretreatment prior to basic or enhanced runoff treatment BMPs. Presettling basins are a typical pretreatment BMP used to remove suspended solids. All of the basic runoff treatment BMPs may also be used for pretreatment to reduce suspended solids.

8.5.2 Applications

Pretreatment must be provided where the basic treatment BMP or the receiving water may be adversely affected by non-targeted pollutants (e.g., oil), or may by overwhelmed by a heavy load of targeted pollutants (e.g., suspended solids). BMPs that require pretreatment include but are not limited to: sand filters, canister systems, infiltration basins, infiltration trenches, and infiltration galleries that receive runoff from pollution generating surfaces.

A detention pond sized to meet the flow control standard in Chapter 2 may also be used to provide pretreatment for suspended solids removal.

8.5.3 Best Management Practices for Pretreatment

This section has only one BMP for presettling basins. Ecology has approved some manufactured treatment devices for pretreatment through the TAPE process. See Ecology's Emerging Stormwater Treatment Technologies web page for a list of approved pretreatment technologies: < https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies >. Only those BMPs that have received a GULD may be used to meet the requirements of this manual.

Presettling Basin (Ecology BMP T6.10)

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 or to groundwater; it must be further treated by a basic or enhanced runoff treatment BMP.

Design Criteria

- A presettling basin shall be designed to include a wet pool sedimentation area at least 6 inches deep at the bottom of the BMP. The total treatment volume of the presettling basin shall be at least 30 percent of the total water quality design volume.

- Drawdown time of the presettling storage area (excluding wet pool area) must not exceed 48 hours.
- If the runoff in the presettling basin will be in direct contact with the soil (e.g., not within a concrete vault), it must be lined per the liner requirement in Section 8.4.3.
- The presettling basin shall conform to the following:
    - The length-to-width ratio shall be at least 3:1. Berms or baffles may be used to lengthen the flow path.
    - The minimum depth shall be 4 feet; the maximum depth shall be 6 feet.
- 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

All BMPs shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the City.

All BMPs shall be 100 feet from any septic tank/drainfield (except wet vaults shall be a minimum of 20 feet).

All BMPs shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical assessment 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). 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, or has an embankment height of greater than 6 feet at the downstream toe, then dam safety design and review are required by Ecology. See Chapter 7, Section 7.5, for more detail.

8.6 Infiltration and Bioretention Treatment BMPs

8.6.1 Purpose

This section provides site suitability, design, and maintenance criteria for infiltration treatment BMPs. Infiltration treatment BMPs serve the dual purpose of removing pollutants (TSS, heavy metals, phosphates, and organics) and recharging aquifers.

An infiltration treatment BMP is an impoundment, typically a basin, trench, gallery, or bioretention system. The infiltration treatment BMPs described in this section include:

- Infiltration Basins
- Infiltration Trenches
- Infiltration Galleries
- Bioretention Cells, Swales, and Planter Boxes
- Permeable Pavements
- CAVFS.

Note that the soil infiltration requirements for runoff treatment are substantially different from those for flow control. Soils used for infiltration 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. Specific requirements are outlined in Section 8.6.3 and 8.6.4 below.

8.6.2 Applications and Limitations

The infiltration and bioretention BMPs listed above are capable of achieving most of the performance objectives cited in Section 8.3 for specific runoff treatment options. 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 groundwater resources, and will not cause a violation of groundwater quality standards. The default bioretention soil mix (see Chapter 7, Section 7.4.4) is known to release elevated levels of nutrients for a period of time after installation. A high performance bioretention soil mix has been developed that may be used in locations near phosphorus-sensitive waterbodies. Refer to the latest guidance on using high performance soil mixes, available on Ecology's website at: <https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html>

Infiltration treatment BMPs 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 and nutrient control to prevent biofouling. Appropriate pretreatment devices may include a presettling basin, wet pond/vault, constructed wetland, media filter, and oil-water separator. An infiltration basin is preferred over a trench or gallery for ease of maintenance reasons.

Also note that the terms bioretention and rain garden are sometimes used interchangeably. However, in the City (in accordance with Ecology's distinction), the term "bioretention" is used to describe an engineered BMP that includes designed soil mixes and perhaps underdrains and control structures. The term "rain garden" is used to describe a landscape feature to capture stormwater on small project sites. Notable differences between rain gardens and bioretention areas include:

- Rain gardens have less restrictive design criteria for the soil mix and do not include underdrains and other control structures.

- Rain gardens are an on-site stormwater management BMP option for projects that only have to comply with Core Requirements #1 through #5.

- Bioretention areas are an on-site stormwater management BMP option for:
  1) projects that only have to comply with Core Requirements #1 through #5; and
  2) projects that trigger Core Requirements #1 through #10.

- Bioretention areas and rain gardens are applications of the same LID concept and can be highly effective for reducing surface runoff and removing pollutants.

8.6.3 Soil Suitability for Infiltration Treatment

Infiltration treatment BMPs that intend to use the native soil to provide runoff treatment (i.e., using an infiltration basin, trench, or gallery, as opposed to rain gardens, bioretention, or vegetated filter strips that each have specific soil media requirements) meet the requirements for basic, phosphorus, and enhanced treatment if 91 percent of the influent runoff file (indicated by an approved continuous simulation model) is successfully infiltrated within 48 hours. Soil suitability criteria #1 and #2 below apply for infiltration basins, trenches, and galleries (related requirements for bioretention and permeable pavements are covered in Chapter 7, Sections 7.4.4 and 7.4.6). (Note that bioretention designs may also be used without imported compost materials in areas where the native soils meet the criteria in this section.) Conformance with the below requirements shall be documented in the project Soils Report.

If the native soils do not meet the criteria below, runoff treatment must be provided prior to infiltration either by a layer within the infiltration BMP (such as is the case for bioretention), a runoff treatment BMP upstream of the infiltration BMP, or by a layer of engineered soil that meets the soil suitability criteria below. Refer to Chapter 7, Section 7.2.3 for guidance to determine the appropriate level of runoff treatment, based on land use and project type, that is necessary to precede the infiltration BMP.

Soil suitability criteria #1: The measured (initial) soil infiltration rate (field measured, before safety factors) must be 9 inches per hour, or less. Design (long-term) infiltration rates up to 3.0 inches per hour can be used with approval by the City, 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 soil suitability criteria #2 (summarized below) to adequately control the target pollutants.

Soil suitability criteria #2:

- Cation Exchange Capacity (CEC) of the soil must be greater than or equal to 5 milliequivalents per 100 grams of dry soil. Consider empirical testing of soil sorption capacity, if practicable. Ensure that soil CEC is sufficient for expected pollutant loadings, particularly heavy metals. Lower CEC content may be considered if it is based on a soil loading capacity determination for the target pollutants that is approved by the City.

- Organic content of the treatment soil (ASTM D2974): Organic matter can increase the sorptive capacity of the soil for some pollutants. A minimum of 1 percent organic content is necessary.

- Depth of soil used for infiltration runoff treatment must be a minimum of 18 inches (measured from the bottom of the BMP). Depth of soil below permeable pavements serving as pollution-generating hard surfaces may be reduced to 1 foot if the permeable pavement does not accept run-on from other surfaces.

- Waste fill materials shall not be used as infiltration soil media nor shall such media be placed over uncontrolled or non-engineered fill soils.

For all infiltration BMPs, the site infiltration rate must be determined using one of the methods described in detail in Chapter 7, Appendix 7A.

8.6.4 Best Management Practices for Infiltration and Bioretention Treatment

Although they are very effective at runoff treatment, five of the six BMPs discussed below (infiltration basins; infiltration trenches; infiltration galleries; bioretention cells, swales, and planter boxes; and permeable pavements) are more commonly designed to provide flow control, and therefore the design details for these BMPs are provided in Chapter 7, Section 7.4. This includes the imported soil requirements for bioretention BMPs, which meet the enhanced treatment requirements and do not typically require pretreatment. Selection of a specific BMP should be coordinated with the runoff treatment BMP options provided in Section 8.3. Soil suitability criteria #1 and #2 (outlined in Section 8.6.3) must be met for infiltration basins and trenches, as well as for bioretention BMPs designed without imported compost materials (i.e., if used in phosphorus treatment areas).

Infiltration Basins (Ecology BMP T7.10)

See Chapter 7, Section 7.2 for information pertinent to infiltration basins, trenches, and galleries. See Chapter 7, Section 7.4.9 for information specific to infiltration basins.

Infiltration Trenches (Ecology BMP T7.20)

See Chapter 7, Section 7.2 for information pertinent to infiltration basins, trenches, and galleries. See Chapter 7, Section 7.4.7 for information specific to infiltration trenches.

Infiltration Galleries

See Chapter 7, Section 7.2 for information pertinent to infiltration basins, trenches, and galleries. See Chapter 7, Section 7.4.8 for information specific to infiltration galleries.

Bioretention Cells, Swales, and Planter Boxes (Ecology BMP T7.30)

See Chapter 7, Section 7.4.4 for information specific to bioretention cells, swales, and planter boxes.

Permeable Pavements (Ecology BMP T5.15)

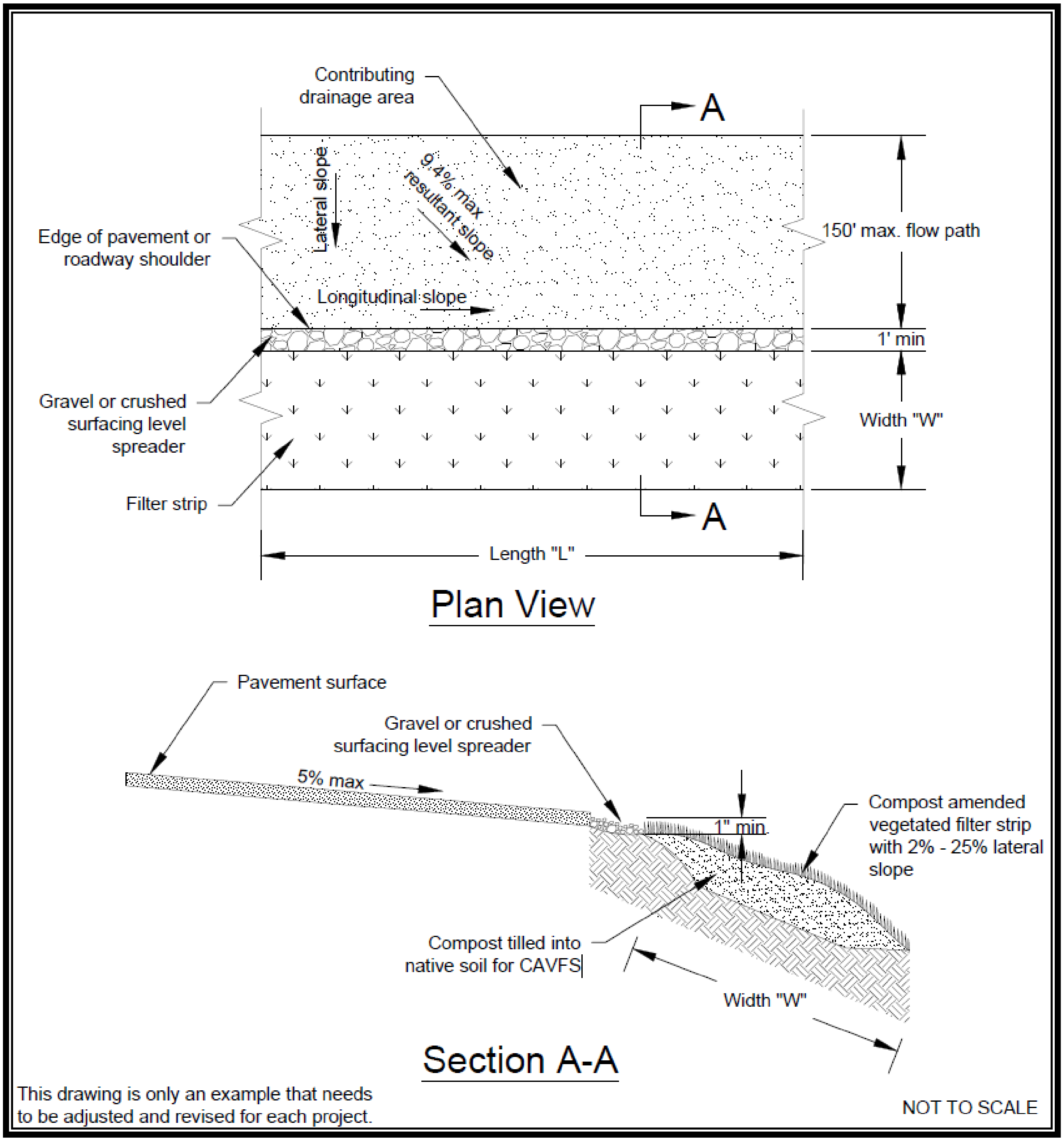
See Chapter 7, Section 7.4.6 for information specific to permeable pavements.

Compost-Amended Vegetated Filter Strip (CAVFS) (Ecology BMP T7.40)

The CAVFS is a variation of the vegetated filter strip that adds soil amendments to the roadside embankment (see Figure 8.2). 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. CAVFS have somewhat higher construction costs due to more expensive materials, but require less land area for runoff treatment, which can reduce overall costs.

Applications and Limitations

CAVFS can be used to meet basic and enhanced runoff treatment performance goals. It has practical application in areas where there is space for roadside embankments that can be built to the CAVFS specifications.



Source: Ecology

Figure 8.2. Example of a Compost Amended Vegetated Filter Strip (CAVFS).

Design Criteria

The CAVFS design incorporates composted material into the native soils in accordance with the criteria in postconstruction soil quality and depth BMP requirements for turf areas (see Chapter 7, Section 7.4.1). However, as noted below, the compost shall not contain biosolids or manure. 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 percent 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 percent organic content. Water or roll to compact soil to 85 percent 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 preapproved rate described above and still be able to achieve the 5 percent organic content target.

- The final soil mix (including compost and soil) shall have an initial saturated hydraulic conductivity less than 12 inches per hour, and a minimum long-term hydraulic conductivity of 1 inch per hour, per ASTM Designation D 2434 (Standard Test Method for Permeability of Granular Soils) at 85 percent 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" in bioretention cells, swales, and planter boxes (see Chapter 7, Section 7.4.4).

- The final soil mixture shall have a minimum organic content of 5 percent by dry weight per ASTM Designation D 2974 (Standard Test Method for Moisture, Ash and Organic Matter of Peat and Other Organic Soils).

- Achieving the above recommendations will depend on the specific soil and compost characteristics. In general, the recommendation can be achieved with 60 percent to 65 percent loamy sand mixed with 25 percent to 30 percent compost or 30 percent sandy loam, 30 percent coarse sand, and 30 percent compost.

- The final soil mixture shall be tested prior to installation for fertility, micronutrient analysis, and organic material content.

- Clay content for the final soil mix shall be less than 5 percent.

- Compost must not contain biosolids, manure, any street or highway sweepings, or any catch basin solids.

- The pH for the soil mix should be between 5.5 and 7.0. 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.

- The soil mix shall 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 soil mix should be loamy sand (USDA soil textural classification).

Compost Component

- Follow the specifications for compost for bioretention cells, swales, and planter boxes in (see Chapter 7, Section 7.4.4).

Landscaping (planting considerations) and Vegetation Establishment

Refer to the most recent version of the WSDOT HRM for specific criteria related to planting and vegetation establishment.

Modeling Method

The CAVFS will have an “element” in most of the approved continuous simulation models that must be used for determining the amount of water that is treated by the CAVFS. To fully meet runoff treatment requirements, 91 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 simulation models should be able to report the amount of water that it estimates will pass through the soil profile.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

8.7 Filtration Treatment BMPs

8.7.1 Purpose

This section presents criteria for the design and construction of runoff treatment filters including basin, vault, and linear filters. Filtration treatment BMPs collect and treat design runoff volumes to remove TSS, phosphorus, and insoluble organics (including oils) from stormwater. See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Five BMPs are discussed in this section:

- Basic Sand Filter Basin
- Large Sand Filter Basin
- Sand Filter Vault
- Linear Sand Filter
- Media Filter Drain (previously referred to as the Ecology embankment).

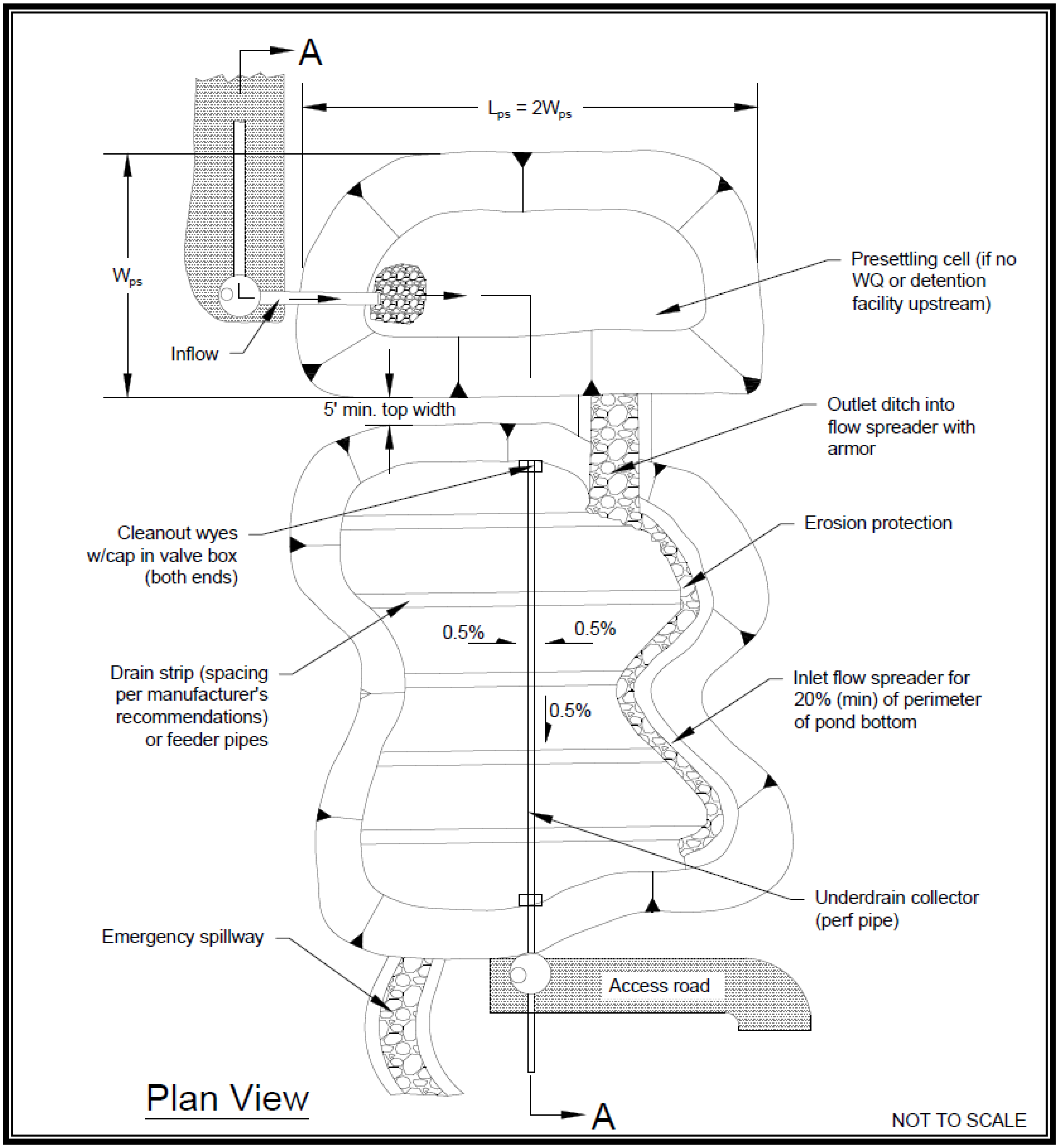
8.7.2 Description

A typical sand filtration system consists of a pretreatment system, flow spreader(s), sand bed, and 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 BMP if the filtered runoff requires additional treatment to remove soluble groundwater pollutants; or where additional groundwater protection is mandated.

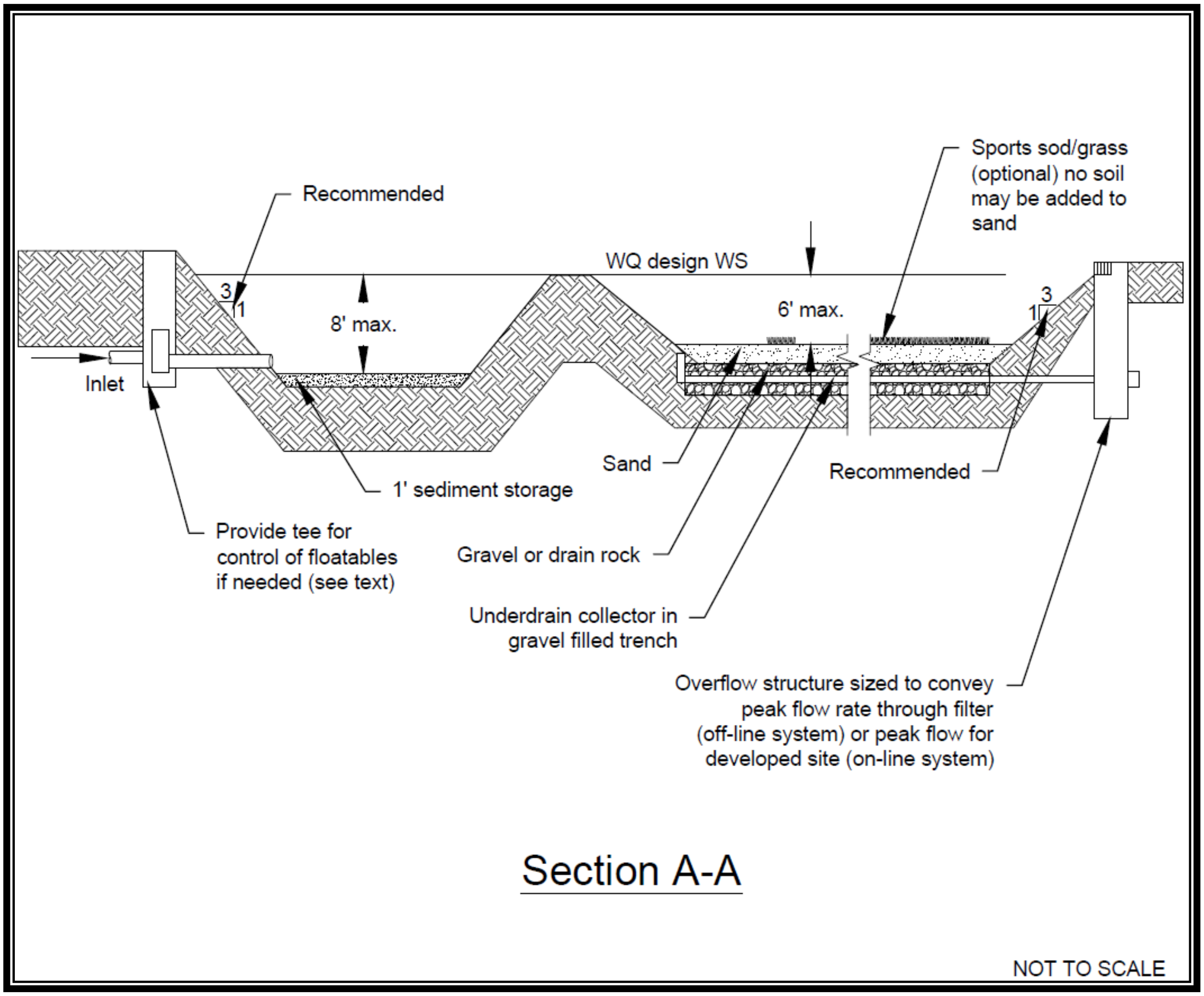
The variations of a sand filter include a basic or large sand filter basin, sand filter vault, linear sand filter, and media filter drain (MFD). Figures 8.3 through 8.7 provide examples of various sand filter configurations. Flow splitter configurations can be found in Chapter 6, Section 6.3.5.

The 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 crushed rock, perlite, dolomite, and gypsum.



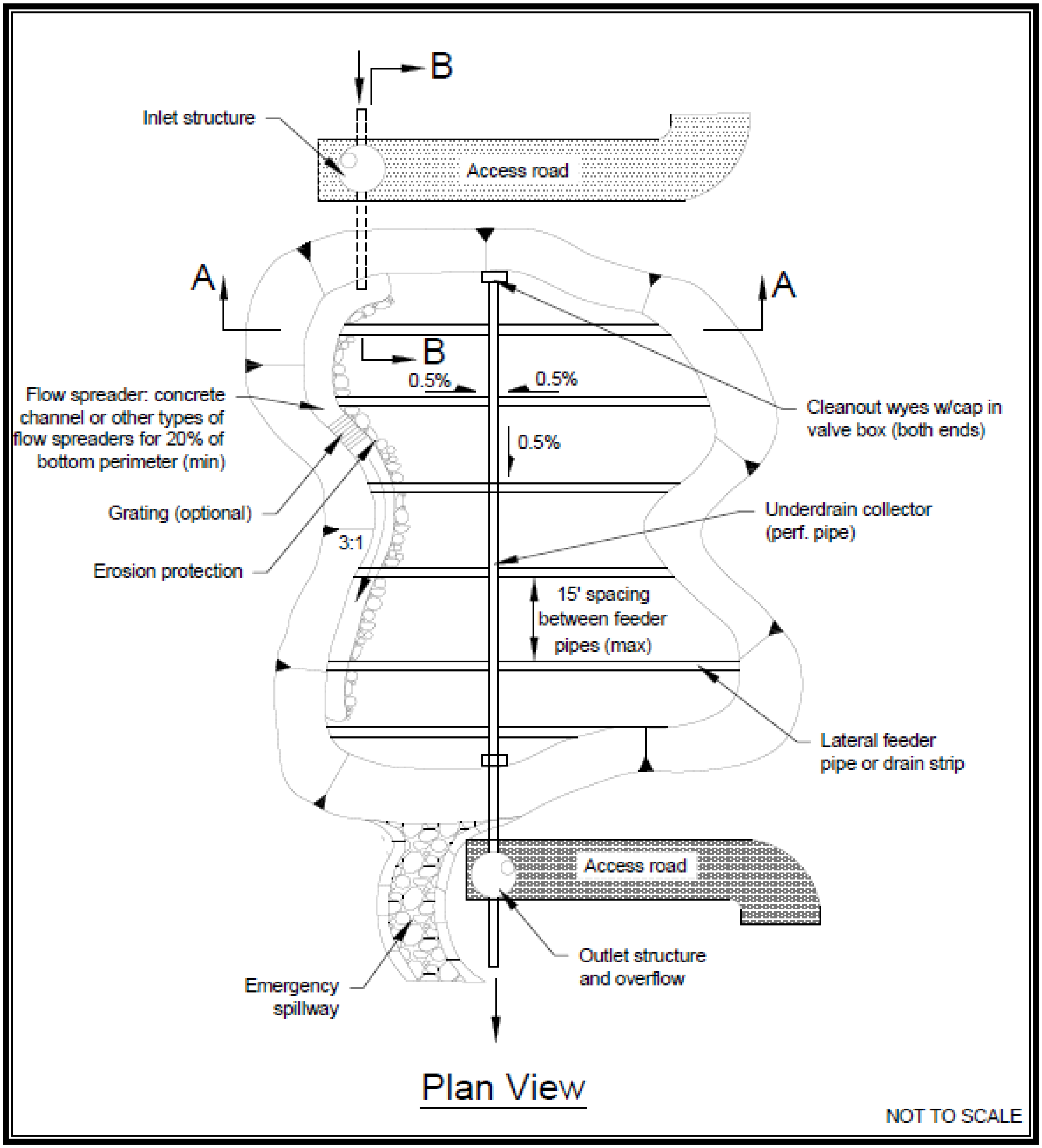
Source: Ecology

Figure 8.3a. Sand Filter Basin with Pretreatment Cell (plan view).



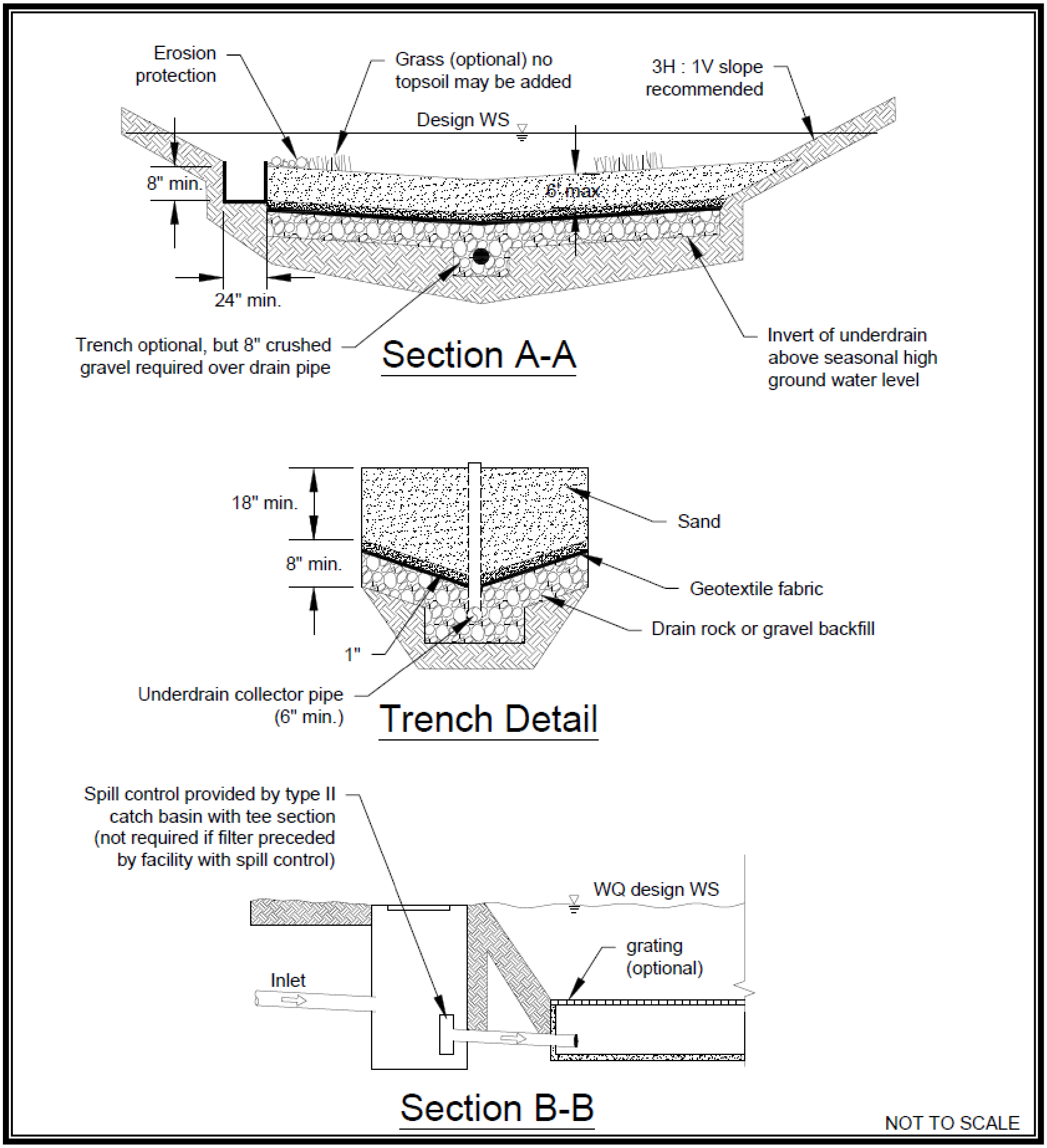
Source: Ecology

Figure 8.3b. Sand Filter Basin with Pretreatment Cell (section view).



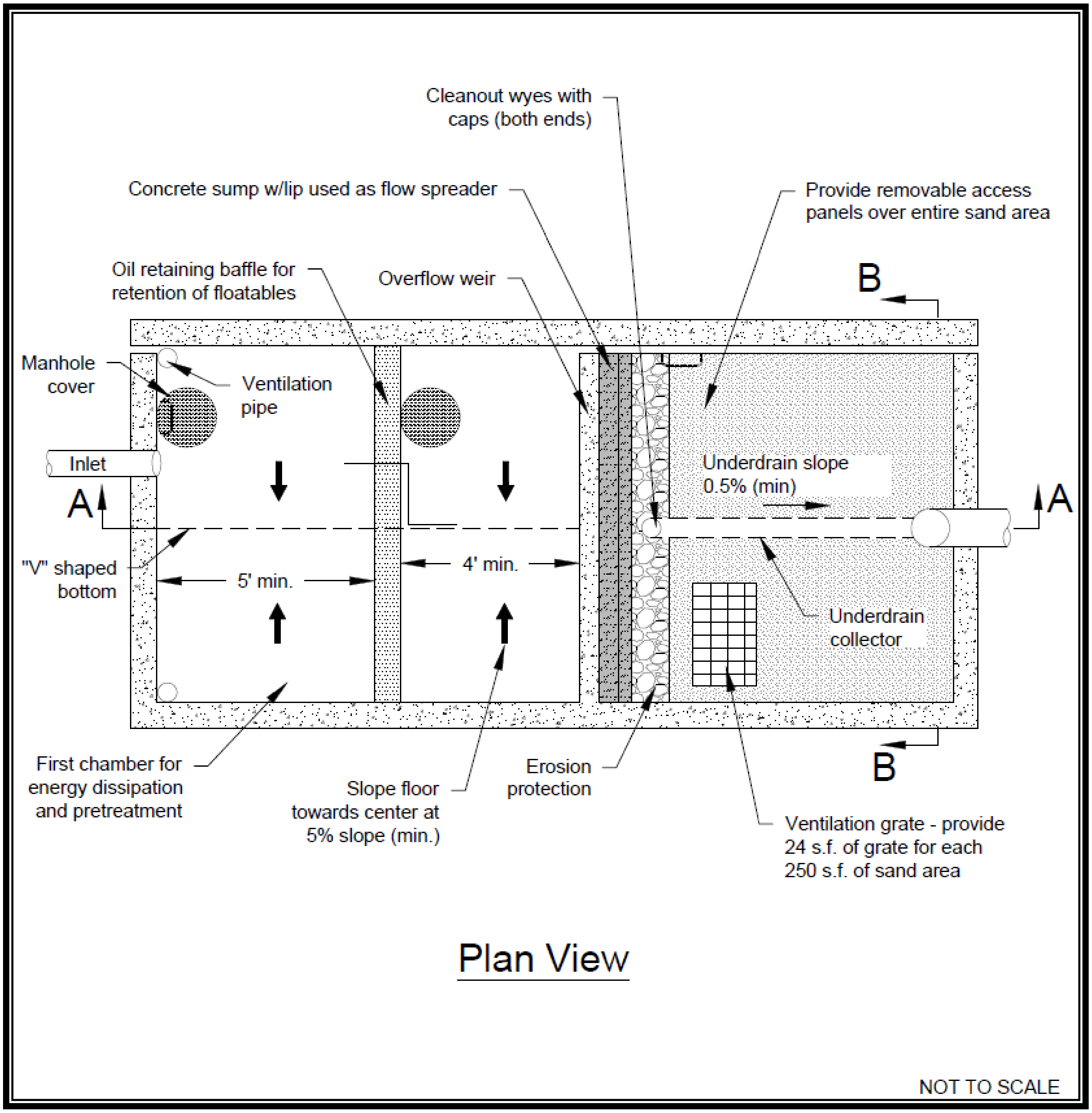
Source: Ecology

Figure 8.4a. Sand Filter Basin with Level Spreader (plan view).



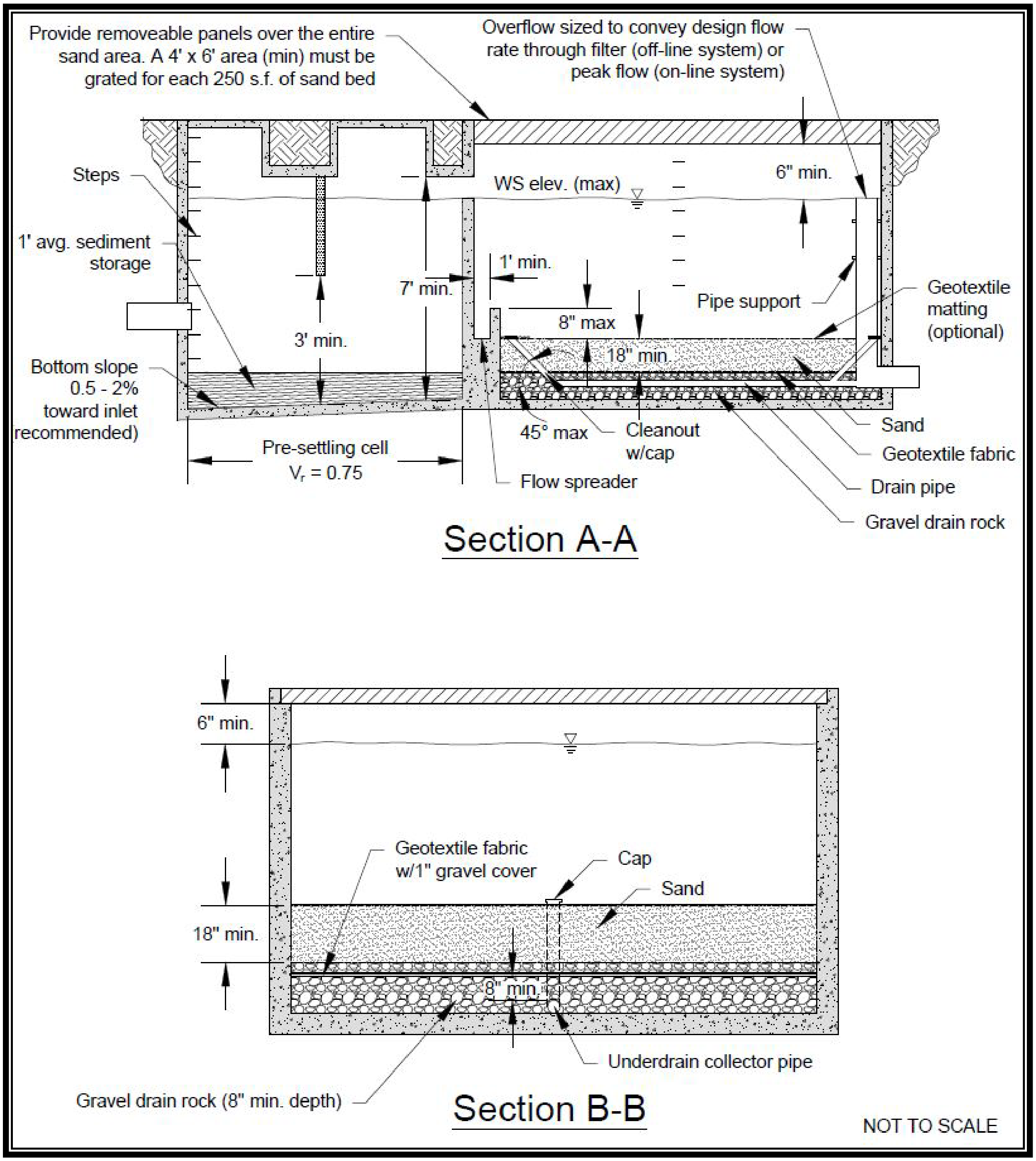
Source: Ecology

Figure 8.4b. Sand Filter Basin with Level Spreader (section view).



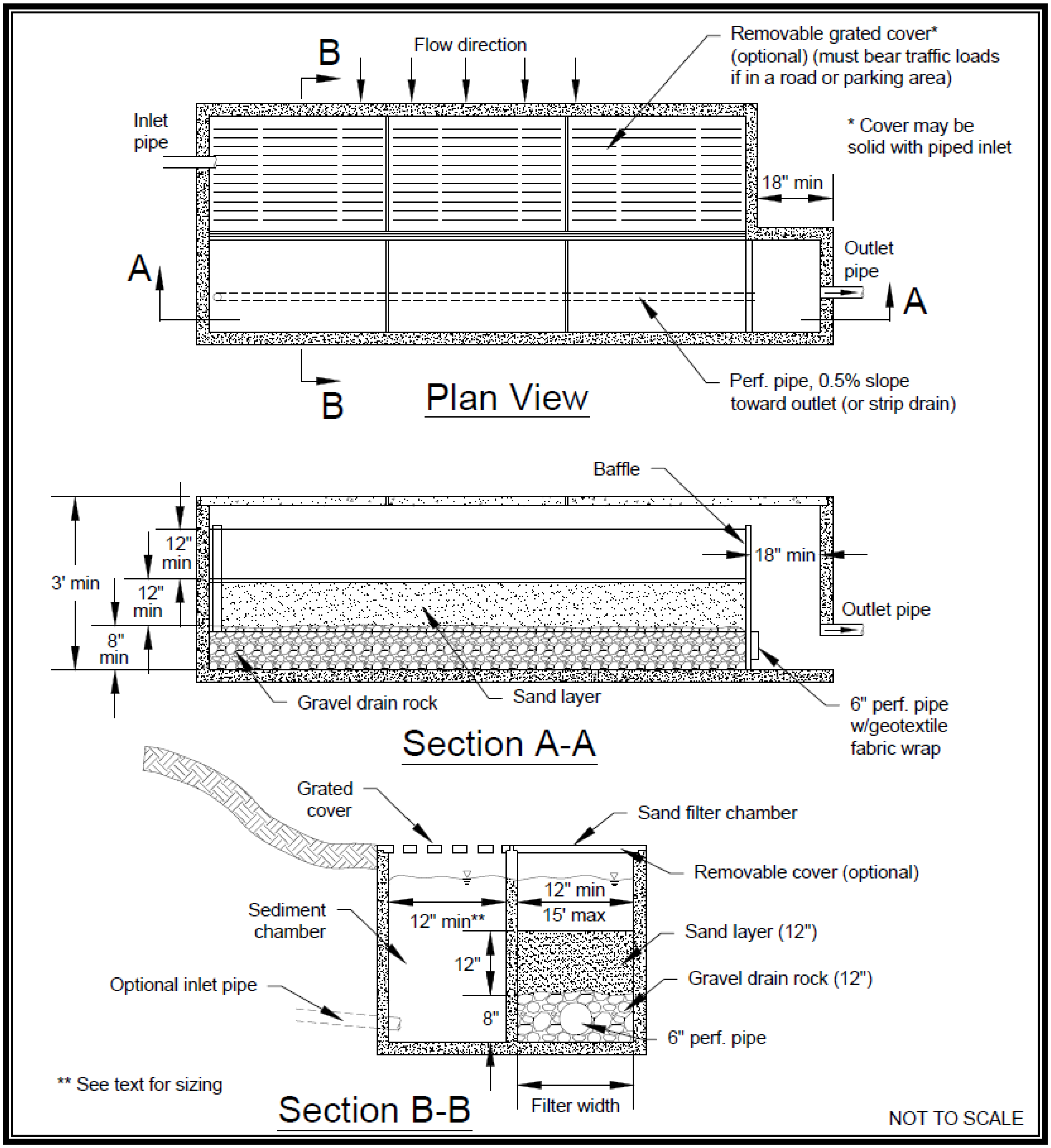
Source: Ecology

Figure 8.5a. Sand Filter Vault (plan view).



Source: Ecology

Figure 8.5b. Sand Filter Vault (section view).



Source: Ecology

Figure 8.6. Linear Sand Filter.

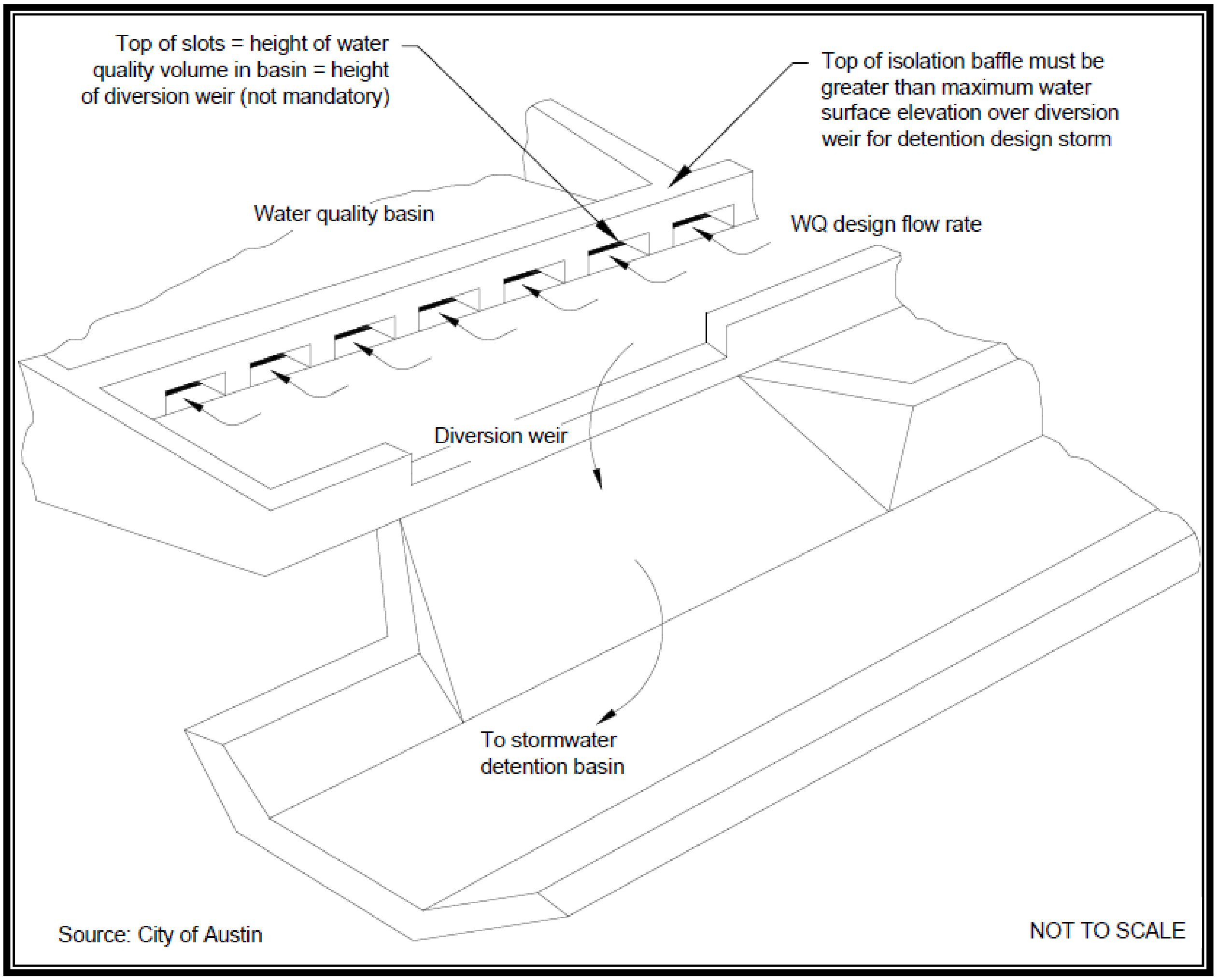


Figure 8.7. Example Isolation/Diversion Structure.

8.7.3 Performance Goals

Refer to Section 8.3 for descriptions of the basic, oil, phosphorus, and enhanced treatment goals.

Basic Sand Filter Basin, Sand Filter Vault, and Linear Sand Filter

Basic sand filter basins are expected to achieve the following runoff treatment goals:

- Basic treatment goal
- Oil treatment goal

Large Sand Filter Basin

Large sand filters are expected to meet the phosphorus treatment goal by collecting and treating 95 percent of the runoff volume. Only 5 percent of the total runoff volume as modeled by a continuous simulation model would bypass or overflow from a large sand filter basin.

Media Filter Drain

Media filter drains are expected to achieve the:

- Basic treatment goal
- Phosphorus treatment goal
- Enhanced treatment goal

8.7.4 Applications and Limitations

Filtration BMPs 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 filter, or where adequate pretreatment is provided for these pollutants. Specific applications include residential subdivisions, parking lots for commercial and industrial establishments, gas stations, sites that require oil control BMPs, high-density multifamily housing, roadways, and bridge decks.

Locate sand filter BMPs off-line before or after detention (Chang 2000). Sand filter vaults are suited for locations with space constraints in retrofit and new/redevelopment situations. Design overflow or bypass structures to handle the larger storms. Size off-line systems to treat 91 percent of the runoff volume predicted by a continuous simulation model. If a project must comply with Core Requirement #7, route both the flows bypassing the filtration BMP and the treated water to a flow control BMP.

A pretreatment BMP is necessary to reduce velocities to the sand filter BMP and remove debris, floatables, large particulate matter, and oils. In high water table areas, adequate drainage of the sand filter BMP may require additional engineering analysis and design considerations. Consider an underground sand filter in areas subject to freezing conditions (Urbonas 1997).

8.7.5 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
- Sufficient pretreatment of oil, debris, and solids in the tributary runoff.

8.7.6 Design Requirements

Sand filter BMPs must capture and treat the water quality design volume, which is 91 percent of the total runoff volume (95 percent for large sand filter basin) as predicted by an approved, equivalent continuous runoff model. Only 9 percent of the total runoff volume (5 percent for large sand filter) would bypass or overflow from the sand filter BMP. **Additional design criteria specific to each sand filter BMP are provided at the end of this section. The criteria outlined under the basic sand filter basin BMP apply to all sand filter BMPs, unless otherwise noted under the subsequent BMP descriptions for sand filter vaults and linear sand filters.**

Sand Filter Sizing Procedure

The following design criteria apply to all sand filter BMPs, unless otherwise noted under the subsequent BMP descriptions for sand filter vaults and linear sand filters.

General BMP sizing methods are provided below, followed by design criteria to be used when designing a sand filter BMP with an approved continuous simulation model.

Modeling Method

When using continuous simulation modeling to size a sand filter BMP, apply the assumptions listed in Table 8.6. Several approved continuous simulation models include built-in elements to size sand filter BMPs.

Table 8.6. Sand Filter Design and Sizing Criteria.

Variable	Assumption
Computational Time Step	15 minutes
Inflows to BMP	Model output for water quality design
Ponding Depth	Maximum water depth over the filter media
Precipitation Applied to BMP	Checked (always activated when sizing above ground sand filters)
Evaporation Applied to BMP	Checked (always activated when sizing above ground sand filters)
Media depth	18 inches or other as designed
Infiltration Reduction Factor	Inverse of safety factor (i.e., safety factor of 2 is a reduction factor of 0.5). Safety factors for infiltration rates are discussed in Chapter 7, Appendix 7A.
Sand Media Hydraulic Conductivity	1 inch per hour
Use Wetted Surface Area	Only if side slopes are 3:1 or flatter

8.7.7 Construction Criteria

Until all project improvements are completed that produce surface runoff, and all exposed ground surfaces are stabilized by revegetation or landscaping, sand filtration systems may not be operated, and no surface runoff may be permitted to enter the system. Construction runoff may be routed to a pretreatment sedimentation BMP, but discharge from sedimentation BMPs should bypass downstream sand filter BMPs.

Careful level placement of the sand is necessary to avoid formation of voids within the sand filter 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 must 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 to 15 gallons of water per cubic foot of sand.

8.7.8 Best Management Practices for Sand Filtration

Basic Sand Filter Basin (Ecology BMP T8.10)

The following design requirements apply to all sand filter BMPs, unless otherwise noted under the subsequent descriptions for sand filter vaults and linear sand filters.

A basic sand filter basin is constructed so that its surface is at grade and open to the elements, similar to an infiltration basin. However, instead of infiltrating into native soils, stormwater filters through a constructed sand bed with an underdrain system. See Figures 8.3 through 8.7.

Basic and Large Sand Filter Basins

A summary of the basic and large sand filter basin design requirements are given below.

On-Line Sand Filter Design

- On-line sand filter BMPs shall 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.
- Size on-line sand filter BMPs placed ***downstream*** of a detention BMP using an approved continuous simulation model to filter the water quality design flow rate.
- 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 sand filter BMPs shall have overflows (primary, secondary, and emergency) in accordance with the design criteria for detention ponds.

Off-Line Sand Filter Design

- Off-line sand filters placed ***upstream*** of a detention BMP must have a flow splitter designed to send all flows at or below the 15-minute water quality design flow rate, as predicted by an approved continuous simulation model, to the sand filter BMP.
- The sand filter BMP must be sized to filter all the runoff sent to it (no overflows from the treatment BMP shall occur). Note that WWHM allows any bypasses and

the runoff filtered through the sand to be directed to the downstream detention BMP.

- ***Off-line*** sand filter BMPs placed ***downstream*** of a detention BMP must have a flow splitter designed to send all flows at or below the 2-year peak inflow rate from the detention pond, as predicted by an approved continuous simulation model, to the runoff treatment BMP. The sand filter BMP must be sized to filter all the runoff sent to it (no overflows from the sand filter BMP shall occur).

- For off-line sand filter BMPs downstream of a detention BMP, design the underdrain structure to pass the 2-year peak inflow rate, as determined using 15-minute time steps in an approved continuous simulation model.

Additional Design Criteria for Basic and Large Sand Filter Basins

Hydraulics

- Pretreat (e.g., presettling basin or other methods, depending on pollutants) runoff directed to the sand filter BMP to remove debris and other solids. In high-use sites, the pretreatment should be an appropriate oil treatment as described in Section 8.3.2.

- If the drainage area maintains a base flow between storm events, bypass the base flow around the filter to keep the sand filter BMP from remaining saturated for extended periods.

- Assume a design filtration rate of 1 inch per hour. Though the sand medium specified below will initially infiltrate at a much higher rate, that rate will slow as the sand 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.

- Design inlet bypass and flow spreading structures (e.g., flow spreaders, weirs, or multiple orifice openings) 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 to prevent gouging of the sand medium and to promote uniform flow. Include emergency spillway or overflow structures.

    - If the sand filter is curved or an irregular shape, provide a flow spreader for a minimum of 20 percent of the filter perimeter.

    - If the length-to-width ratio of the sand filter is 2:1 or greater, locate a flow spreader on the longer side of the sand filter and for a minimum length of 20 percent of the sand filter perimeter.

  - Provide erosion protection along the first foot of the sand filter adjacent to the flow spreader. Methods for this include geotextile weighted with sand bags at 15-foot intervals and quarry spalls.

- Include an ***overflow*** in the design. The overflow height must 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 (Chapter 7, Section 7.5.1).

Underdrains

- Types of underdrains include:
  - A central collector pipe with lateral feeder pipes, 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.
  - Longitudinal pipes in an 8-inch gravel backfill or drain rock with a collector pipe at the outlet end.

- Size underdrain piping to handle the 2-year recurrence frequency flow indicated by an approved continuous simulation model (using a 15-minute time step). Note that for large sand filter basins, size the underdrain using: (95 percent Runoff Volume)/(91 percent Runoff Volume) * 2-year recurrence interval flow (using a 15-minute time step).

- Use underdrain pipe with a minimum of internal diameter of 6 inches, with two rows of 1/2-inch holes spaced 6 inches apart longitudinally (maximum), and rows 120 degrees apart (laid with holes downward). Maintain a maximum perpendicular distance between two feeder pipes, or the edge of the sand filter and a feeder pipe, of 15 feet. All piping is to be schedule 40 PVC or greater wall thickness.

- Slope the main collector underdrain pipe 0.5 percent minimum.

- Use a geotextile fabric (specifications in Appendix 8A) between the sand layer and drain rock or gravel. Cover the geotextile fabric with 1 inch of drain rock/gravel. Drain rock shall be 0.75- to 1.5-inch rock or gravel backfill, washed free of clay and organic material.

- Place cleanout wyes with caps or junction boxes at both ends of the collector pipes. Extend cleanouts to the surface of the filter. Supply a valve box for access to the cleanouts.

Sand Medium Specification

- Sand shall be 18 inches minimum depth. The sand in a filter must consist of a medium sand meeting the size gradation (by weight) given in Table 8.7. 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. (**Note:** Do not use WSDOT Standard Specification 9-03.13 Backfill for Sand Drains or 9-03.13(1) Sand Drainage Blanket. Neither of these WSDOT Standard Specifications meet the required specification for sand filter BMPs).

Table 8.7. Sand Medium Specification.

U.S. Sieve Number	Percent Passing
4	100
8	70–100
16	40–90
30	25–75
50	2–25
100	<4
200	<2

Impermeable Liners for Sand Bed Bottom

- Impermeable liners are required where the underflow could cause problems with structures. If an impermeable liner is not provided, then an analysis must be provided identifying possible adverse effects of seepage zones on groundwater, and near building foundations, basements, roads, parking lots, and sloping sites. Sand filters without impermeable liners shall not be built on fill sites and must be located at least 20 feet downslope and 100 feet upslope from building foundations.

- Impermeable liners shall consist of geomembrane or concrete.

- If a geomembrane liner is used it must have a minimum thickness of 30 mils and be ultraviolet resistant. Protect the geomembrane liner from puncture, tearing, and abrasion by installing geotextile fabric on the top and bottom of the geomembrane. (See Section 8.4.3.)

- 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 must be 5 inches thick Class A or better and reinforced by steel wire mesh. The steel wire mesh must 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 must 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 must be installed that retains the sand and meets the specifications listed in Appendix 8A, unless the basin has been excavated to bedrock.

Other Criteria

- Include an access ramp with a maximum grade of 15 percent, or equivalent, for maintenance purposes at the inlet and the outlet of a surface filter. Consider an access port for inspection and maintenance.
- Side slopes for earthen/grass embankments must not exceed 3:1 to facilitate mowing.
- High groundwater may damage underground structures or affect the performance of sand filter BMP underdrain systems. There must be sufficient clearance (at least 2 feet) between the seasonal high groundwater level and the bottom of the sand filter to obtain adequate drainage.

Sand Filter Vault (Ecology BMP T8.20)

A sand filter vault (see Figures 8.5a and 8.5b) 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 sand filter vaults where space limitations preclude aboveground BMPs.
- Sand filter vaults are not suitable where high water table and heavy sediment loads are expected.
- In high water table areas, buoyancy and infiltration must be accounted for in the design.
- An elevation difference of 4 feet between inlet and outlet of the sand filter vault is needed.

Design Criteria for Sand Filter Vaults

- See design criteria for sand filter basins in Section 8.7.8 above.
- Sand filter vaults may be designed as off-line systems or on-line for small drainages.

- In an off-line system, a diversion structure must be installed to divert the design flow rate into the sediment chamber and bypass the remaining flow to a flow control BMP(if necessary to meet Core Requirement #5, #7, and/or #8), 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 shall 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 sand filter bed shall 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 presettling 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 1 foot above to 1 foot below the design flow water level. Provision for the passage of flows in the event of plugging must be provided. Access opening and ladders must be provided on both sides of the baffle.

- To prevent anoxic conditions, a minimum of 24 square feet of ventilation grate shall 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.

Linear Sand Filter (Ecology BMP T8.30)

Linear sand filters (see Figure 8.6) are typically long, shallow, two-celled, rectangular vaults. The first cell is designed for settling coarse particles, and the second cell contains a sand filter bed. Stormwater flows into the second cell via a weir section that also functions as a flow spreader.

Application and Limitations

- Linear sand filters are applicable in long narrow spaces such as the perimeter of a paved surface.
- Linear sand filters can be used as a part of a treatment train as downstream of a vegetated filter strip, upstream of an infiltration BMP, or upstream of a wet pond or a biofiltration BMP for oil control.
- Linear sand filters are appropriate to treat runoff from small contributing basins (less than 2 acres of impervious area).
- Linear sand filters are appropriate to treat runoff from sites that require an oil control BMP.

Additional Design Criteria for Linear Sand Filters

- The two cells shall be divided by a divider wall that is level and extends a minimum of 12 inches (minimum of 6 inches) above the top of the sand bed.
- Stormwater may enter the sediment cell by sheet flow or a piped inlet.
- The width of the sand filter 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 described in sand filter vaults.
- Linear sand filters must conform to the materials and structural suitability criteria specified for wet vaults.
- Set the presettling cell width in Table 8.8 as follows:

Table 8.8. Presettling Cell Width.

Item	Dimensions			
Sand filter width, (w) inches	12-24	24-48	48-72	72+
Presettling cell width, inches	12	18	24	w/3

Media Filter Drain (Ecology BMP T8.40)

The MFD, previously referred to as the Ecology embankment, is a linear, flow-through, stormwater runoff treatment device that can be sited along roadway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Cut-slope applications may also be considered. The MFD can be used where available right-of-way is limited, sheet flow from the roadway surface is feasible, and lateral gradients are generally less than 25 percent (4H:1V). The MFD has a 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 WSDOT HRM Resource web page <https://www.wsdot.wa.gov/Publications/Manuals/M31-16.htm>.

Media filter drains 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. This layer of crushed surfacing base course must be porous enough to allow treated flows to freely drain away from the MFD mix.

Typical MFD configurations are shown in Figures 8.8, 8.9, and 8.10.

The MFD removes suspended solids, phosphorus, and metals from roadway runoff through physical straining, ion exchange, carbonate precipitation, and biofiltration.

The underdrain trench is an option for hydraulic conveyance of treated stormwater to a desired location, such as a downstream flow control BMP or stormwater outfall. The trench’s perforated underdrain pipe is a protective measure to ensure free flow through the MFD 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 MFD mix and underdrain trench.

It is critical to note that water must sheet flow across the MFD. Channelized flows or ditch flows running down the middle of the dual MFD (continuous off-site inflow) shall be minimized.

Application and Limitations

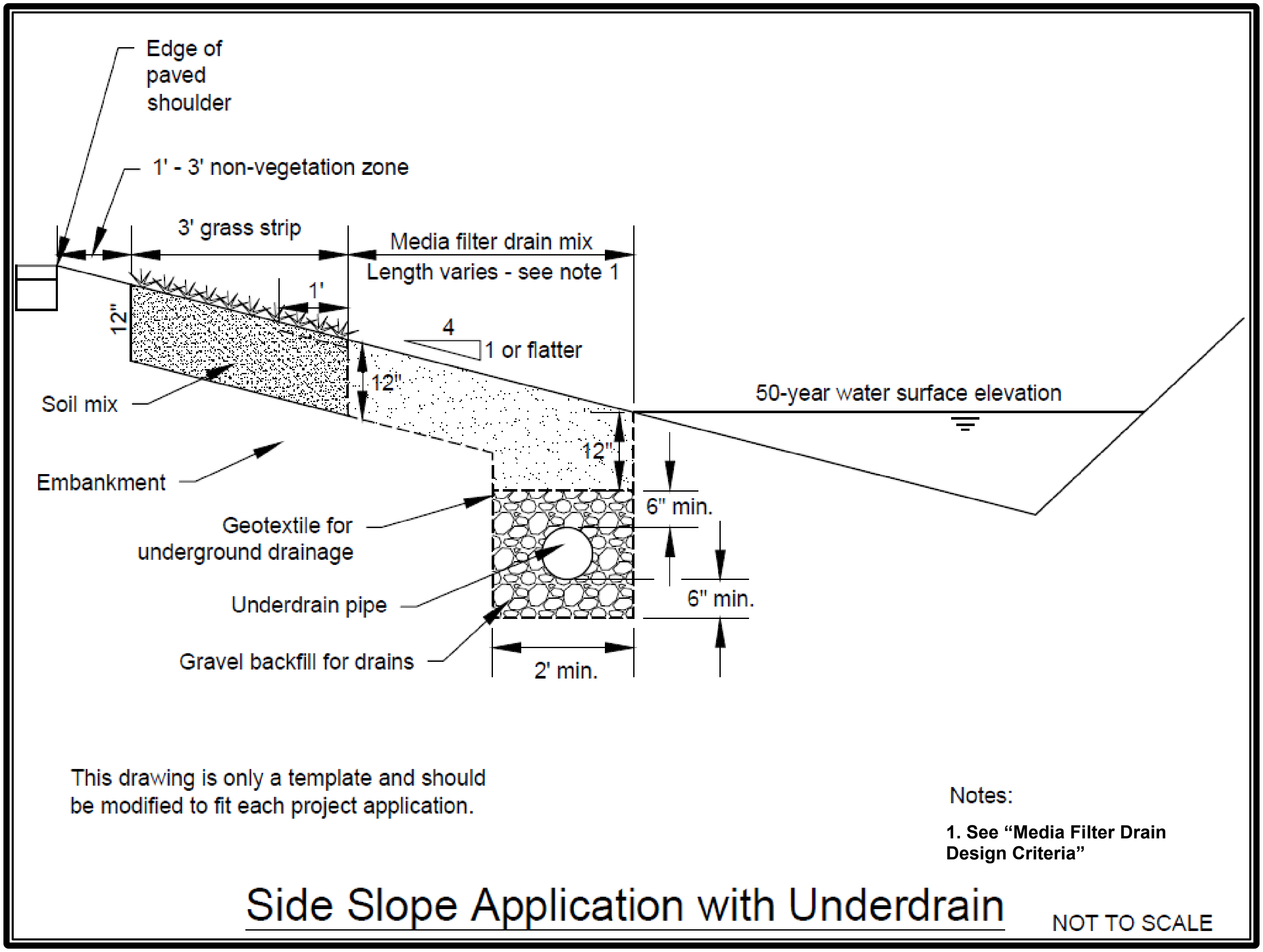
In many instances, conventional runoff treatment is not feasible due to right-of-way constraints (such as adjoining wetlands and geotechnical considerations). The MFD and the dual MFD designs are runoff treatment options that can be sited in most right-of-way confined situations. In many cases, a MFD or a dual MFD can be sited without the acquisition of additional right-of-way needed for conventional stormwater BMPs or capital-intensive expenditures for underground wet vaults.

Applications

Media Filter Drain

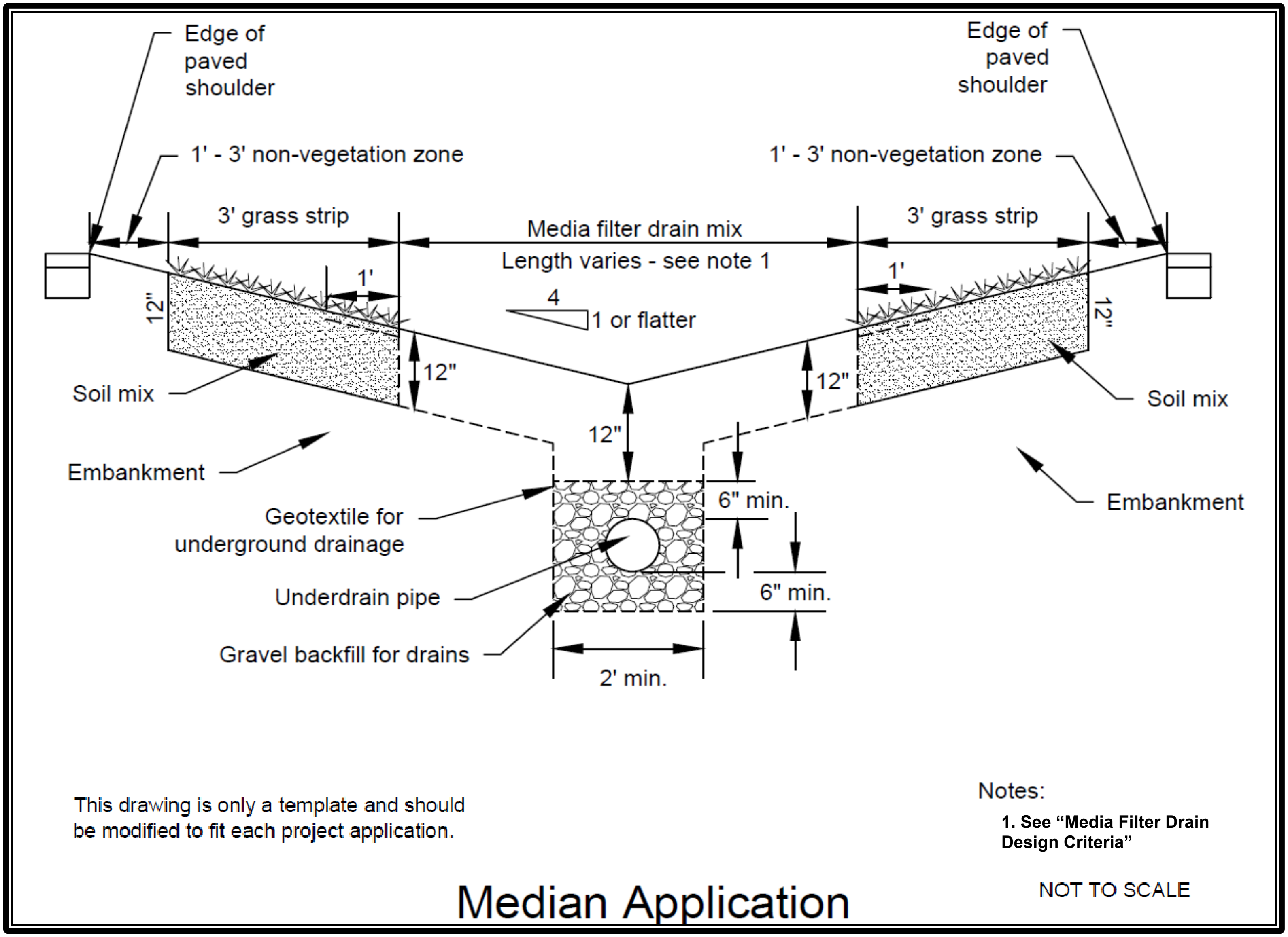
The MFD can achieve basic, phosphorus, and enhanced treatment.

Since maintaining sheet flow across the MFD is required for its proper function, the ideal locations for MFDs in roadway settings are roadway side slopes or other long, linear grades with lateral side slopes less than 4H:1V and longitudinal slopes no steeper than 5 percent. 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 MFD shall not exceed 150 feet.



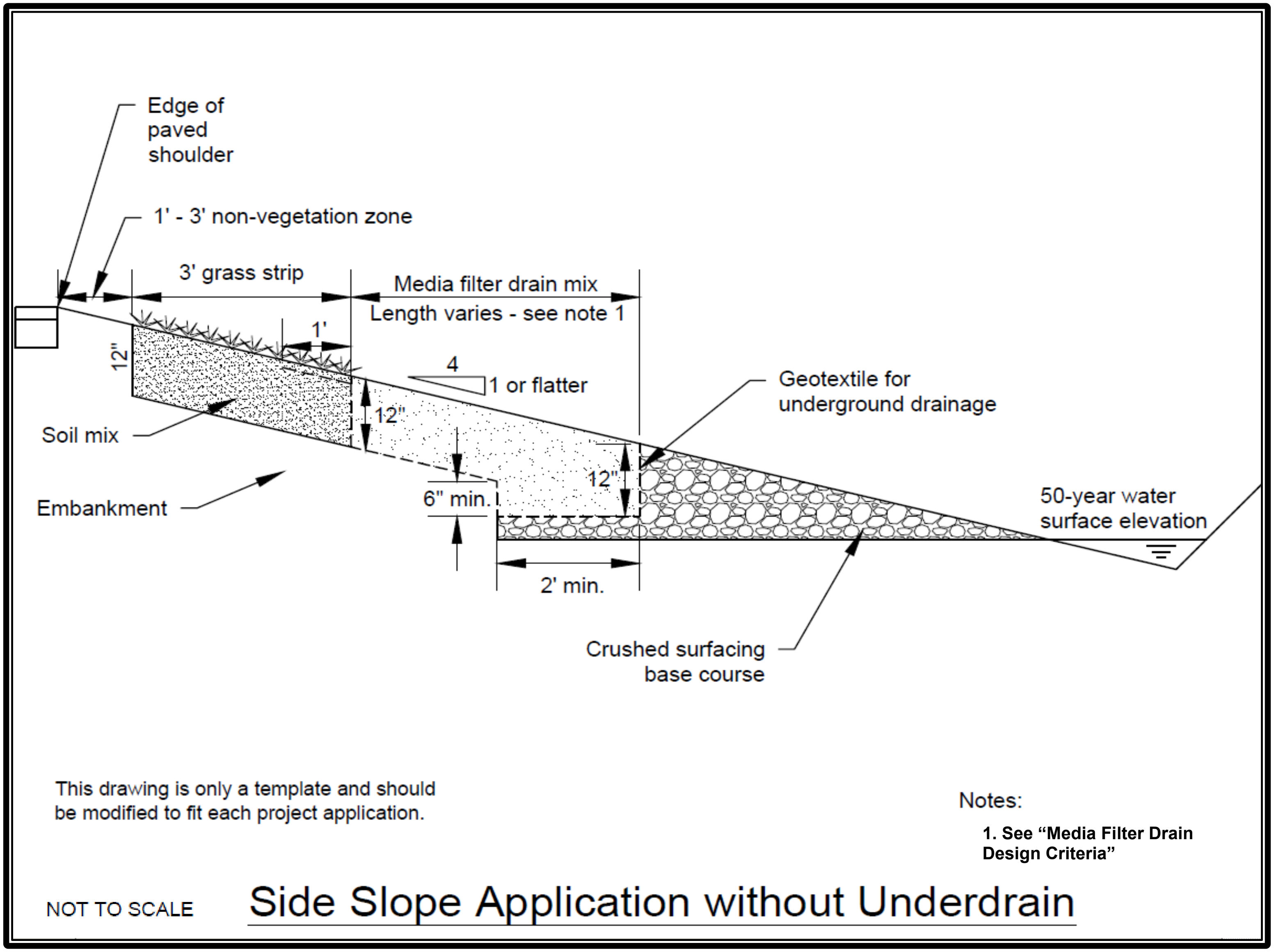
Source: Ecology

Figure 8.8. Media Filter Drain: Cross-Section.



Source: Ecology

Figure 8.9. Dual Media Filter Drain: Cross-Section.



Source: Ecology

Figure 8.10. Media Filter Drain without Underdrain Trench.

If there is sufficient roadway embankment width, the designer should consider placing the grass strip and media mix downslope when feasible. The project engineer must ensure the MFD does not intercept seeps, springs, or groundwater.

Dual Media Filter Drain for Roadway Medians

The dual MFD 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 MFDs in a roadway setting are medians, roadside drainage, borrow ditches, or other linear depressions. It is especially critical for water to sheet flow across the dual MFD. Channelized flows or ditch flows running down the middle of the dual MFD (continuous off-site inflow) shall be minimized.

Limitations

Steep Slopes

Avoid construction on longitudinal slopes steeper than 5 percent. 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 the Sizing Criteria and Filter Geometry subsections in the Media Filter Drain Design Criteria section below.)

Wetlands

Do not construct in wetlands and wetland buffers. In many cases, a MFD (due to its small lateral footprint) can fit within the roadway fill slopes adjacent to a wetland buffer. In situations where the roadway fill prism is located adjacent to wetlands, an interception trench/underdrain will need to be incorporated as a design element in the MFD.

Shallow Groundwater

Mean high water table levels at the project site need to be determined to ensure the MFD mix bed and the underdrain (if needed) will not become saturated by shallow groundwater.

Unstable Slopes

In areas where slope stability may be problematic, consult a geotechnical engineer.

Areas of Seasonal Groundwater Inundations or Basement Flooding

Site-specific piezometer data may be needed in areas of suspected seasonal high groundwater inundations. The hydraulic and runoff treatment performance of the dual MFD 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.

Media Filter Drain Design Criteria

The basic design concept behind the MFD and dual MFD is to fully filter all runoff through the MFD mix. Therefore, the infiltration capacity of the medium and drainage below needs to match or exceed the hydraulic loading rate.

Media Filter Drain Mix Bed Sizing Procedure

The MFD mix shall be a minimum of 12 inches deep, including the section on top of the underdrain trench.

For runoff treatment, sizing of the MFD mix bed is based on the requirement that the runoff treatment flow rate from the pavement area, $Q_{Roadway}$, cannot exceed the long-term infiltration capacity of the MFD, $Q_{Infiltration}$:

$$Q_{Roadway} \leq Q_{Infiltration}$$

For western Washington, $Q_{Roadway}$ is the flow rate at or below which 91 percent of the runoff volume for the developed threshold discharge areas will be treated, based on a 15-minute time step, and can be determined using and approved continuous runoff model.

The long-term infiltration capacity of the MFD is based on the following equation:

$$\frac{LTIR * L * W}{C * SF} = Q_{Infiltration}$$

where:

LTIR = Long-term infiltration rate of the MFD 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 43,200 ((in/hr)/(ft/sec))

SF = Safety factor (equal to 1.0, unless unusually heavy sediment loading is expected)

Assuming that the length of the MFD is the same as the length of the contributing pavement, solve for the width of the MFD:

$$W \geq \frac{Q_{Roadway} * C * SF}{LTIR * L}$$

Western Washington project applications of this design procedure have shown that, in almost every case, the calculated width of the MFD mix bed does not exceed 1 foot. Therefore, Table 8.9 was developed to simplify the design steps and should be used to establish an appropriate width.

Table 8.9. Western Washington Design Widths for Media Filter Drains.

Pavement Width That Contributes Runoff to the MFD	Minimum MFD Mix Bed Width[a]
≤ 20 feet	2 feet
≥ 20 and ≤ 35 feet	3 feet
> 35 feet	4 feet

[a] Width does not include the required 1-to-3-foot gravel vegetation-free zone or the 3-foot filter strip width (see Figure 8.8).

Sizing Criteria

Width

The width of the MFD mix bed is determined by the amount of contributing pavement routed to the MFD. The surface area of the MFD mix bed needs to be sufficiently large to fully infiltrate the runoff treatment design flow rate using the long-term filtration rate of the MFD mix. For design purposes, a 50 percent safety factor is incorporated into the long-term MFD mix filtration rate to accommodate variations in slope, resulting in a design filtration rate of 10 inches per hour. The MFD mix bed shall have a bottom width of at least 2 feet in contact with the conveyance system below the MFD mix.

Length

In general, the length of a MFD or dual MFD is the same as the contributing pavement. Any length is acceptable as long as the surface area MFD mix bed is sufficient to fully infiltrate the runoff treatment design flow rate.

Cross-Section

In profile, the surface of the MFD should preferably have a lateral slope less than 4H:1V (<25 percent). 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 the City, 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 MFD mix bed. Consultation with a geotechnical engineer is required.

Inflow

Runoff is conveyed to an MFD using sheet flow from the pavement area. The longitudinal pavement slope contributing flow to a MFD shall be less than 5 percent.

Although there is no lateral pavement slope restriction for flows going to a MFD, the designer must ensure flows remain as sheet flow.

Underdrain Design

Underdrain pipe can provide a protective measure to ensure free flow through the 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 MFD 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 the flexibility of incrementally increasing the underdrain diameter where long lengths of underdrain are required. When underdrain pipe connects to a stormwater 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 MFDs:

- Calculate the flow rate per foot from the contributing basin to the MFD. The design storm event used to determine the flow rate should be relevant to the purpose of the underdrain. For example, if the underdrain will be used to convey treated runoff to a detention BMP, size the underdrain for the 50-year storm event. (See the WSDOT Hydraulics Manual, Figure 2-2.1, for conveyance flow rate determination <www.wsdot.wa.gov/Publications/Manuals/M23-03.htm>.)

$$\frac{Q_{highway}}{ft} = \frac{Q_{highway}}{L_{MFD}}$$

where:

$\frac{Q_{highway}}{ft}$ = contributing flow rate per foot (cfs/ft)

L_{MFD} = length of MFD contributing runoff to the underdrain (ft)

- Calculate the MFD flow rate of runoff per foot given an infiltration rate of 10 in/hr through the MFD mix.

$$Q_{\frac{MFD}{ft}} = \frac{f \times W \times 1ft}{ft} \times \frac{1ft}{12in} \times \frac{1hr}{3600\,\text{sec}}$$

where:

$Q_{\frac{MFD}{ft}}$ = flow rate of runoff through MFD mix layer (cfs/ft)

W = width of underdrain trench (ft) –see WSDOT Standard Plan B-55.20-00; the minimum width is 2 feet

f = infiltration rate though the MFD mix (in/hr) = 10 in/hr

- 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.

$$Q_{\frac{UD}{ft}} = \text{smaller}\left\{Q_{\frac{highway}{ft}} \text{ or } Q_{\frac{MFD}{ft}}\right\}$$

where:

$Q_{\frac{UD}{ft}}$ = underdrain design flow rate per foot (cfs/ft)

- Determine the underdrain design flow rate using the length of the MFD and a factor of safety of 1.2.

$$Q_{UD} = 1.2 \times Q_{\frac{UD}{ft}} \times W \times L_{MFD}$$

where:

Q_{UD} = estimated flow rate to the underdrain (cfs)

W = width of the underdrain trench (ft) – per WSDOT Standard Specification 2-09.4; the minimum width is 2 ft

L_{MFD} = length of MFD contributing runoff to the underdrain (ft)

- Given the underdrain design flow rate, determine the underdrain diameter. See Chapter 7, Section 7.4.4 (Underdrain (Optional)) for additional underdrain design criteria.

$$D = 16\left(\frac{(Q_{UD} \times n)}{s^{0.5}}\right)^{3/8}$$

where:

D = underdrain pipe diameter (inches)

n = Manning's coefficient

s = slope of pipe (ft/ft)

Filter Geometry

- **No-Vegetation Zone:** The no-vegetation zone (vegetation-free zone) is a shallow gravel zone located directly adjacent to the roadway pavement. The no-vegetation zone is a crucial element in a properly functioning MFD or other BMPs that use sheet flow to convey runoff from the roadway 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 shall 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 roadway side slope. The baseline design criterion for the grass strip within the MFD 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 MFD. Composted material used in the grass strip shall meet the specifications for compost used in bioretention soil mix. See Chapter 7, Section 7.4.4.

- **Media Filter Drain Mix Bed:** The MFD 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 MFD mix. The combination of physical filtering, precipitation, ion exchange, and biofiltration enhances the water treatment capacity of the mix. The MFD 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 MFD should be 10 inches per hour.

- **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.

- **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 BMP or stormwater outfall.

  - In Type C and D soils, an underdrain pipe would help to ensure free flow of the treated runoff through the MFD mix bed. In some Type 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 shall be a minimum of 2 feet wide for either the conventional or dual MFD.

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 MFD mix shall be kept free draining up to the 50-year storm event water surface elevation represented in the downstream ditch.

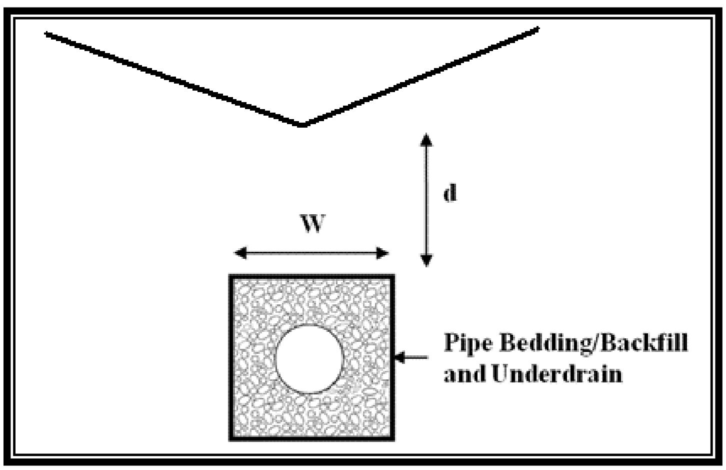
Materials

Media Filter Drain Mix

The MFD mix used in the construction of MFDs consists of the amendments listed in Table 8.10 at the end of this section. 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 WSDOT Standard Specifications:

- Gravel Backfill for Drains, 9-03.12(4)
- Underdrain Pipe, 7-01.3(2) (see Figure 8.11)
- Construction Geotextile for Underground Drainage, 9-33.1



Source: WSDOT

Figure 8.11. Media Filter Drain Underdrain Installation.

Crushed Surfacing Base Course

If the design is configured to allow the MFD to drain laterally into a ditch, the crushed surfacing base course below the MFD shall conform to Section 9-03.9(3) of the WSDOT Standard Specifications.

Berms, Baffles, and Slopes

See Sizing Criteria, Cross-Section, under Media Filter Drain Design Criteria above.

Construction Criteria

- **Erosion and Sediment Control:** Keep effective erosion and sediment control measures in place until grass strip is established.

- **Traffic Control:** Do not allow vehicles or traffic on the MFD to minimize rutting and maintenance repairs.

- **Signing:** Non-reflective guideposts will delineate the MFD. This practice allows personnel to identify where the system is installed and to make appropriate repairs should damage occur to the system. If the MFD is within the 1-year time of travel zone for a wellhead protection area or within a Category I critical aquifer recharge area, signage prohibiting the use of pesticides must be provided.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Table 8.10. Media Filter Drain Mix.

Amendment	Quantity
Mineral aggregate: Aggregate for MFD Mix Aggregate for MFD Mix shall be manufactured from ledge rock, talus, or gravel in accordance with Section 3-01 of the *Standard Specifications for Road, Bridge, and Municipal Construction* (2021 or later), which meets the following test requirements for quality. The use of recycled material is not permitted: Los Angeles Wear, 500 Revolutions 35% max. Degradation Factor 30 min. Aggregate for the MFD Mix shall conform to the following requirements for grading and quality: **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 % fracture, by weight, min. 75 Static stripping test Pass The fracture requirement shall be at least two fractured faces and will apply to material retained on the U.S. No. 10. Aggregate for the MFD 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.	3 cubic yards
Perlite Horticultural grade, free of any toxic materials 0–30% passing U.S. No. 18 Sieve 0–10% passing U.S. No. 30 Sieve	1 cubic yard per 3 cubic yards of mineral aggregate
Dolomite: $CaMg(CO_3)2$ (calcium magnesium carbonate) Agricultural grade, free of any toxic materials 100% passing U.S. No. 8 Sieve 0% passing U.S. No. 16 Sieve	10 pounds per cubic yard of perlite
Gypsum: Noncalcined, agricultural gypsum $CaSO_4 \cdot 2H_2O$ (hydrated calcium sulfate) Agricultural grade, free of any toxic materials 100% passing U.S. No. 8 Sieve 0% passing U.S. No. 16 Sieve	1.5 pounds per cubic yard of perlite

8.8 Biofiltration Treatment BMPs

8.8.1 Purpose

This section addresses four BMPs that are classified as biofiltration BMPs:

- Basic Biofiltration Swale
- Wet Biofiltration Swale
- Continuous Inflow Biofiltration Swale
- Vegetated Filter Strip.

Biofiltration BMPs use vegetation in conjunction with slow and shallow-depth flow for runoff treatment and remove pollutants by means of sedimentation, filtration, infiltration, settling, and/or plant uptake. Biofiltration BMPs 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.

Biofiltration BMPs discussed in this section are designed to remove low concentrations and quantities of TSS, heavy metals, petroleum hydrocarbons, and/or nutrients from stormwater.

8.8.2 Applications

Biofiltration BMPs can be used as basic treatment BMPs 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 sites requiring oil control BMPs, a pretreatment BMP for those components would be necessary. Off-line placement is preferred to avoid flattening vegetation and the erosive effects of high flows. Consider biofiltration BMPs in retrofit situations where appropriate (Center for Watershed Protection 1998).

8.8.3 Site Suitability

Consider the following factors for determining site suitability for biofiltration BMPs:

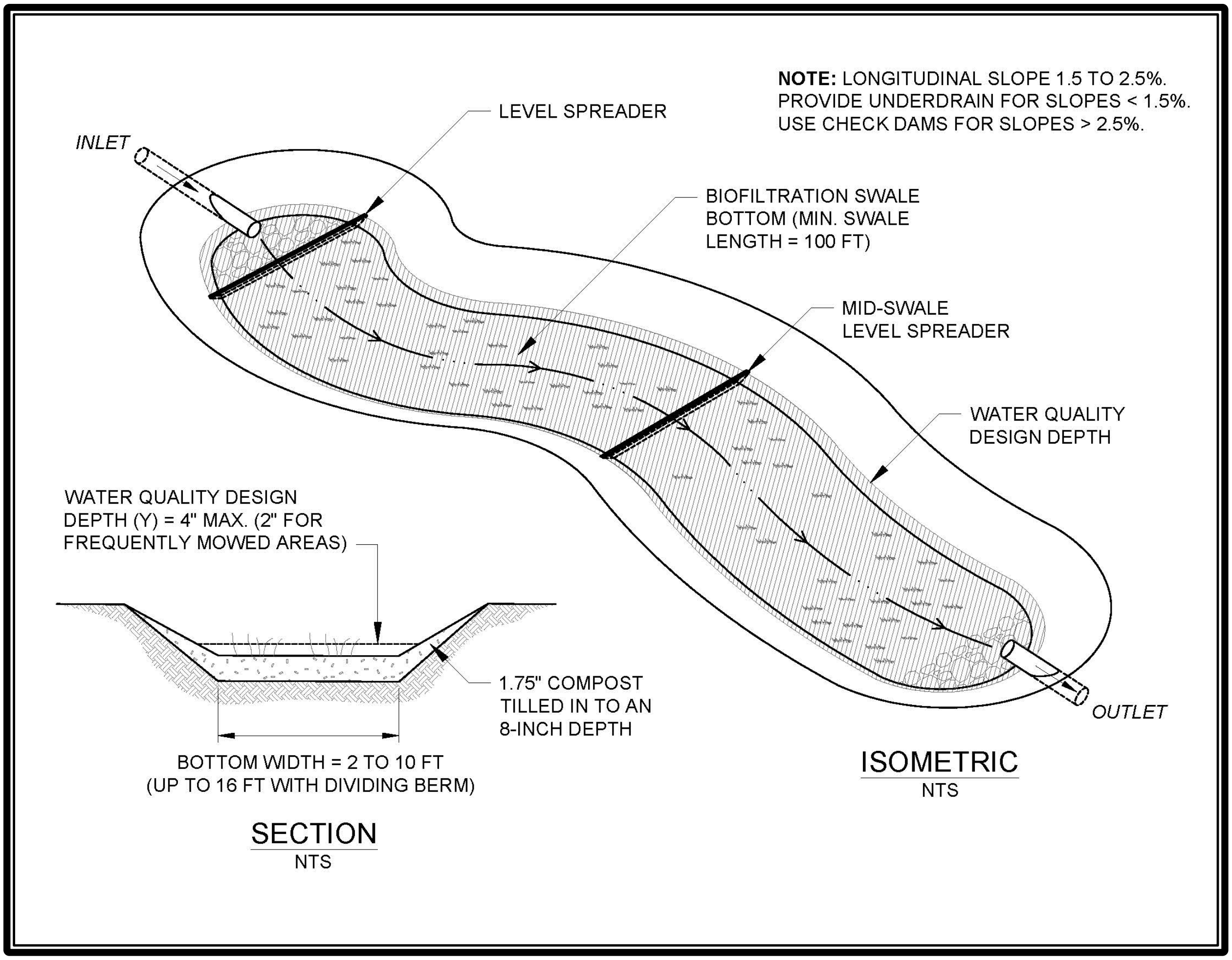
- Target pollutants are amenable to biofiltration
- Accessibility for operation and maintenance
- Suitable growth environment (soil, etc.) for the vegetation
- Adequate siting for a pretreatment BMP if high petroleum hydrocarbon levels (oil/grease) or high TSS loads could impair treatment capacity or efficiency

- If the biofiltration BMP can be impacted by snowmelts and ice, refer to Caraco and Claytor 1997 for additional design criteria.

8.8.4 Best Management Practices

Basic Biofiltration Swale (Ecology BMP T9.10)

Biofiltration swales are typically shaped as a trapezoid or a parabola. See Figure 8.12 for typical cross-sections.



Source: City of Seattle

Figure 8.12. Biofiltration Swale Access Features.

Limitations

Data suggest that the performance of biofiltration swales is highly variable from storm to storm. It is therefore recommended that treatment methods that perform more consistently, such as sand filters and wet ponds, be considered before using a biofiltration swale. Biofiltration swales downstream of runoff treatment BMPs of equal or greater effectiveness can convey runoff but should not be expected to offer a runoff treatment benefit (Horner 2000).

Basic Biofiltration Swale Design Criteria

- Design criteria are specified in Table 8.11. A 9-minute hydraulic residence time is used at a multiple of the peak 15-minute water quality design flow rate (Q) representing 91 percent runoff volume as determined by an approved continuous simulation model (see Chapter 2).

- Most biofiltration swales are currently designed to be on-line BMPs. However, an off-line design is possible. Biofiltration swales designed as an off-line BMP should engage a bypass around the biofiltration swale when the flow rate entering the biofiltration swale exceeds the off-line water quality design flow rate (as determined by an approved continuous simulation model). 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.

- Use a wide radius curved path to gain length where land is not adequate for a linear swale (avoid sharp bends to reduce erosion or provide for erosion protection).

- Install level spreaders (minimum 1 inch gravel) at the head and every 50 feet in biofiltration swales of ≥4 feet width. Include sediment cleanouts (weir, settling basin, or equivalent) at the head of the biofiltration swale as needed.

- Use energy dissipators (bioengineered methods or riprap) for increased downslopes.

- Maintain access to biofiltration swale inlet, outlet, and to mowing (Figure 8.13).

Table 8.11. Sizing Criteria.

Design Parameter	Biofiltration Swale	Filter Strip
Longitudinal Slope	0.015–0.025[a]	0.01–0.33
Maximum velocity	1 ft/sec (@ K multiplied by the water quality design flow rate); for stability, 3 ft/sec maximum	0.5 ft/sec (@ K multiplied by the water quality design flow rate)
Maximum water depth[b]	2 inches—if mowed frequently; 4 inches if mowed infrequently	1 inch maximum
Manning coefficient (22)	(0.2–0.3)[c] (0.24 if mowed infrequently)	0.35
Bed width (bottom)	(2–10 feet)[d]	—
Freeboard height	0.5 feet	—
Minimum hydraulic residence time at water quality design flow rate	9 minutes (18 minutes for continuous inflow)	9 minutes
Minimum length	100 feet	Sufficient to achieve hydraulic residence time in the filter strip

Table 8.11 (continued). Sizing Criteria.

Design Parameter	Biofiltration Swale	Filter Strip
Maximum side slope	3H:1V 4H:1V preferred	Inlet edge ≥ 1 inch lower than contributing paved area
Maximum tributary drainage flow path	—	150 feet
Maximum longitudinal slope of contributing area	—	0.05 (steeper than 0.05 need upslope flow spreading and energy dissipation)
Maximum lateral slope of contributing area	—	0.02 (at the edge of the strip inlet)

[a] For swales, if the slope is less than 1.5 percent 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 percent 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 Figure 8.13).

[b] Below the design water depth install an erosion control blanket, at least 4 inches of topsoil, and the selected biofiltration mix. Above the water line use a straw mulch or sod.

[c] 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.

[d] 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 8.15).

Guidance for Bypassing Off-Line BMPs

Most biofiltration swales should be designed as off-line BMPs. However, an on-line design is possible with approval by the City of Lacey. Swales designed in an off-line mode must 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 an approved continuous runoff model, by the ratio determined in Figure 8.17b (presented later in this section). This modified design flow rate is an estimate of the design flow rate determined by using Santa Barbara Urban Hydrograph (SBUH) procedures.

Sizing Procedure for Biofiltration Swales

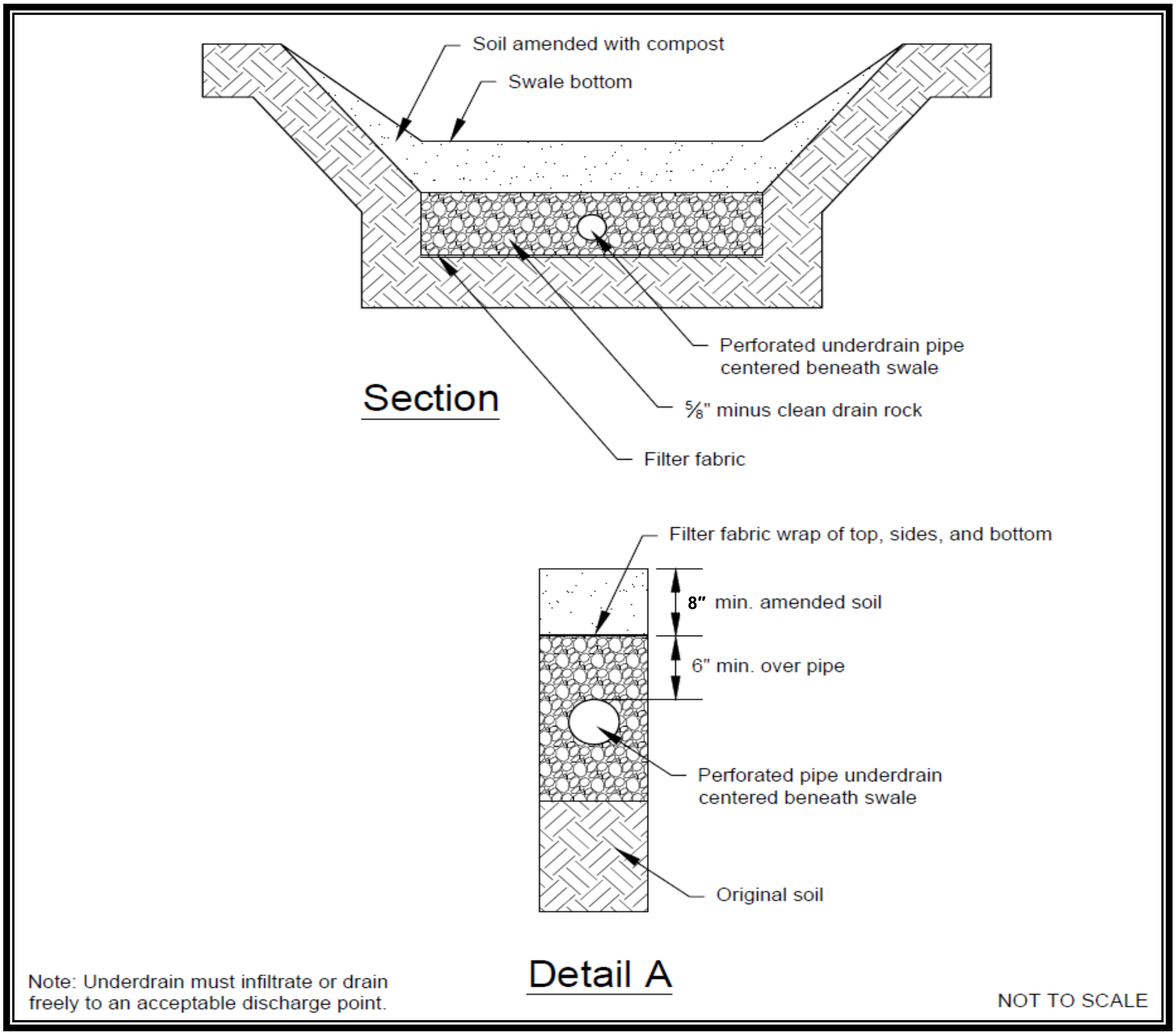
This guide provides biofiltration swale design procedures in full detail, along with examples.

Preliminary Steps (P)

P-1. Determine the water quality design flow rate (Q) in 15-minute time-steps using an approved continuous simulation model. Use the correct flow rate, off-line or on-line, for the design situation.

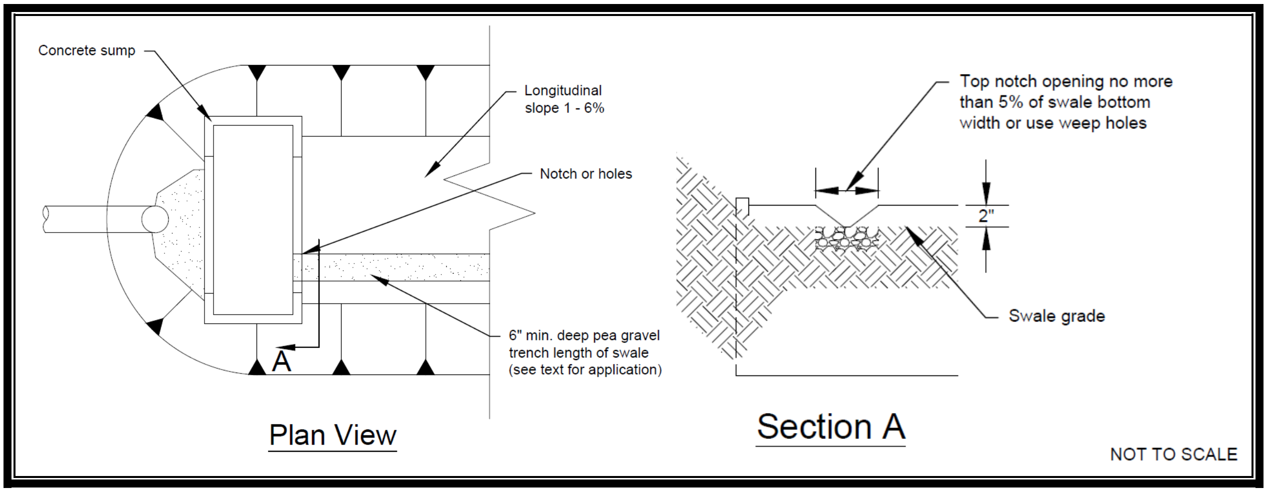
P-2. Establish the longitudinal slope of the proposed biofiltration swale.

P-3. Select a vegetation cover suitable for the site. Refer to Tables 8.13, 8.14, and 8.15 (presented later in the text) to select vegetation for western Washington.



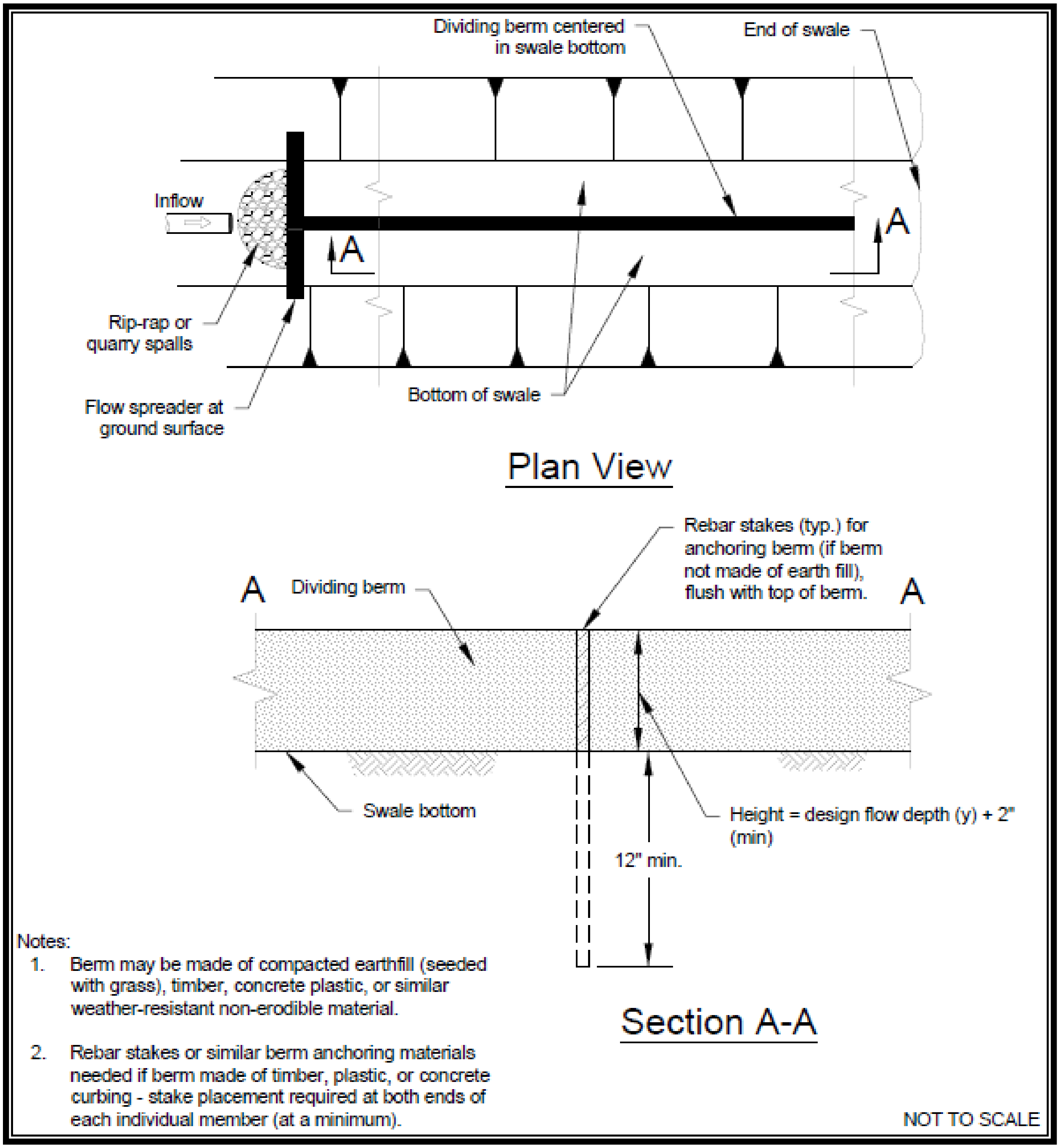
Source: King County

Figure 8.13. Biofiltration Swale Underdrain Detail.



Source: King County

Figure 8.14. Biofiltration Swale Low-Flow Drain Detail.



Source: King County

Figure 8.15. Swale Dividing Berm.

Design Calculations for Biofiltration Swale

The procedure recommended here is an adaptation appropriate for biofiltration applications of the type being installed in the Puget Sound region. This procedure reverses Chow's order (Chow 1959), 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 biofiltration swale 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 8.11).

D-2. Select a value of Manning's n (Table 8.11 with footnote number three).

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 biofiltration swale width dimension:

$$Q = \frac{1.49AR^{0.67}s^{0.5}}{n} \qquad (1)$$

$$A_{rectangle} = Ty \qquad (2)$$

$$R_{rectangle} = \frac{Ty}{T + 2y} \qquad (3)$$

Where:

Q = Water quality design flow rate in 15-minute time steps (feet³/s, cfs)

n = Manning's n (dimensionless)

s = Longitudinal slope as a ratio of vertical rise/horizontal run (dimensionless)

A = Cross-sectional area (feet²)

R = Hydraulic radius (feet)

T = top width of trapezoid or width of a rectangle (feet)

y = depth of flow (feet)

b = bottom width of trapezoid (feet)

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>>y and Z^2>>1, and that certain terms are nearly negligible. The approximation solutions for rectangular and trapezoidal shapes are:

$$R_{rectangle} \approx y, \quad R_{trapezoid} \approx y, \; R_{parabolic} \approx 0.67y, \; R_v \approx 0.5y$$

Substitute $R_{trapezoid}$ and $A_{trapezoid} = by + Zy^2$ 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 the 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 feet, either investigate how Q can be reduced, divide the flow by installing a low berm, or arbitrarily set b = 10 feet and continue with the analysis. For other biofiltration swale shapes, refer to Figure 8.16.

D-5. Compute A:

$$A_{rectangle} = Ty \text{ or } A_{trapazoid} = by + Zy^2$$

$$A_{filter\ strip} = Ty$$

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 an approved continuous runoff model. The value of K is determined from Figure 8.17a for on-line BMPs, or Figure 8.17b for off-line BMPs.

If V > 1.0 feet/sec (or V > 0.5 feet/sec for a filter strip), repeat steps D-1 to D-6 until the condition is met. A velocity greater than 1.0 feet/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 biofiltration swale. If the value of V suggests that a longer biofiltration swale will be needed than space permits, investigate how Q can be reduced (e.g., use of LID BMPs), or increase y and/or T (up to the allowable maximum values) and repeat the analysis.

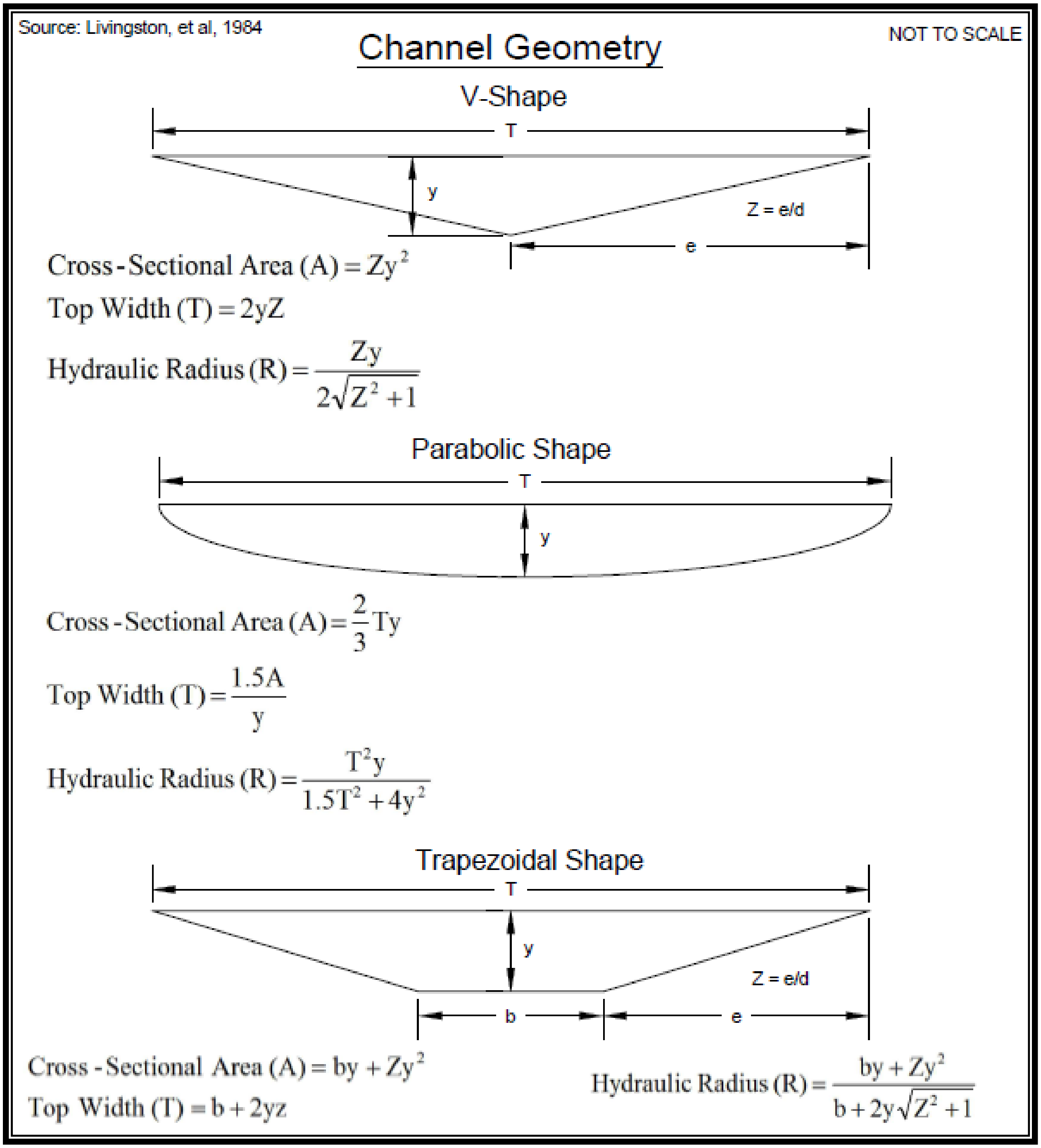
D-7. Compute the biofiltration swale length (L, feet)

$$L = Vt\ (60\ \text{sec/min})$$

Where: t = hydraulic residence time (min)

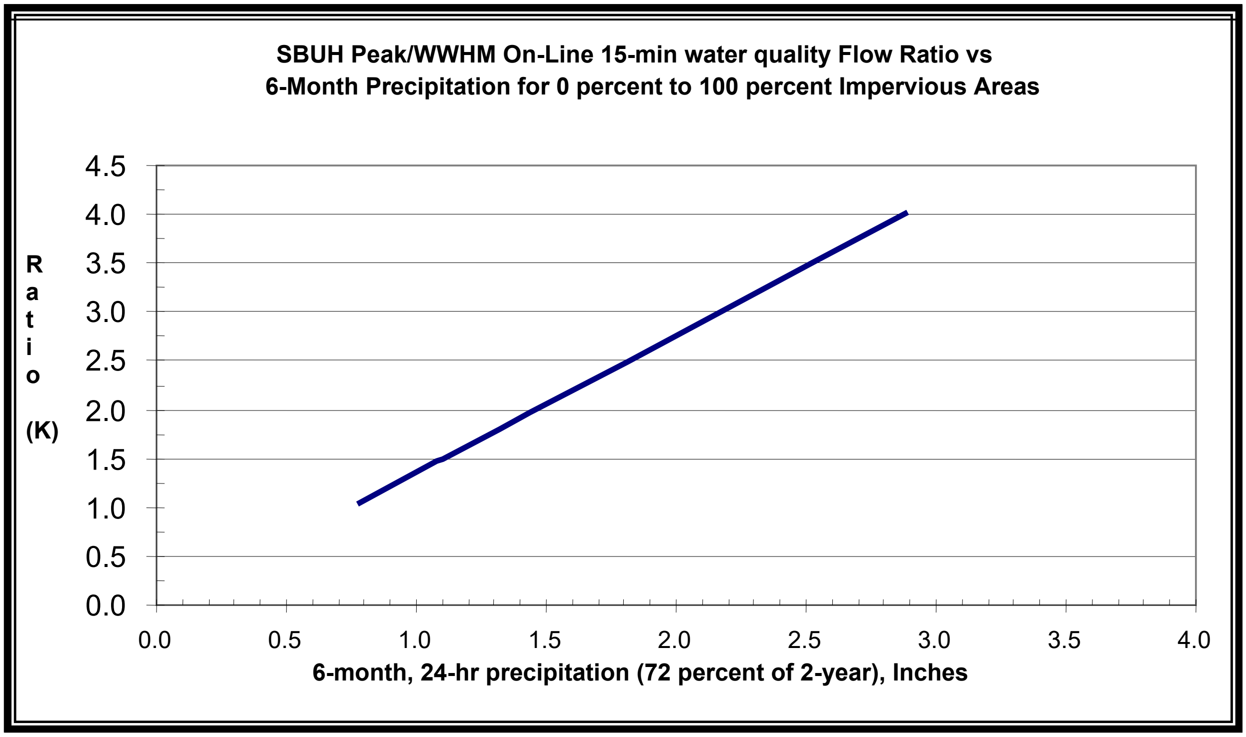
Use t = 9 minutes for this calculation (use t = 18 minutes for a continuous inflow biofiltration swale). If a biofiltration swale length is greater than the space permits, follow the advice in Step D-6.

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 feet biofiltration swale for t = 9 minutes, recalculating A (if V less than 1 foot/sec) and recalculating T.



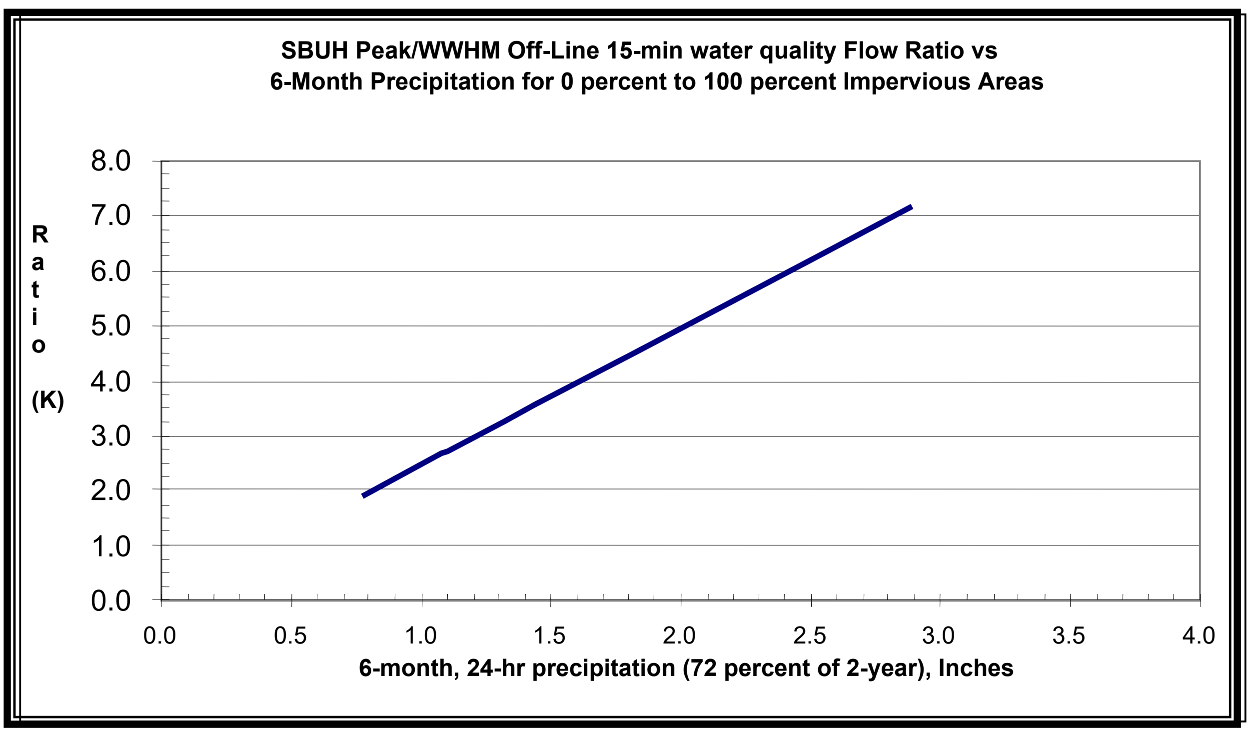
Source: Livingston, et al. 1984

Figure 8.16. Geometric Formulas for Common Swale Shapes.



Source: King County

Figure 8.17a. Ratio of SBUH Peak/Water Quality Flow.



Source: King County

Figure 8.17b. Ratio of SBUH Peak/Water Quality Flow.

D-8. If there is still not sufficient space for the biofiltration swale, the City and the project applicant should consider the following solutions (listed in order of preference):

- Divide the site drainage to flow to multiple biofiltration BMPs.
- Use infiltration to provide lower discharge rates to the biofiltration swale (<u>only</u> if the applicable infiltration requirements in Chapter 7 and 8 are met).
- Increase vegetation height and design depth of flow (**Note:** the design must ensure that vegetation remains standing during design flow).
- Reduce the developed surface area to gain space for the biofiltration swale.
- Increase the longitudinal slope.
- Increase the side slopes.
- Nest the biofiltration swale within or around another runoff treatment BMP.

Stability Check (SC) Steps

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 simulation model.

SC-2. Estimate the vegetation coverage ("good" or "fair") and height on the first occasion that the biofiltration swale 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 8.12. When uncertain, be conservative by selecting a relatively low degree.

The maximum permissible velocity for erosion prevention (Vmax) is 3 feet per second.

Table 8.12. 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

[a] 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.

SC-5. Refer to Figure 8.18 to obtain a first approximation for VR of 3 feet per second.

SC-6. Compute hydraulic radius, R, from VR in Figure 8.18 and a Vmax.

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.

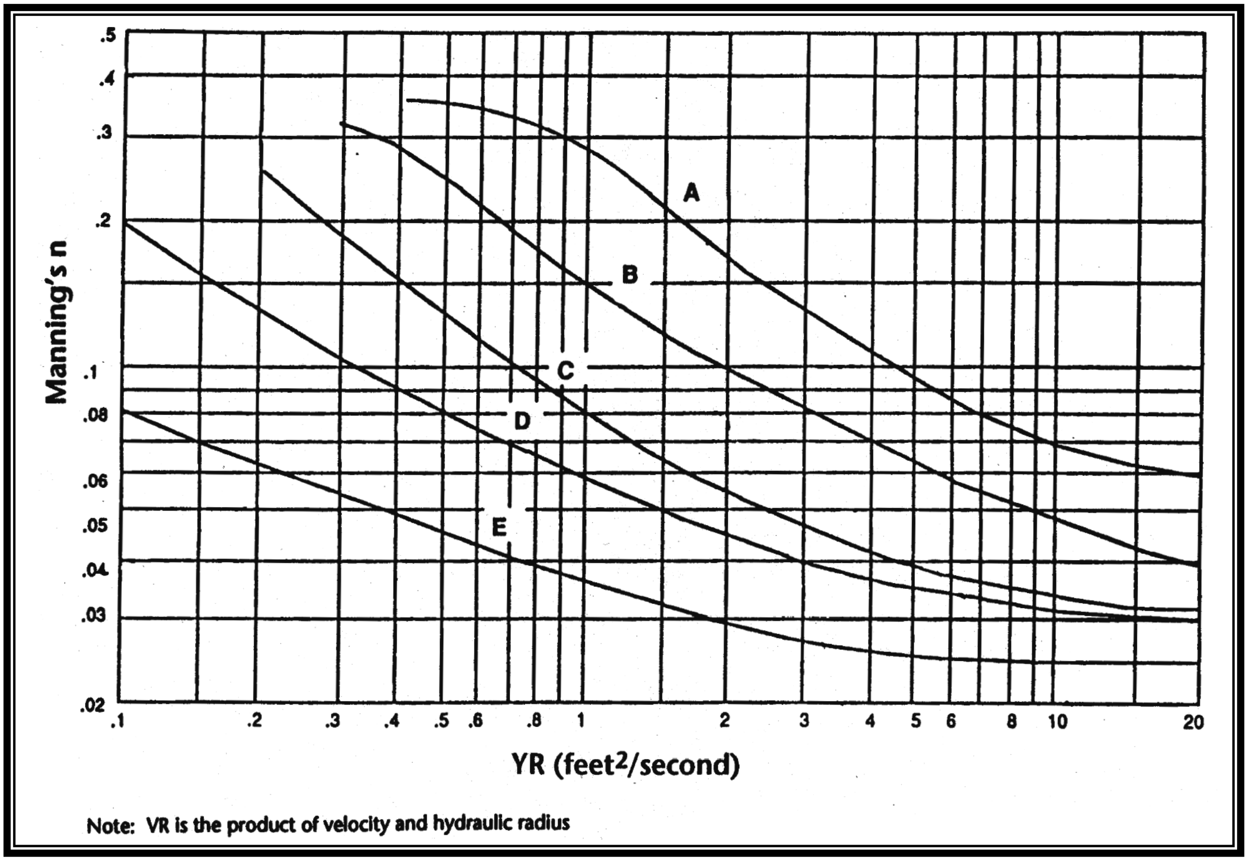
SC-9. Compute the actual V for the final design conditions:

Check to be sure $V < V_{\text{max of 3 ft/sec}}$

SC-10. Compute the required biofiltration 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 the biofiltration swale dimensions.



Source: Livingston, et al. 1984

Figure 8.18. The Relationship of Manning's n with VR for Various Degrees of Flow Retardance (A–E).

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 swale capacity design (Step D-1). Use the larger of the two and add 0.5 feet 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 swale 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-1. Review all of the criteria and guidelines for biofiltration swale planning, design, installation, and operation above and specify all of the appropriate features for the application.

Example of Sizing Calculations for Biofiltration Swales

Preliminary Steps (Example)

P-1. Assume that the water quality design flow rate (Q) is 0.2 cfs. Assume an on-line BMP.

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 Steps for Biofiltration Swale Capacity (Example)

D-1. Set winter grass height at 5 inches 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:

$n = 0.20 \quad y = 0.25$ ft

$Q = 0.2$ cfs $\quad s = 0.02$

$Z = 3$

$$b \approx \frac{2.5Qn}{1.49y^{1.67}s^{0.5}} - Zy$$

$b \approx 4.0$ ft

At n_2; $b_2 = 6.5$ ft

D-4b. Calculate the top width (T)

$$T = b + 2yZ = 4.0 + [2(0.25)(3)] = 5.5 \text{ ft}$$

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)

$$V = K\frac{Q}{A} = 0.17 \text{ ft / sec}$$

for K = 1. Actual K is determined per Figure 8.18

$0.17 < 1.0$ ft/sec $\therefore$ OK

D-7. Calculate the length (L)

L = Vt (60 sec/min)

= 0.17 (9)(60)

For t = 9 min, L = 92 feet 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, so long as the minimum length (L) is never less than 100 feet.

Stability Check Steps (Example)

SC-1. Base the check on passing the 100-year return frequency flow (15-minute time steps) through the biofiltration swale with a mixture of Kentucky bluegrass and tall fescue on loose erodible soil. Assume that the 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 8.12, Degree of Retardance = D (low)

$$\text{Set } V_{max} = 3 \text{ ft/sec}$$

SC-4. Select trial Manning’s n = 0.04

SC-5. From Figure 8.18, $VR_{appx} = 3$ ft²/s

SC-6. Calculate R

$$R = \frac{VR_{appx}}{V_{max}} = 1.0 \text{ ft}$$

SC-7. Calculate VR_{actual}

$$VR_{actual} = \frac{1.49}{n} R^{1.67} s^{0.5} = 5.25 \text{ ft}^2 / \text{sec}$$

SC-8. VR_{actual} from Step SC-7 > VR_{appx} from Step SC-5 by > 5 percent.

Select new trial n = 0.0475

Figure 8.18: VR_{appx} = 1.7 ft²/s

R = 0.57 ft.

VR_{actual} = 1.73 ft²/s (within 5 percent of VR_{appx} = 1.7)

SC-9. Calculate V

$$V = \frac{VR_{actual}}{R} = \frac{1.73}{0.57} = 3 \text{ ft} / \text{sec}$$

$V = 3$ ft/sec ≤ 3 ft/sec, $V_{max} \therefore$ OK

SC-10. Calculate Stability Area

$$A_{Stability} = \frac{Q}{V} = \frac{1.92}{3} = 0.64 \text{ ft}^2$$

SC-11. Stability Check

$A_{Stability}$ = 0.64 ft² is less than $A_{Capacity}$ from Step D-5 ($A_{Capacity}$ = 1.19 ft²). $\therefore$OK

If $A_{Stability} > A_{Capacity}$, 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 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 ft freeboard to that depth.

Total channel depth = 0.75 ft

Top Width = b + 2yZ

= 4 + (2)(0.75)(3)

= 8.5 ft

SC-14. Recalculate hydraulic radius and flow rate

For b = 4 ft, y = 0.75 ft

Z = 3, s = 0.02, n = 0.2

$A = by + Zy^2 = 4.68\ ft^2$

$R = \{by + Zy^2\}/\{b + 2y(Z^2 + 1)^{0.5}\} = 0.53$ ft.

SC-15. Calculate Flow Capacity at Greatest Resistance

$$Q = \frac{1.49AR^{0.67}s^{0.5}}{n} \qquad = 3.2 \text{ cfs}$$

$Q = 3.2 \text{ cfs} > 1.92 \text{ cfs} \therefore \text{OK}$

Completion Step (Example)

CO-1. Assume 100 ft of swale length is available.

The final channel dimensions are:

Bottom width, b = 4 ft

Channel depth = 0.75 ft

Top width = b + 2yZ = 8.5 ft

No check dams are needed for a 2 percent slope.

Soil Criteria

- Till the following topsoil mix to a depth of at least 8 inches:
  - Sandy loam 60–90 percent
  - Clay 0–10 percent
  - Composted organic matter 10–30 percent

- Use compost amended soil where practicable. Composted material shall meet the specifications for compost used in the bioretention soil mix (see Chapter 7, Section 7.4.4). Note that this excludes the use of biosolids and manures.

- For longitudinal slopes of less than 2 percent, use more sand to obtain more infiltration.

- If groundwater contamination is a concern, seal the bed with a low permeability liner (see Section 8.4.3).

Vegetation Criteria

- See Tables 8.13, 8.14, and 8.15 for recommended grasses, wetland plants, and groundcovers.
    - The following invasive species shall not be used: *Phalaris arundinacea* (reed canarygrass), *Lythrum salicaria* (purple loosestrife), *Phragmites* spp. (reeds), *Iris pseudacorus* (yellow iris) and Cattails (*Typha* spp.).
    - The seed mix in Table 8.13 is suitable for the bottom of the swale and the dry side slopes, and rates are provided as pounds of pure live seed per acre.
    - Table 8.14 provides alternative groundcovers and grass species options for dry side slopes. The seed mix in Chapter 5, Table 5.5 is another low-growing grass option for side slopes.

- 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 1-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 biofiltration swale to prevent erosion.

- Fertilizing a biofiltration swale should be avoided if at all possible in any application where nutrient control is an objective. Test the soil for nitrogen, phosphorus, 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.

Table 8.13. Biofiltration Swale Seed Mix.

Common Name	Species	Pounds Pure Live Seed per Acre
American sloughgrass	*Beckmannia syzigachne*	0.9
Tufted hairgrass	*Deschampsia cespitosa*	0.6
Blue wildrye	*Elymus glaucus*	11.4
Native red fescue	*Festuca rubra* var. *rubra*	2.8
Meadow barley	*Hordeum brachyantherum*	9.8
Northwestern mannagrass	*Glyceria occidentalis*	5.2
Total		**30.7**

Table 8.14. Groundcovers and Grasses Suitable for the Upper Side Slopes of a Biofiltration Swale in Western Washington.

Groundcovers	
Kinnikinnick	*Arctostaphylos uva-ursi*
Strawberry	*Fragaria chiloensis*
Broadleaf lupine	*Lupinus latifolius*
Grasses (drought-tolerant, minimum mowing)	
Dwarf tall fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
Hard fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
Tufted fescue	*Festuca amethystine*
Buffalo grass	*Buchloe dactyloides*
Red fescue	*Festuca rubra*
Tall fescue grass	*Festuca arundinacea*
Blue oatgrass	*Helictotrichon sempervirens*

Construction Criteria

The biofiltration swale shall 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 shall remain in place until the biofiltration swale vegetation is established (see Chapter 5 for erosion and sediment control BMPs). Avoid compaction during construction. Grade biofiltration swales to attain uniform longitudinal and lateral slopes.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Wet Biofiltration Swale (Ecology BMP T9.20)

A *wet biofiltration swale* is a variation of a basic biofiltration swale. Designers can use wet biofiltration swales where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil. 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 and 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).

Wet Biofiltration Swale 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 biofiltration swale 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 biofiltration 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

Wet biofiltration swales must be designed as off-line facilities.

A high-flow bypass (i.e., an off-line design) is required for flows greater than the off-line water quality design flow multiplied by the ratio indicated in Figure 8.17b. 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 biofiltration 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:

- A list of acceptable plants and recommended spacing is shown in Table 8.15. 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.

- 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 two-thirds of the swale after 4 weeks.

Table 8.15. Recommended Plants for Wet Biofiltration Swale.

Common Name	Scientific Name	Spacing (on center)
Shortawn foxtail	*Alopecuris aequalis*	seed
Water foxtail	*Alopecuris geniculatus*	seed
Spike rush	*Eleocharis* spp.	4 inches
Slough sedge[a]	*Carex obnupta*	6 inches or seed
Sawbeak sedge	*Carex stipata*	6 inches
Sedge	*Carex* spp.	6 inches
Western mannagrass	*Glyceria occidentalis*	seed
Velvetgrass	*Holcus mollis*	seed
Slender rush	*Juncus tenuis*	6 inches
Watercress[a]	*Rorippa nasturtium-aquaticum*	12 inches
Water parsley[a]	*Oenanthe sarmentosa*	6 inches
Hardstem bulrush	*Scirpus acutus*	6 inches
Small-fruited bulrush	*Scirpus microcarpus*	12 inches

[a] Good choices for wet biofiltration swales with significant periods of flow, such as those downstream of a detention BMP.

Note: Cattail (*Typha latifolia*) is not appropriate for most wet biofiltration swales because of its very dense and clumping growth habit, which prevents water from filtering through the clump.

Recommended Design Features

Same as for basic biofiltration swales.

Construction Criteria

Same as for basic biofiltration swales.

Operations and Maintenance Criteria

Same as for basic biofiltration swales.

Continuous Inflow Biofiltration Swale (Ecology BMP T9.30)

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 biofiltration swale design is modified by increasing the biofiltration swale length to achieve an equivalent average residence time.

Applications and Limitations

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 biofiltration 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 biofiltration 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 biofiltration 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.

Continuous Inflow Biofiltration Swale Design Criteria

Same as specified for **basic biofiltration swale** except for the following:

- The design flow for continuous inflow biofiltration swales must include runoff from the pervious side slopes draining to the swale along the entire swale length. Therefore, they must be on-line BMPs.

- If only a single design flow is used, the flow rate at the outlet shall be used. The goal is to achieve an average residence time through the continuous inflow biofiltration swale of 9 minutes as calculated using the on-line water quality design flow rate multiplied by the ratio, K, in Figure 8.17a. 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 water quality 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.

Construction Criteria

Same as for basic biofiltration swales.

Operations and Maintenance Criteria

Same as for basic biofiltration swales.

Vegetated Filter Strip (Ecology BMP T9.40)

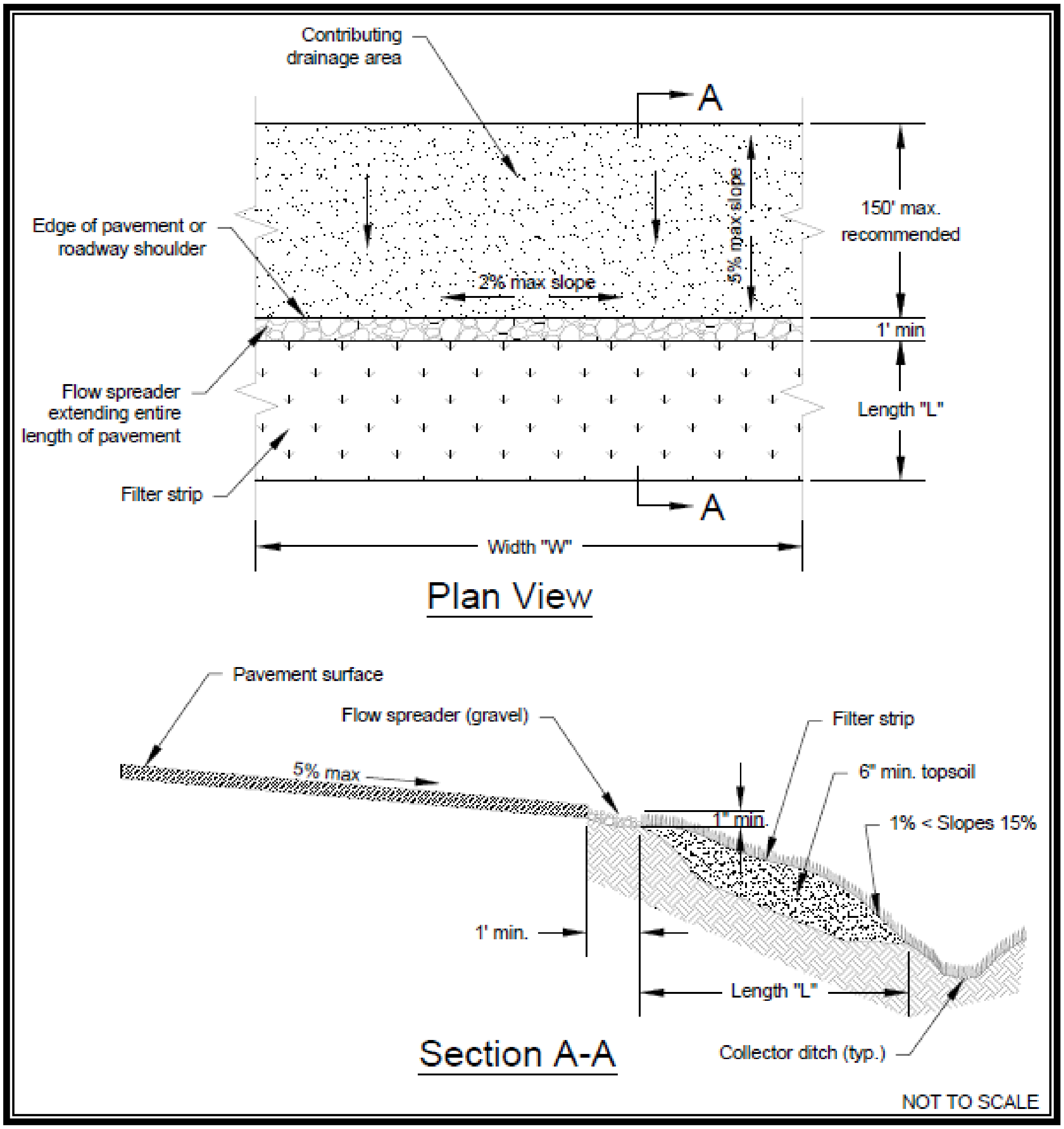
A vegetated filter strip is flat with no side slopes (Figure 8.19). Contaminated stormwater is distributed as sheet flow across the inlet width of the vegetated filter strip. Runoff treatment is provided by passage of water over the surface, and through grass.

Applications and Limitations

The vegetated filter strip is typically used on-line and adjacent and parallel to a paved area such as parking lots, driveways, and roadways.

Design Criteria

- Use the design criteria specified in Table 8.11.
- If groundwater contamination is a concern, seal the bed with a treatment liner (see Section 8.4.3).
- Vegetated filter strips must only receive sheet flow.
- Use curb cuts ≥ 12-inch wide and 1-inch above the vegetated filter strip inlet. Curb cuts shall be spaced at 10 feet, maximum.



Source: Ecology

Figure 8.19. Typical Filter Strip.

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:

$Ty = A_{rectangle,\ ft^2}$

$y \approx R_{rectangle}$, design depth of flow, ft. (1 inch maximum)

Q = peak water quality design flow rate based on an approved continuous simulation model, ft^3/sec

K = The ratio determined by using Figure 8.18

n = Manning's roughness coefficient

s = Longitudinal slope of vegetated filter strip parallel to direction of flow

T = Width of vegetated filter strip perpendicular to the direction of flow, ft.

A = Vegetated filter strip inlet cross-sectional flow area (rectangular), ft^2

R = hydraulic radius, ft.

Rearranging for y:

$y = [KQn/1.49Ts^{0.5}]^{0.6}$

y must not exceed 1 inch

Note: As in biofiltration swale design, an adjustment factor of K accounts for the differential between the water quality design flow rate calculated by an approved continuous simulation model and the SBUH design flow rate.

Calculate the design flow velocity V, ft/sec, through the vegetated filter strip:

$$V = KQ/Ty$$

V must not exceed 0.5 ft/sec

Calculate required length, in feet, of the vegetated filter strip at the minimum hydraulic residence time, t, of 9 minutes:

$$L = tV = 540V$$

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

8.9 Wet Pool BMPs

8.9.1 Purpose

This section presents the methods, criteria, and details for analysis and design of wet ponds, wet vaults, and stormwater wetlands. These BMPs have as a common element a permanent pool of water—the wet pool.

Wet pool BMPs may be single-purpose facilities, providing only runoff treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wet pool BMP can often be stacked under the detention BMP with little further loss of development area. See the Combined Detention and Wet Pool Facilities (Ecology BMP T10.40) subsection below for a description of combined detention and wet pool BMPs.

This section addresses four BMPs that are classified as wet pool BMPs:

- Wet Ponds, Basic and Large
- Wet Vaults
- Stormwater Treatment Wetlands
- Combined Detention and Wet Pool BMPs.

8.9.2 Applications

The wet pool BMP designs described for the four BMPs in this section will achieve the performance objectives cited in Section 8.3 for specific treatment options.

8.9.3 Best Management Practices for Wet Pool BMPs

Wet Ponds – Basic and Large (Ecology BMP T10.10)

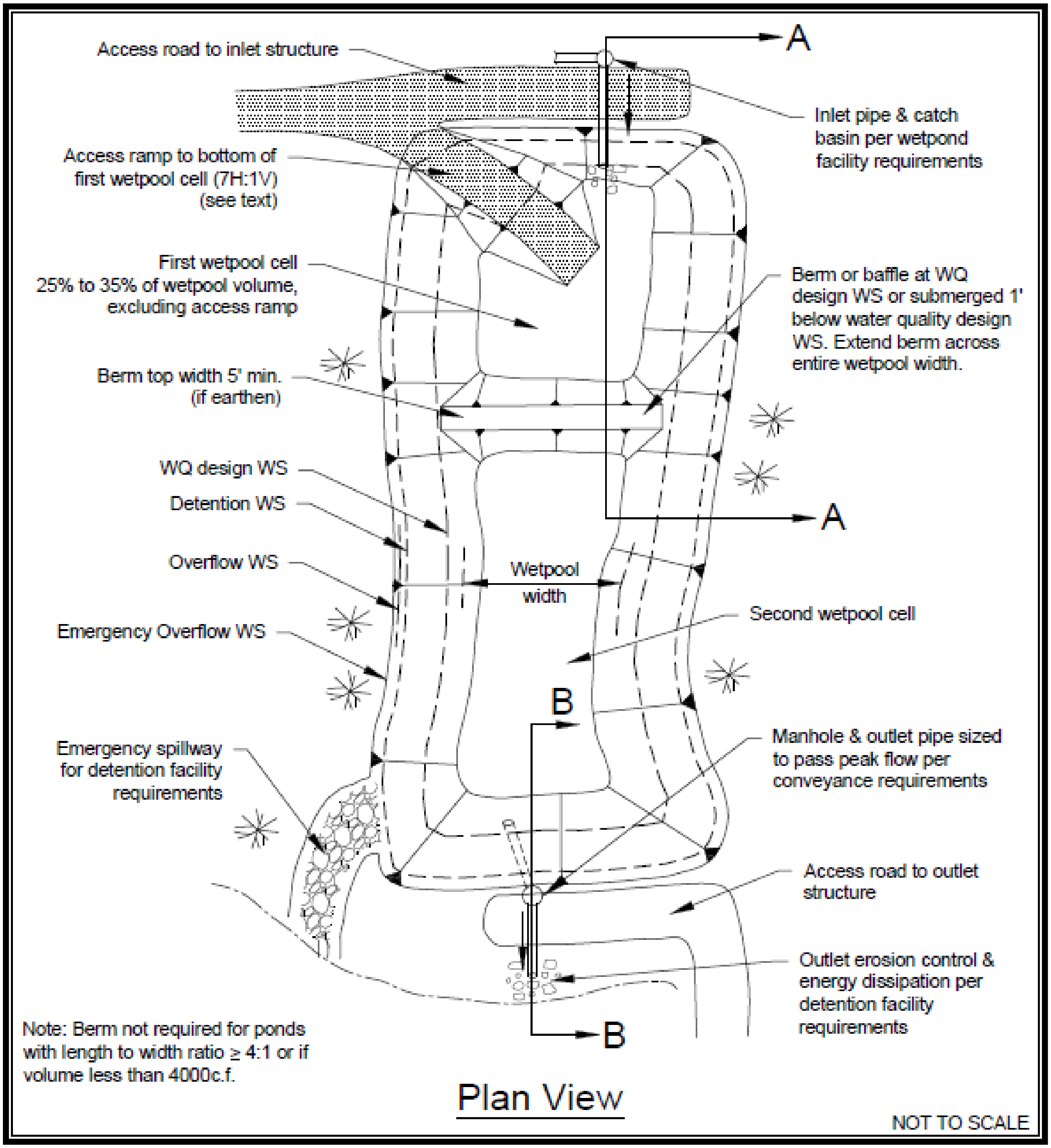
A wet pond is a constructed stormwater pond that retains a permanent pool of water (“wet pool”) at least during the wet season. The volume of the wet pool is related to the effectiveness of the pond in settling particulate pollutants. As an option, a shallow marsh area can be created within the permanent pool volume to provide additional treatment for nutrient removal. Peak flow control can be provided in a “live storage” area above the permanent pool. Figures 8.20a and 8.20b illustrate a typical wet pond BMP.

The following design criteria cover two wet pond applications—the basic wet pond and the large wet pond. Large wet ponds are designed for higher levels of pollutant removal.

Applications and Limitations

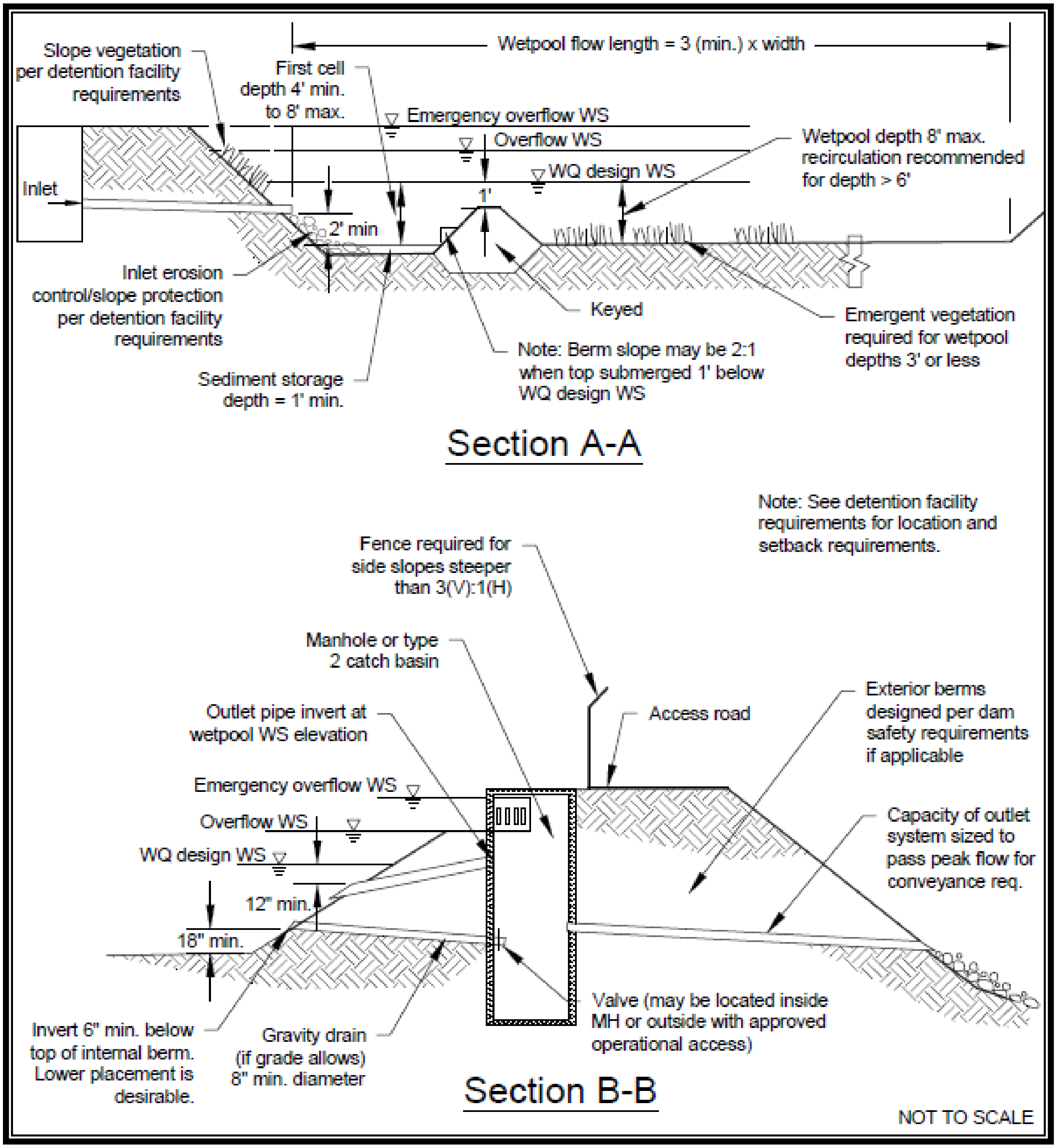
A wet pond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. Wet ponds are designed to hold a permanent pool of water, therefore, the first cell of the wet pond must be lined with a treatment liner or low permeability liner (see Section 8.4.3).

Although high groundwater levels must be avoided for most stormwater BMPs (due to buoyancy concerns), the standing water in a wet pond will neutralize any buoyancy effects from high groundwater. Thus, the wet pool storage of wet ponds may be provided below the groundwater level without interfering unduly with treatment effectiveness. However, if combined with a detention function, the live storage must be above the seasonal high groundwater level.



Source: King County

Figure 8.20a. Wet Pond.



Source: King County

Figure 8.20b. Wet Pond.

Wet Pond Design Criteria

The primary design factor that determines a wet pond's treatment efficiency is the volume of the wet pool. The larger the wet pool volume, the greater the potential for pollutant removal. For a basic wet pond, the wet pool volume provided shall be equal to or greater than the water quality design 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 percent of the entire runoff volume over a multi-decade period of record. WWHM identifies this volume for the user.

A large wet pond requires a wet pool volume at least 1.5 times larger than the water quality design 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 and promote plug flow, the pond should be designed to force the water 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 wet pond into two cells rather than a constricted area such as a pipe
- Maximizing the flow path between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Sizing Procedure

Procedures for determining a wet pond's dimensions and volume are outlined below.

Step 1: Identify required wet pool volume using an approved continuous runoff model—water quality design volume. A large wet pond requires a volume at least 1.5 times the water quality design volume.

Step 2: Determine wet pool dimensions. Determine the wet pool dimensions satisfying the design criteria outlined below and illustrated in Figures 8.20a and 8.20b. A simple way to check the volume of each wet pool cell is to use the following equation:

$$V = \frac{h(A_1 + A_2)}{2}$$

Where V = wet pool volume (cf)

h = wet pool average depth (ft)

A_1 = water quality design surface area of wet pool (sf)

A_2 = bottom area of wet pool (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 wet pool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

a. Use the nomographs in Chapter 6, Appendix 6B, to select a trial size for the pond outlet pipe sufficient to pass the on-line water quality design flow, Q_{wq} indicated by an approved continuous simulation model.

b. Use the nomographs in Chapter 6, Appendix 6B, to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.

c. Use the nomographs in Chapter 6, Appendix 6B, to determine the flow area A_c at critical depth.

d. Calculate the flow velocity at critical depth (V_c) using the continuity equation:

$$V_c = Q_{wq} / A_c$$

e. Calculate the velocity head (V_H)

$$V_H = V_c^2 / 2g$$

where g is the gravitational constant, 32.2 ft/sec.

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

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 wet pond dimensions. General wet pond design criteria and concepts are shown in Figures 8.20a and 8.20b.

Wet Pool Geometry

- The wet pool 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 wet pool volume. Both cells must have level pond bottoms.

- The baffle or berm volume shall not count as part of the total wet pool 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 City.

- 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 flow path through the BMP. The ratio of flow path length to width from the inlet to the outlet shall be at least 3:1. The ***flow path 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.

- Wet ponds with wet pool 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 wet ponds, 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 flow path length for all inlets.

- The wet pool cells shall be lined per the liner requirements outlined in Section 8.4.3.

Berms, Baffles, and Slopes

- A berm or baffle shall extend across the full width of the wet pool, and tie into the wet pond 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 water quality design water surface or be 1 foot below the water quality design water surface. If at the water quality 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 wet pond.

- If good vegetation cover is not established on the berm, erosion control measures must 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 1 foot below the design water surface to discourage access by pedestrians.
- Note that wet ponds can also be designed to include oil containment booms at locations where oil control is required. Design guidelines for oil containment booms are not included in this chapter, but can be found in the WSDOT HRM.
- Requirements for wet pond side slopes are the same as for detention ponds (see Chapter 7, Section 7.5.1).

Embankments

Embankments that impound water must comply with the Washington State Dam Safety Regulations (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, or has an embankment height of greater than 6 feet at the downstream toe, then dam safety design and review are required by Ecology. See Chapter 7, Section 7.5.1 for additional requirements.

Inlet and Outlet

See Figures 8.20a and 8.20b for details on the following requirements:

- The inlet to the wet pond shall be submerged with the inlet pipe invert a minimum of 2 feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible. Conveyance modeling for the stormwater system leading to the wet pond must be shown to include consideration of the backwater effects of the submerged inlet.

  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.

- The runoff shall be discharged uniformly and at a velocity below 3 feet per second in Type A and B soils, and 5 feet per second in Type C and D soils or as necessary to prevent erosion and to ensure quiescent conditions within the BMP.

- An overflow 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 Chapter 7, Figure 7.28 for an illustration). The overflow 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 water quality 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 wet pond.

- The pond outlet pipe shall be sized, at a minimum, to pass the on-line water quality design flow. **Note:** The highest invert of the outlet pipe sets the water quality design water surface elevation.

- The overflow criteria for single-purpose (runoff treatment only, not combined with flow control) wet ponds are as follows:

  - 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.

  - The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the water quality design flow through the pond outlet pipe. **Note:** The grate invert elevation sets the overflow water surface elevation.

  - The grated opening shall be sized to pass the 100-year recurrence interval design flow. The capacity of the outlet system shall 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 Chapter 7, Section 7.5.1).

- The City may require a bypass/shutoff valve to enable the pond to be taken off-line for maintenance purposes.

- A gravity drain for maintenance is required where feasible. The engineer must demonstrate why a drain is not feasible and show in the Maintenance and Source Control Manual how to drain the pond.

  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 must 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 BMPs shall be a minimum of 20 feet from any structure, property line, and any vegetative buffer required by the City, and 100 feet from any septic tank/drainfield.

- All BMPs shall be a minimum of 50 feet from any steep (greater than 15 percent) slope. A geotechnical assessment 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 (see Chapter 7, Section 7.5.1). Access and maintenance roads shall extend to both the wet pond inlet and outlet structures. An access ramp shall be provided to the bottom of all cells, unless a trackhoe (maximum reach of 20 feet) can reach all portions of the cell and can load a truck parked at the pond edge or on the internal berm of a wet pond or combined pond.

- If the dividing berm is also used for access, it should be built to sustain loads of up to 80,000 pounds.

Signage

- See the signage requirements in Chapter 7, Section 7.5.1 for wet pond sign requirements.

Planting Requirements

Planting requirements for detention ponds (see Chapter 7, Section 7.5.1) also apply to wet ponds.

- Large wet ponds intended for use as a phosphorus treatment BMP 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 wet pond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 8.16 for recommended emergent wetland plant species for wet ponds.

  Intent: Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

- Cattails (*Typha latifolia*) are not recommended because they tend to crowd out other species and will typically establish themselves anyway.

- If the wet pond discharges to a phosphorus-sensitive lake or wetland, shrubs that form a dense cover should be planted on slopes above the water quality 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.

- 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 shall be planted on berms meeting the criteria of dams regulated for safety. In addition to shade, trees and shrubs also help discourage waterfowl use and the associated 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) typically have fewer leaves than other deciduous trees.

Table 8.16. Emergent Wetland Plant Species Recommended for Wet Ponds.

Species	Common Name	Notes	Maximum Depth
INUNDATION TO 1 FOOT			
Agrostis exarata[a]	Spike bent grass	Prairie to coast	to 2 feet
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 feet
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	to 2 feet
Juncus tenuis	Slender rush	Wet soils, wetland margins	
Oenanthe sarmentosa	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
Scirpus atrocinctus (formerly *S. cyperinus*)	Woolgrass	Tolerates shallow water; tall clumps	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sagittaria latifolia	Arrowhead		
INUNDATION 1 FOOT TO 2 FEET			
Agrostis exarata[a]	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sparganium emmersum	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 FOOT TO 3 FEET			
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 feet
Beckmannia syzigachne[a]	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus[b]	Hardstem bulrush	Single tall stems, not clumping	to 3 feet
Scirpus validus[b]	Softstem bulrush		
INUNDATION GREATER THAN 3 FEET			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 feet
Nymphaea odorata[a]	White waterlily	Shallow to deep ponds	to 6 feet

[a] Nonnative species. *Beckmannia syzigachne* is native to Oregon. Native species are preferred.

[b] Scirpus 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.

Primary sources: Kulzer 1990; Shank 1991; Hitchcock and Cronquist 1973.

Recommended Design Features

The following design features shall be incorporated into the wet pond design where site conditions allow. See also the landscaping requirements for detention ponds in Chapter 7, Section 7.5.1:

- For wet pool 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.
- The access and maintenance road could be extended along the full length of the wet pond and could double as play courts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.
- 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). Refer to Chapter 7, Section 7.5.1 if fencing is included in the design.
- 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.
- 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 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 is complete (unless used as part of a liner; see Section 8.4.3).

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Wet Vaults (Ecology BMP T10.20)

A wet vault is an underground structure similar in appearance to a detention vault, except that a wet vault has a permanent pool of water (wet pool) which dissipates energy and improves the settling of particulate pollutants (see the wet vault details in Figure 8.21). Being underground, the wet vault lacks the biological pollutant removal mechanisms, such as algae uptake, present in wet ponds and stormwater treatment wetlands.

Applications and Limitations

A wet vault may be used for commercial, industrial, or roadway projects if there are space limitations precluding the use of other runoff treatment BMPs. The use of **wet vaults for residential development is highly discouraged.** Combined detention and wet vaults are allowed; see Section 8.9.3.

A wet vault 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 wet vaults are relatively difficult and expensive to maintain. The need for maintenance is often not visible without a deliberate inspection, and as a result routine maintenance often does not occur. Therefore, wet vaults **shall only be permitted after it has been demonstrated to the satisfaction of the City that more desirable BMPs are not practicable.**

If a wet vault/tank is designed to provide runoff treatment but not flow control it must be located “off-line” from the primary conveyance/detention system. Flows above the peak flow for the water quality design storm (see sizing procedure below) must bypass the BMP in a separate conveyance to the point of discharge. A mechanism must also be provided at the bypass point to take the BMP “off-line” for maintenance purposes. If oil control is required for a project, a wet vault may be combined with an API oil-water separator.

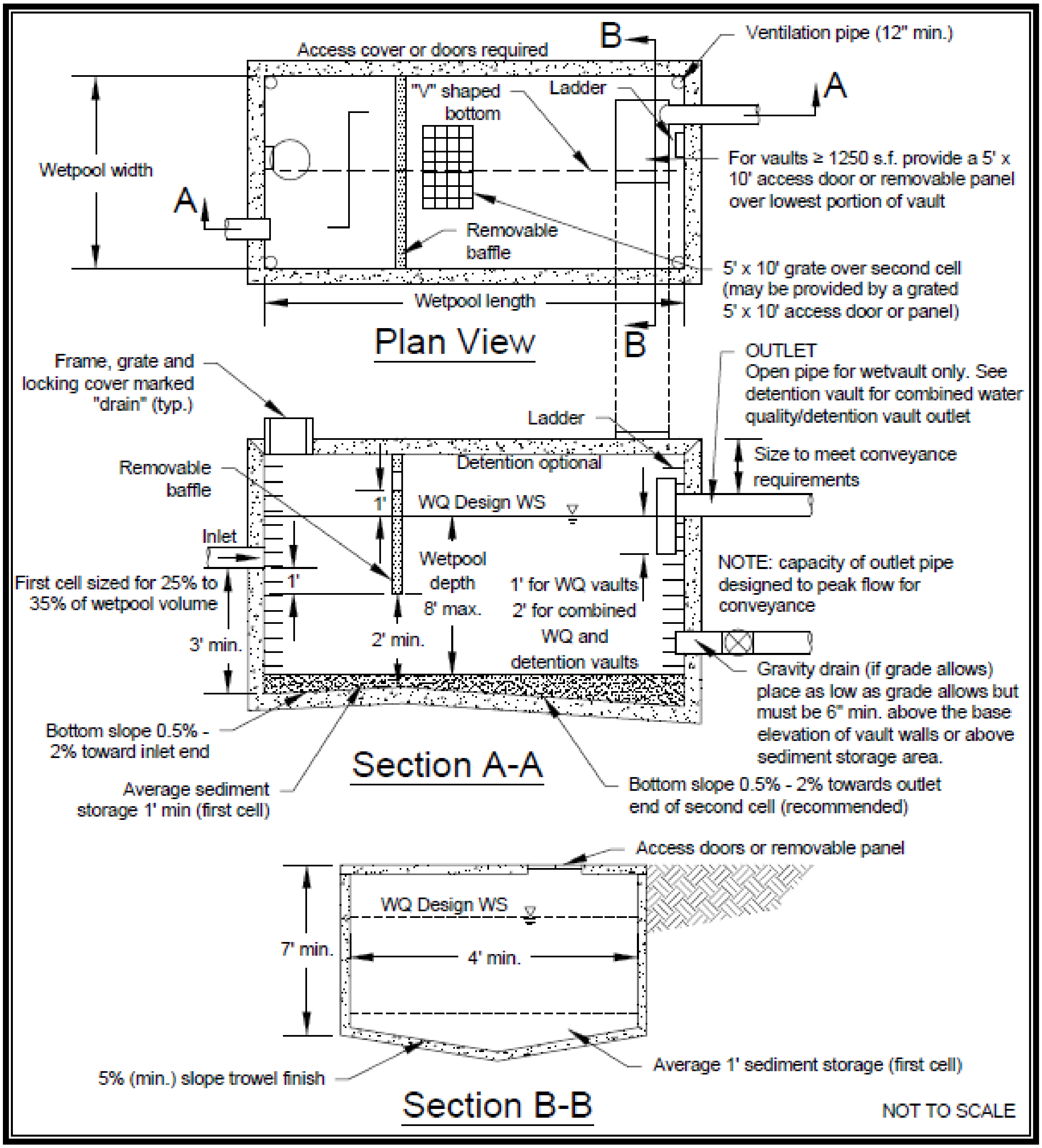
Wet Vault Design Criteria

Sizing Procedure

As with wet ponds, the primary design factor that determines the removal efficiency of a wet vault is the volume of the wet pool. 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.

The sizing procedure for a wet vault is identical to the sizing procedure for a wet pond. The wet pool volume for the wet vault **shall be equal to or greater than the water quality design volume estimated by an approved continuous simulation model**. In addition, because wet vaults are designed to be off-line, the BMP must be designed with a flow splitter that can engage a bypass when the flow rate exceeds the water quality design flow rate.

Typical design details and concepts for the wet vault are shown in Figure 8.21.



Source: King County

Figure 8.21. Wet Vault Geometry.

Wet Pool Geometry

Same as specified for wet ponds (see previous section) 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 Table 8.17:

Table 8.17. Wet Pool Geometry.

Vault Width	Sediment Depth (from bottom of side wall)
15 feet	10 inches
20 feet	9 inches
40 feet	6 inches
60 feet	4 inches

- 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 water quality 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 wet vault 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 flow path.

  Intent: Treatment effectiveness in wet pool BMPs 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 shall 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 to 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 City 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.

- Wet vaults may be constructed using arch culvert sections provided the top area at the water quality 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.

- Wet vaults shall conform to the materials and structural stability criteria specified for detention vaults in Chapter 7, Section 7.5.3.

- Where pipes enter and leave the vault below the water quality design water surface, they shall be sealed using a non-porous, non-shrinking grout.

Inlet and Outlet

- The inlet to the wet vault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom. The top of the inlet pipe shall be submerged at least 1 foot.

  - The inlet pipe must also maintain a flow rate of 2 feet per second under the design water quality storm event to minimize sediment settling in the pipe.

  - Conveyance modeling for the stormwater system leading to the vault must be shown to include consideration of the backwater effects of the submerged vault inlet. Additional information on backwater analyses is provided in Chapter 6, Section 6.3.2.

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.

- The capacity of the outlet pipe and available head above the outlet pipe shall be designed to convey the 100-year recurrence interval 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 flow path length must be maximized from inlet to outlet for all inlets to the vault.

- The outlet pipe shall be back-sloped or have tee section, the lower arm of which should extend 1 foot below the water quality design water surface to provide for trapping of oils and floatables in the vault.

- The City may require a bypass/shutoff valve to enable the vault to be taken off-line for maintenance.

Access Requirements

Same as for detention vaults (see Chapter 7, Section 7.5.3) except for the following additional requirement for wet vaults:

- 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 wet pool 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 Chapter 7, Section 7.5.3).

Construction Criteria

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Modifications for Combining with a Baffle Oil-Water Separator

If the project site requires an oil control BMP and a wet vault is proposed, the vault may be combined with a baffle oil-water separator to meet the runoff treatment requirements with one BMP 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 wet vault. This will result in more frequent inspection and cleaning than for a wet vault used only for TSS removal. See Section 8.10 for information on maintenance of baffle oil-water separators.

- The sizing procedures for the baffle oil-water separator (Section 8.10) 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 wet vault size to match.
- An oil retaining baffle shall be provided in the second cell near the vault outlet. The baffle must not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
- The vault shall have a minimum length-to-width ratio of 5:1.
- The vault shall have a design water depth-to-width ratio of between 1:3 and 1:2.
- The vault shall be watertight and shall be coated to protect from corrosion.
- 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 and accessible.
- Wet vaults used as oil-water separators must be off-line and must bypass flows greater than the off-line water quality design flow multiplied by the off-line ratio indicated in Figure 8.17b.

  Intent: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

Stormwater Treatment Wetlands (Ecology BMP T10.30)

Stormwater treatment wetlands are shallow constructed ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figures 8.22 and 8.23). Wetlands created to mitigate disturbance impacts, such as filling, may not also be used as stormwater treatment BMPs.

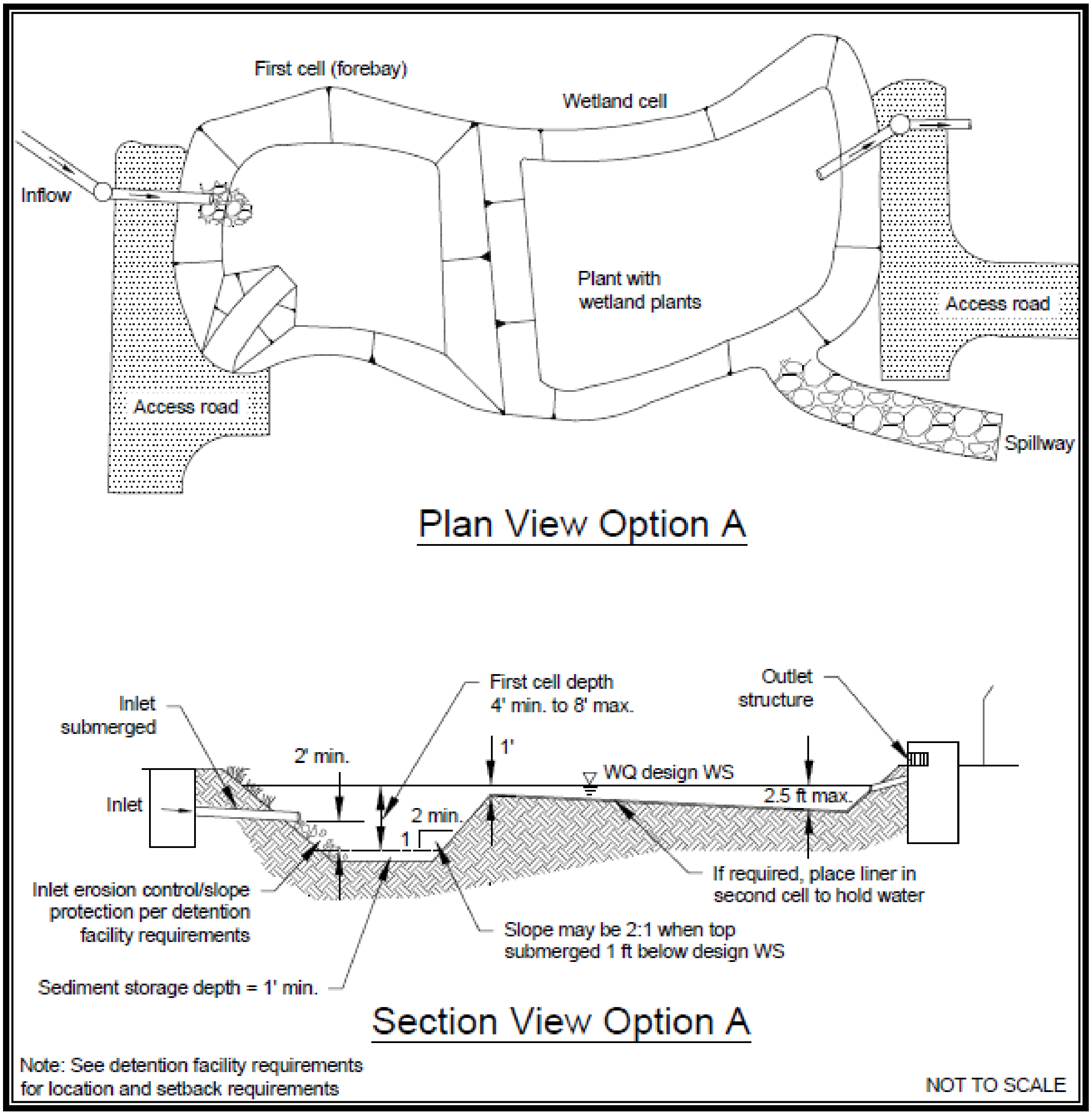
In general, stormwater wetlands perform well to remove sediment, metals, and pollutants that bind to humic or organic acids. Phosphorus removal in stormwater treatment wetlands is highly variable.

Applications and Limitations

This stormwater treatment wetland design occupies about the same surface area as wet ponds, 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 wet ponds, water loss by evaporation is an important concern. Stormwater treatment wetlands are a good water quality BMP choice in areas with high winter groundwater levels.

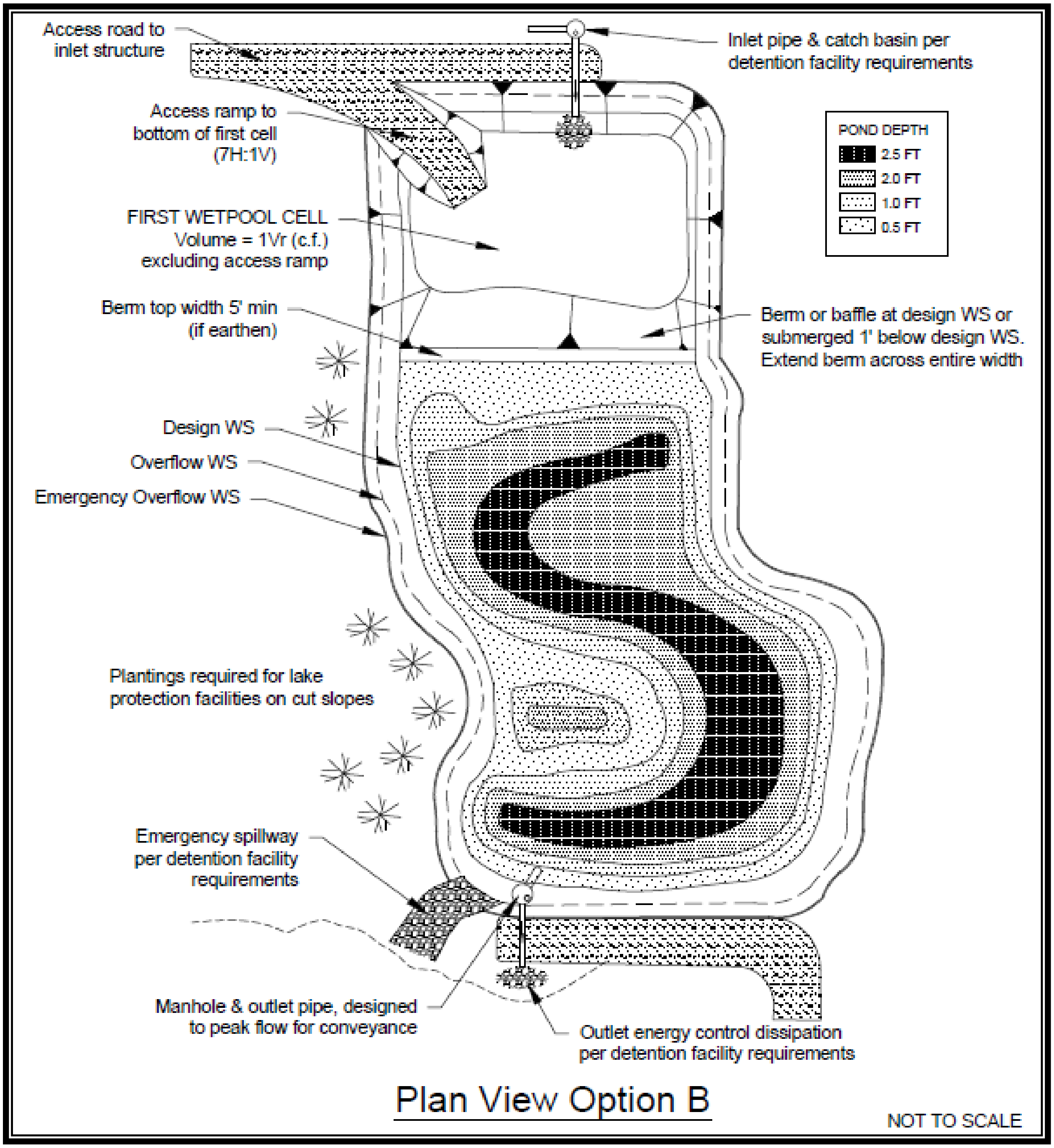
Stormwater Treatment Wetland Design Criteria

When used for runoff treatment, stormwater wetlands employ some of the same design features as wet ponds. 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 that affect plant vigor and biomass are the primary concerns.



Source: King County

Figure 8.22. Stormwater Treatment Wetland – Option One.



Source: King County

Figure 8.23. Stormwater Treatment Wetland – Option Two.

Sizing Procedure

Step 1: The volume of a basic wet pond is used as a template for sizing the stormwater treatment wetland. The design volume is the water quality design volume estimated by an approved continuous simulation model.

Step 2: Calculate the surface area of the stormwater treatment wetland. The surface area of the wetland shall be the same as the top area of a wet pond sized for the same site conditions. Calculate the surface area of the stormwater treatment 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 treatment wetland. Use the volume determined from Criterion 2 under Wetland Geometry, below, and the actual depth of the first cell.

Step 4: Determine the surface area of the second cell (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 9 under Wetland Geometry, below. **Note:** This will result in a BMP that holds less volume than that determined in Step 1 above. This is acceptable.

Intent: The surface area of the stormwater treatment wetland is set to be roughly equivalent to that of a wet pond designed for the same site so as not to discourage use of this option.

Step 6: Choose plants. See Table 8.16 for a list of plants recommended for wet pond water depth zones or consult a wetland scientist.

Wetland Geometry

1. Stormwater treatment wetlands shall consist of two cells, a presettling cell and a wetland cell.

2. The presettling cell shall contain approximately 33 percent of the wet pool 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 8.22). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 9 below).

7. The top of berm shall be either at the water quality design water surface or submerged 1 foot below the water quality design water surface, as with wet ponds. Correspondingly, the side slopes of the berm must meet the following criteria:

    a. If the top of berm is at the water quality 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 8.22). The second example is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 8.23). 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 8.17). The maximum depth is 2.5 feet in either configuration. Other configurations within the wetland geometry constraints listed above may be approved by the City.

9. To the extent possible create a complex microtopography within the wetland.

10. Design the flow path to maximize sinuous flow between wetland cells.

Table 8.18. Distribution of Depths in Wetland Cell.

Dividing Berm at Water Quality 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

Lining Requirements

Stormwater treatment wetlands are not intended to infiltrate. Many wetland plants can adapt to periods of summer drought, however the stormwater wetland design should maximize the duration of wet conditions to the extent possible. Therefore, both cells of the stormwater wetland shall be lined with a low-permeability liner. The criteria for liners given in Section 8.4.3 must be observed. A minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with three 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. A liner may not be required in hydric soils.

Inlet and Outlet

Inlets and outlets to stormwater treatment wetlands shall be configured in accordance with the requirements of wet ponds, see BMP 9.10.

Access and Setbacks

- Location of the stormwater treatment wetland relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Chapter 7, Section 7.5.1).

- Access and maintenance roads shall be provided and designed according to the requirements for detention ponds (see Chapter 7, Section 7.5.1). Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp 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 guidance given in Table 8.16 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 wet pool unless they are removed.

Construction Criteria

Sediment that has accumulated in the pond must be removed after construction in the drainage area is complete (unless used as part of a liner; see Section 8.4.3).

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Combined Detention and Wet Pool BMPs (Ecology BMP T10.40)

Combined detention and water quality wet pool BMPs have the appearance of a detention BMP 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 wet pool BMP when combined with a detention BMP. The following combined BMPs are addressed:

- Detention/wet pond (basic and large)
- Detention/wet vault
- Detention pond/stormwater wetland.

There are two sizes of the combined wet pond, a basic and a large, but only a basic size for the combined wet vault and combined stormwater wetland. The BMP sizes (basic and large) are related to the pollutant removal goals. See Section 8.3 for more information about runoff treatment performance goals.

Applications and Limitations

Combined detention and wet pool BMPs can be efficient uses of space for sites that have both runoff treatment and flow control requirements. The wet pool BMP may often be placed beneath the detention BMP without increasing the combined BMP's surface area. However, the fluctuating water surface of the live storage will create unique challenges for both plant growth and aesthetics.

The basis for pollutant removal in combined BMPs is the same as in the stand-alone wet pool BMPs. However, in the combined BMP, 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 wet pool volume. For the combined detention/stormwater treatment wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

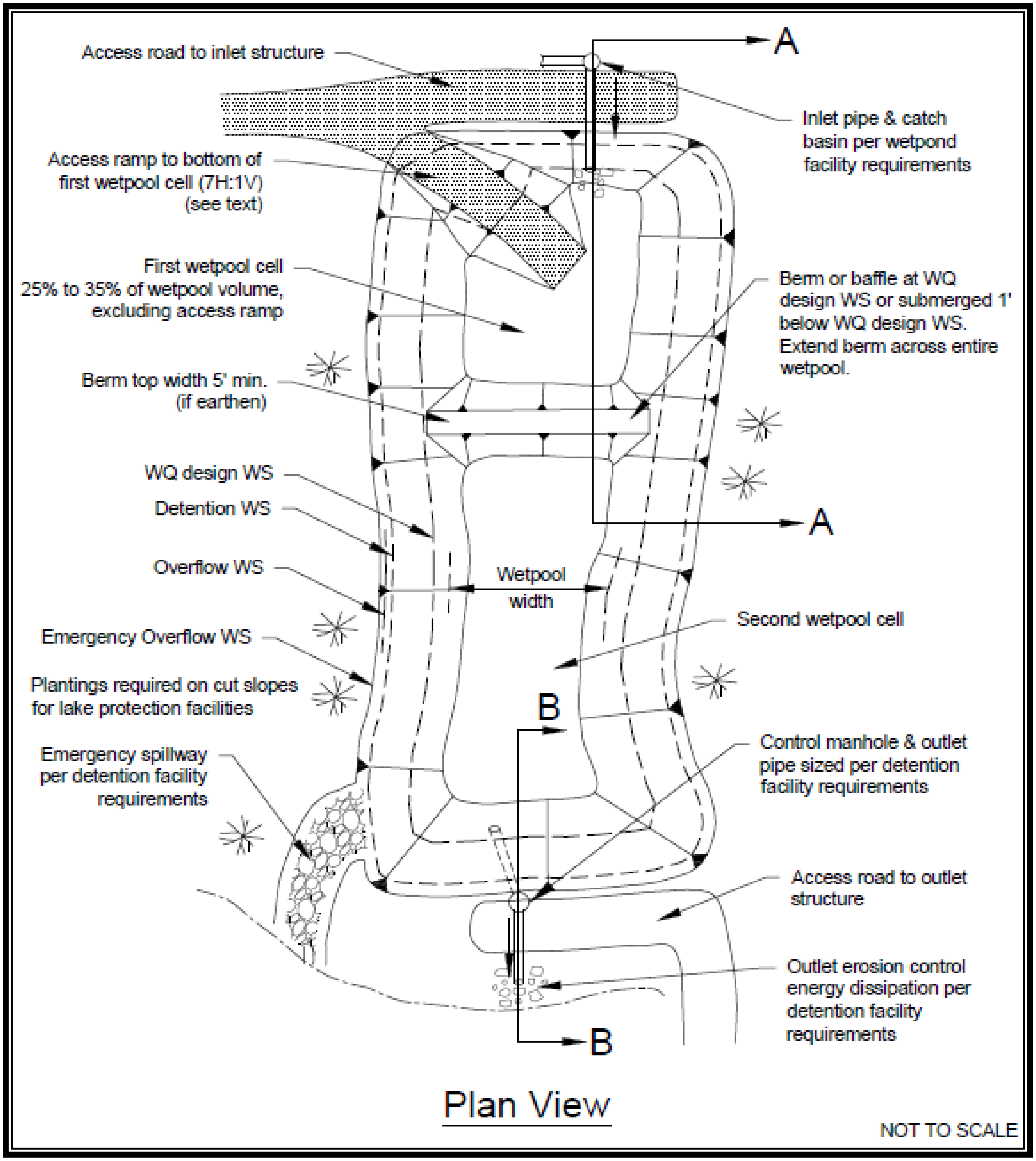
Unlike the wet pool volume, the live storage component of the combined detention and wet pool BMP must be provided above the seasonal high water table.

Design Criteria for Combined Detention and Wet Pond (basic and large)

Typical design details and concepts for a combined detention and wet pond are shown in Figures 8.24a and 8.24b. The detention portion of the BMP shall meet the design criteria and sizing procedures set forth in Chapter 7.

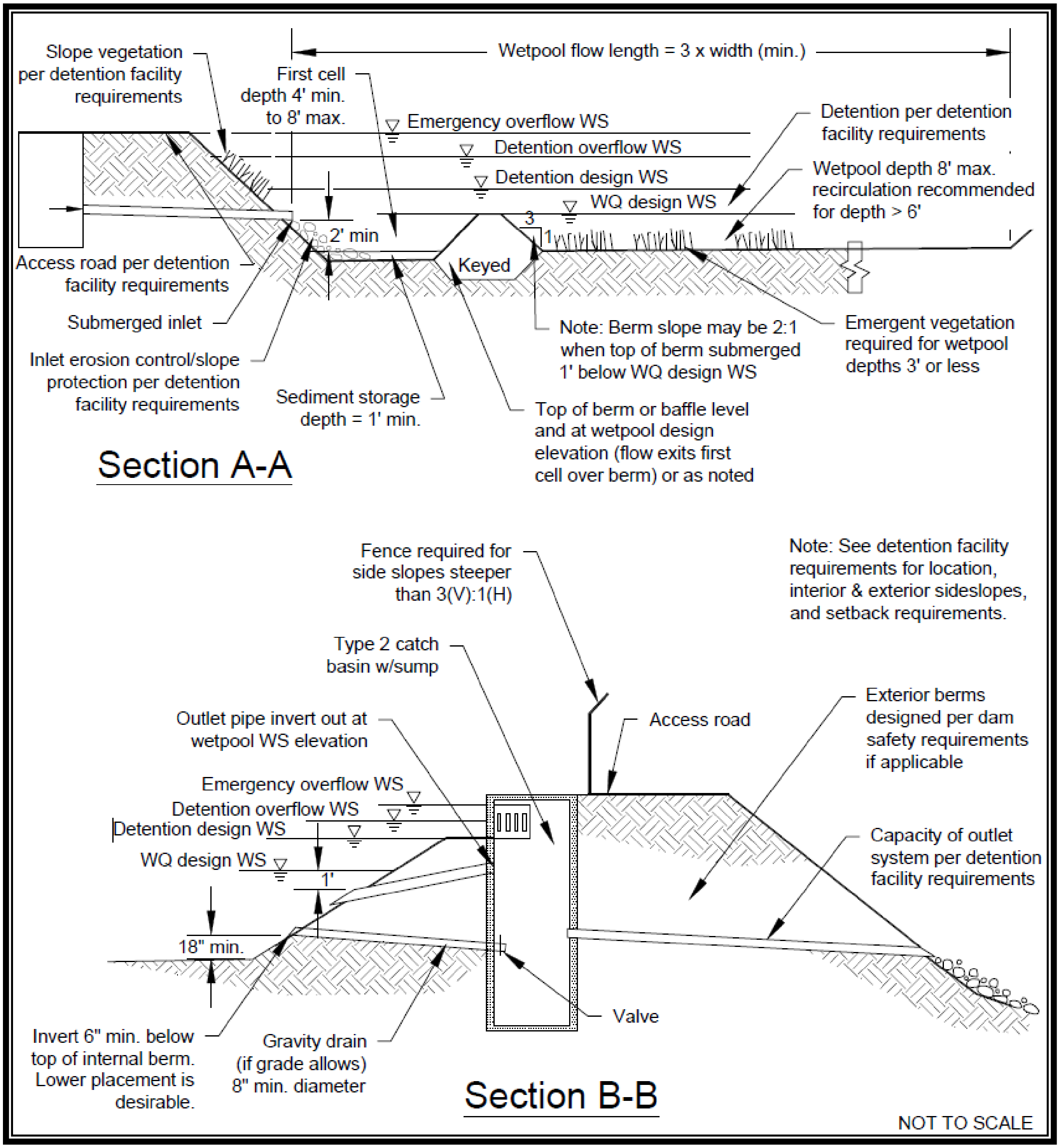
Sizing Procedure

The sizing procedure for combined detention and wet ponds are identical to those outlined for wet ponds and for detention BMPs. The wet pool volume for a combined BMP shall be equal to or greater than the water quality design volume estimated by an approved continuous runoff model. Follow the standard procedure specified in Chapter 7 and guidance documents for use of an approved continuous simulation model to size the detention portion of the pond.



Source: King County

Figure 8.24a. Combined Detention and Wet Pond.



Source: King County

Figure 8.24b. Combined Detention and Wet Pond (continued).

Detention and Wet Pond Geometry

- The wet pool and sediment storage volumes shall not be included in the required detention volume.

- The wet pool geometry criteria in the Wet Ponds – Basic and Large (Ecology BMP T10.10) section above 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 wet pool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wet pond criteria governing water depth must, however, still be met. See Figure 8.25 for two possibilities for wet pool 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 do 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 wet ponds.

Inlet and Outlet

The inlet and outlet criteria in the Wet Ponds – Basic and Large (Ecology BMP T10.10) section above shall apply, with the following modifications:

- A sump must be provided in the outlet structure of combined detention and wet ponds.

- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Chapter 7, Section 7.5.1).

Access and Setbacks

Same as for wet ponds.

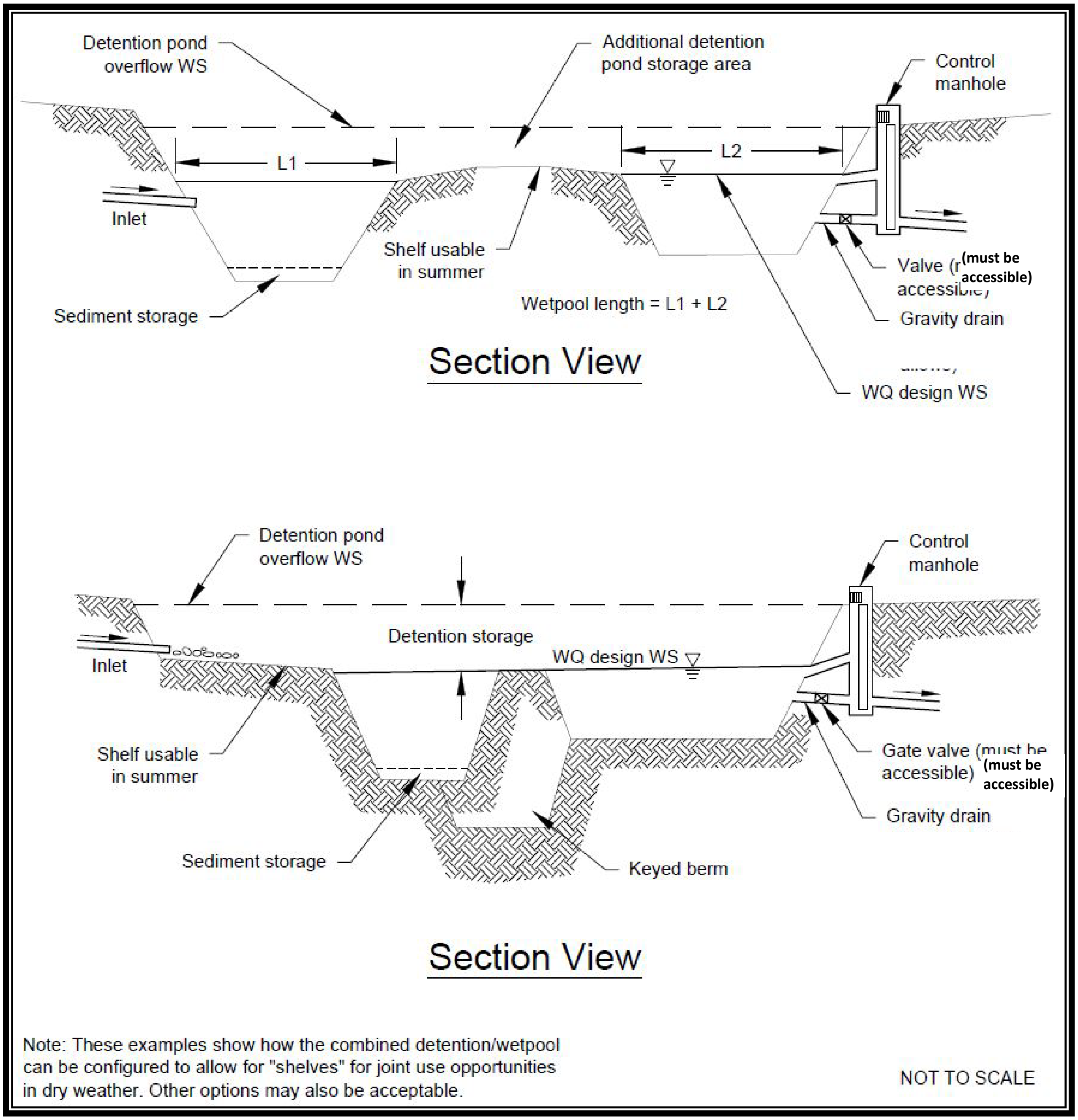
Planting Requirements

Same as for wet ponds.

Design Criteria for Combined Detention and Wet Vault

Sizing Procedure

The sizing procedure for combined detention and wet vaults is identical to those outlined for wet vaults and for detention BMPs. The wet vault volume for a combined BMP shall be equal to or greater than the water quality design volume estimated by an approved continuous simulation model. Follow the standard procedure specified in Chapter 7 to size the detention portion of the vault.



Source: King County

Figure 8.25. Alternative Configurations of Detention and Wet Pool Areas.

Detention and Wet Vault Geometry

The design criteria for detention vaults and wet vaults must both be met, except for the following modifications:

- 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.

Berms, Baffles, and Slopes

The design criteria for detention vaults and wet vaults must both be met, except for the following modifications:

- The oil retaining baffle shall extend a minimum of 2 feet below the water quality design water surface.

  Intent: The greater depth of the baffle in relation to the water quality 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 separate oils remain within the vault, even during storm events.

Note: If a vault is used for detention as well as runoff treatment, the BMP may not be modified to function as an oil control BMP, as is allowed for wet vaults. This is because the added pool fluctuation in the combined detention and wet vault does not allow for the quiescent conditions needed for oil separation.

Inlet and Outlet

Same as for wet vaults.

Access and Setbacks

Same as for wet vaults.

Design Criteria for Combined Detention and Stormwater Treatment Wetland

Sizing Procedure

The sizing procedure for combined detention and stormwater treatment wetlands is identical to those outlined for stormwater treatment wetlands and for detention BMPs. Follow the procedure specified for stormwater treatment wetlands in the previous section to size the stormwater treatment wetland. Follow the standard procedure specified in Chapter 7 to size the detention portion of the combined detention and wetland BMP.

Detention and Wetland Geometry

The design criteria for detention ponds and stormwater treatment wetlands must both be met, except for the following modifications:

- Water Level Fluctuation Restrictions: The difference between the water quality 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 treatment 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 detention and stormwater treatment wetlands to better ensure that fluctuation-tolerant wetland plants will be able to survive . It is not intended to protect native wetland plant communities and is not to be applied to natural wetlands.

- The wetland geometry criteria in the Stormwater Treatment Wetlands (Ecology BMP T10.30) section must be modified such that 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 pond.

  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.

Inlet and Outlet

The inlet and outlet criteria in the Wet Ponds – Basic and Large (Ecology BMP T10.10) shall apply, with the following modifications:

- A sump must be provided in the outlet structure of combined detention and stormwater treatment wetlands.

- The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Chapter 7, Section 7.5.1).

Planting Requirements

The Planting Requirements for Stormwater Treatment Wetlands (Ecology BMP T10.30) are modified to use the following plants, which are better adapted to water level fluctuations:

- *Scirpus acutus* (hardstem bulrush) 2- to 6-foot depth

- *Scirpus microcarpus* (small-fruited bulrush) 1- to 2.5-foot depth

- *Sparganium emersum* (burreed) 1- to 2-foot depth
- *Sparganium eurycarpum* (burreed) 1- to 2-foot depth
- *Veronica* sp. (marsh speedwell) 0- to 1-foot depth

In addition, the shrub Douglas spirea (*Spiraea douglasii*) may be used in combined detention and stormwater treatment wetlands.

Construction, and Operations and Maintenance Criteria

Construction, and operations and maintenance criteria for combined detention and wet pool BMPs are the same as those outlined for each individual detention and wet pool BMP (i.e., as outlined in Chapter 7 and in the previous sections of this chapter).

8.10 Oil-Water Separators

8.10.1 Purpose

This section provides a discussion of oil-water separators, including their application and design criteria. Oil-water separators remove oil and other water-insoluble hydrocarbons, and settleable solids from stormwater runoff.

BMPs are described for baffle type and coalescing plate separators. In addition to the oil-water separators outlined in this chapter, the City may also permit the use of oil control booms for oil control in some situations when designed in accordance with the requirements outlined in the WSDOT HRM.

8.10.2 Description

Oil-water separators are typically the API, also called baffle type (American Petroleum Institute 1990) or the coalescing plate type using a gravity mechanism for separation. See Figures 8.26 and 8.27. Oil-water separators typically consist of three bays: forebay, separator section, and the afterbay. The coalescing plate separators need considerably less space for separation of the floating oil due to the shorter travel distances between parallel plates.

A spill control separator (Figure 8.28 and DG&PWS) is a simple catch basin 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 runoff treatment purposes.***

8.10.3 Performance Objectives

See Section 8.3 for a summary of the oil control performance goals.

8.10.4 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 operations and maintenance

8.10.5 General Design Criteria

There is concern that oil-water separators used for runoff treatment have not performed to expectations (Watershed Protection Techniques 1994; Schueler et al. 1992). Therefore, emphasis should be given to proper application, design, operations and maintenance, (particularly sludge and oil removal), and prevention of coalescing plate fouling and plugging (U.S. Army Corps of Engineers 1994). Other runoff treatment BMPs, such as sand filters and manufactured treatment devices, should be considered for the removal of insoluble oil and TPH.

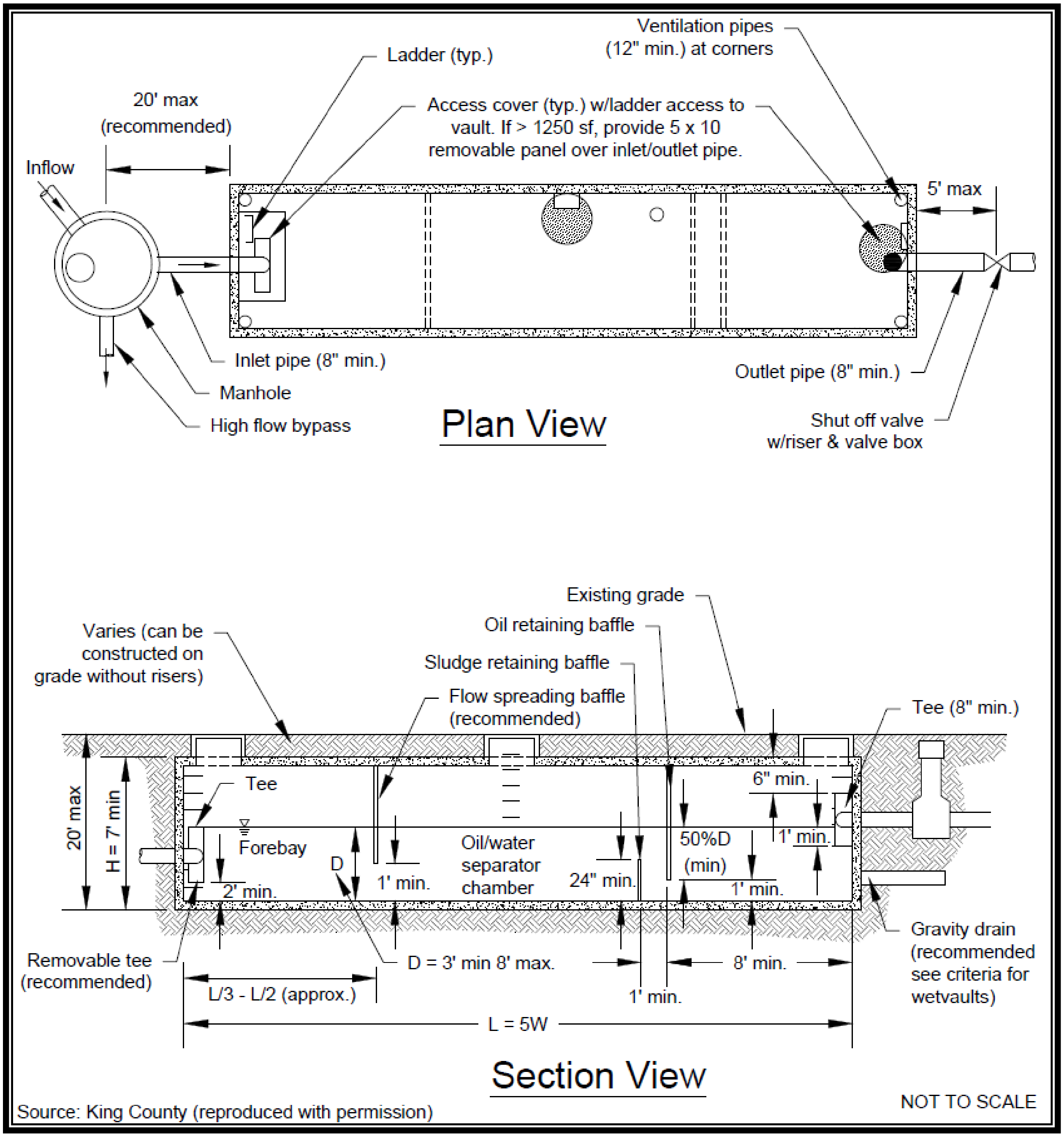


Figure 8.26. API (Baffle Type) Separator.

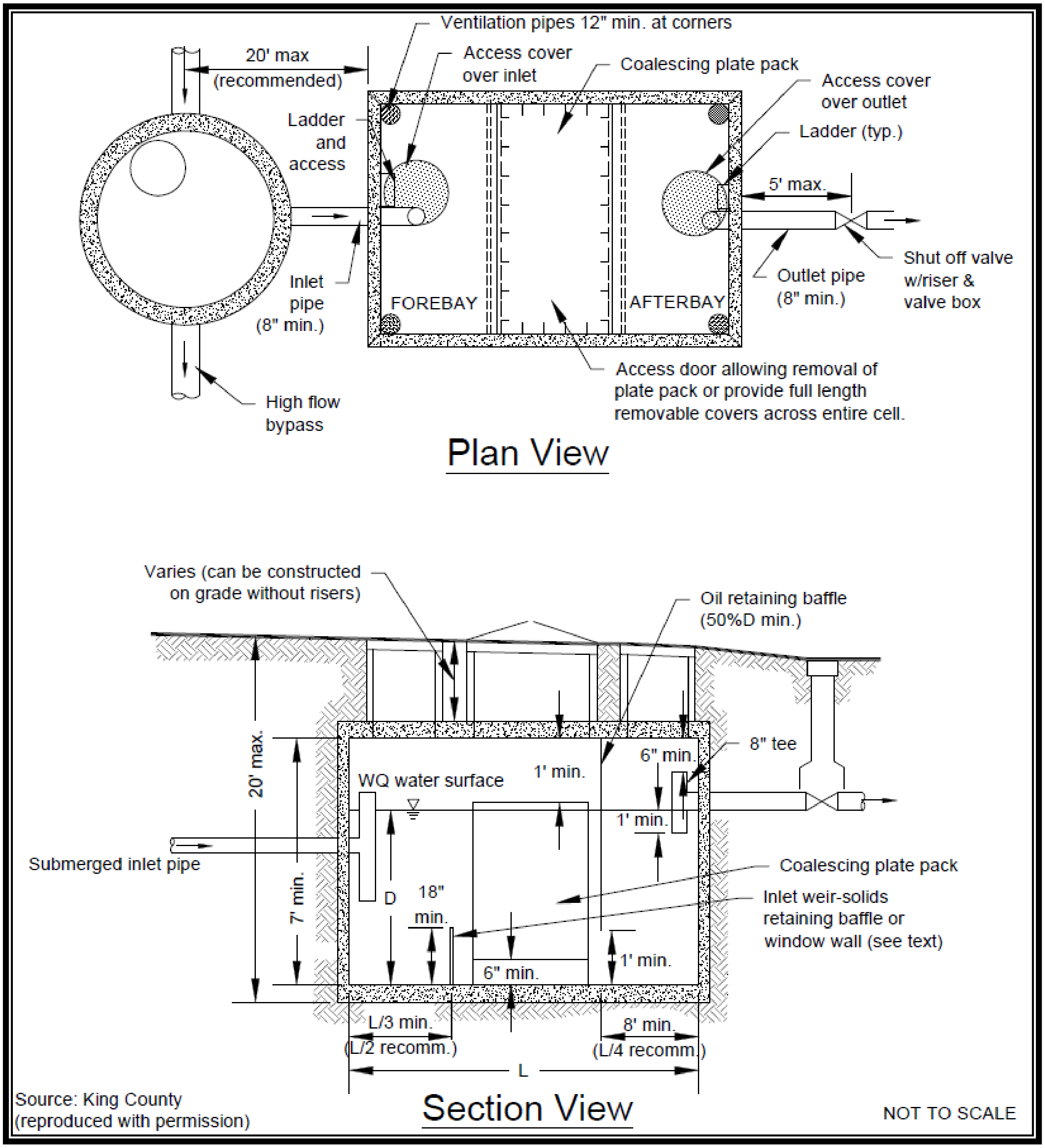
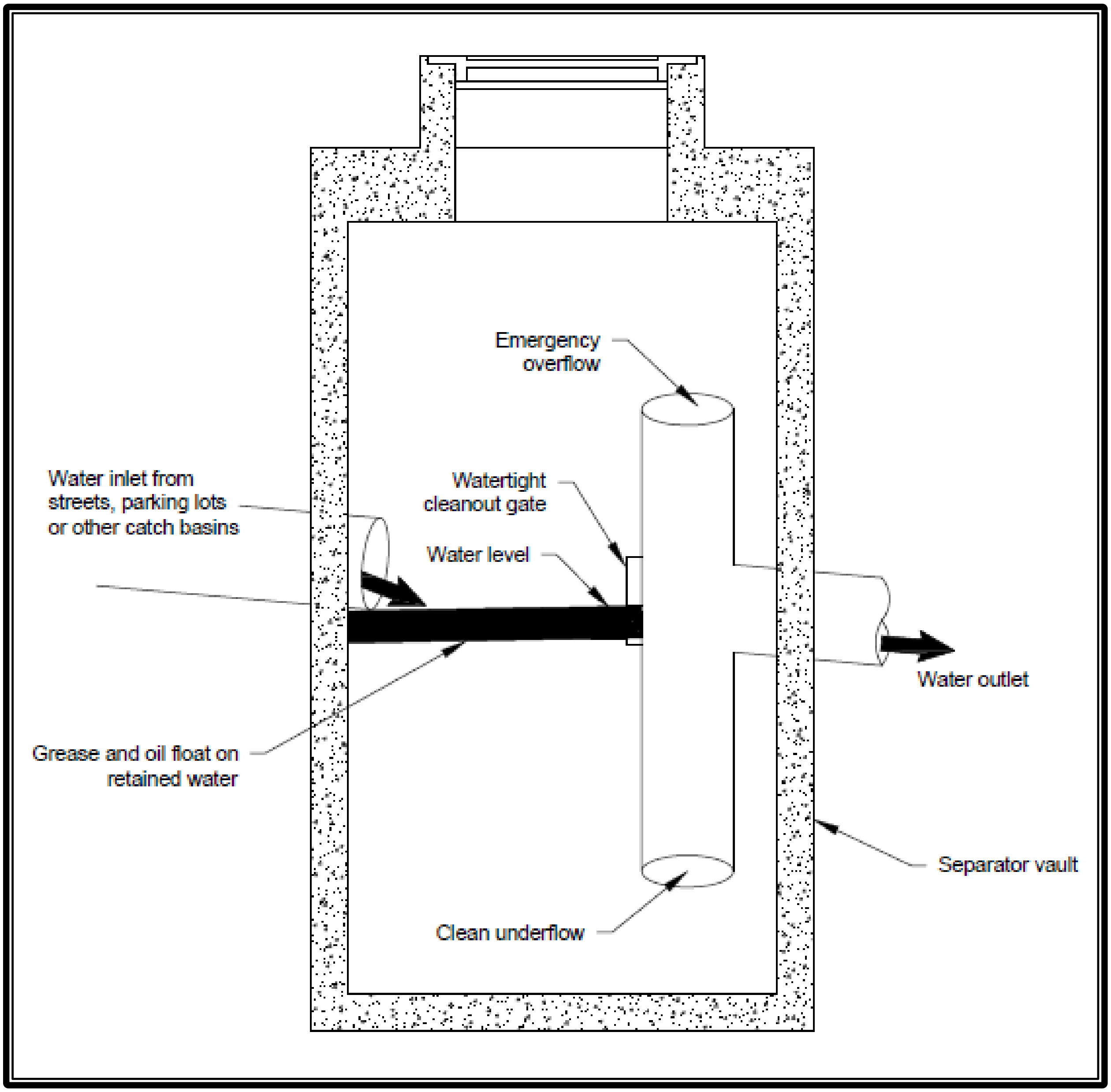


Figure 8.27. Coalescing Plate Separator.



Source: Ecology

Figure 8.28. Spill Control Separator (not for oil treatment).

The following are design criteria applicable to API and coalescing plate oil-water separators:

- 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 8.17b of this chapter. 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 8.17a.

- Use only impervious conveyances for oil contaminated stormwater.
- Add pretreatment for TSS that could cause clogging of the coalescing plate separator, or otherwise impair the long-term effectiveness of the separator.
- Include roughing screens for the forebay or upstream of the separator to remove debris. Screen openings should be about three-fourths inch.

Design Criteria for Separator Bays

- For an off-line BMP, size the separator bay (the second bay) for the water quality design flow rate (15-minute time step) multiplied by the correction factor ratio indicated in Figure 8.17b. (See Section 8.4 for a definition of the water quality design flow rate.)
- For an on-line BMP, size the separator bay (the second bay) for the water quality design flow rate (15-minute time step) multiplied by the correction factor ratio indicated in Figure 8.17a.
- To collect floatables and settleable solids, design the surface area of the forebay at ≥20 ft^2 per 10,000 ft^2 of area draining to the separator. The length of the forebay should be one-third to one-half of the length of all three bays combined. Include roughing screens for the forebay or upstream of the oil-water separator to remove debris, if needed. Screen openings should be about 3/4 inch.
- Include a submerged inlet pipe with a turned-down elbow in the forebay at least 2 feet from the bottom. The outlet pipe should be a Tee, sized to pass the water quality design flow rate and placed at least 12 inches below the water surface.
- Include a shutoff valve at the outlet pipe.
- Use absorbents and/or skimmers in the afterbay (the third bay) as needed.

Design Criteria for Baffles

- Oil retaining baffles (top baffles) must be located at least at one-quarter of the total separator length from the outlet and must extend down at least 50 percent of the water depth and at least 1 foot from the oil-water separator bottom.
- Baffle height to water depth ratios shall be 0.85 for top baffles and 0.15 for bottom baffles.

8.10.6 Oil-Water Separator BMPs

Two BMPs are described in this section: API baffle type separators, and coalescing plate separators.

API (Baffle type) Separator Bay (Ecology BMP T11.10)

API separators are designed for use on large sites greater than 2 acres. The 2019 Ecology Manual presents a design modification for using API separators in drainage areas smaller than 2 acres (e.g., fueling stations, commercial parking lots, etc.). However, Ecology also requires each developer to perform detailed performance verification during at least one wet season when using their modified design. Given this requirement, the City has elected not to allow the use of API separators on sites smaller than 2 acres. The following approach only applies to contributing drainage areas larger than 2 acres:

API Design Criteria

The API design criteria is based on the horizontal velocity of the bulk fluid (V_h), the oil rise rate (V_t), the residence time (t_m), width, depth, and length considerations.

The following is the API sizing procedure:

- Determine the oil rise rate, V_t, in centimeters per second, using Stokes' Law (Water Pollution Control Federation 1985), empirical determination, or 0.033 ft/min for 60μ oil.

- Stokes Law equation for rise rate, V_t (cm/sec):

$$V_t = g(\sigma_w - \sigma_o)D^2 / 18\eta_w$$

Where:

g = gravitational constant (981 centimeters per second squared)

D = diameter of the oil particle (centimeters)

σ_w = water density at the design temperature (grams per cubic centimeter)

σ_o = oil density at the design temperature (grams per cubic centimeter)

η_w = dynamic viscosity of water (gm/cm-sec)

Use

D = 60 microns (0.006 centimeters)

σ_w = 0.999 grams per cubic centimeter (gm/cc) at 32°F

σ_o: Select conservatively high oil density,

For example, if diesel oil @ σ_o = 0.85 gm/cc and motor oil @ σ_o = 0.90 gm/cc can be present then use σ_o = 0.90 gm/cc

η_w = 0.017921 poise (gm/cm-sec) at water temperature of 32°F
(see API publication 421, February 1990)

For Stormwater Inflow from Drainages More Than 2 Acres

- Determine V_t based on above criteria

- Determine Q

  Q = the 15-minute water quality design flow rate in ft^3/min multiplied by the ratio indicated in Figure 8.17a (for on-line BMPs) or Figure 8.17b (for off-line BMPs) for the site location (k). Note that the continuous runoff models likely report the water quality design flow rate in ft^3/sec. Multiply this flow rate by 60 to obtain the flow rate in ft^3/min.

- Calculate horizontal velocity of the bulk fluid, V_h (in ft/min), and depth (d), ft.

  $V_h = 15Vt$

  $d = (Q/2V_h)^{1/2}$, with

  Separator water depth, $3 \leq d \leq 8$ feet (to minimize turbulence). If the calculated depth is less than 3 feet, an API separator is not appropriate for the site. If the calculated depth exceeds 8 feet, consider using two separators (American Petroleum Institute 1990; U.S. Army Corps of Engineers 1994).

- Calculate the minimum residence time (t_m), in minutes, of the separator at depth d:

  $t_m = d/V_t$

- Calculate the minimum length of the separator section, l(s), using:

  F = 1.65

  Depth/width (d/w) of 0.5 (American Petroleum Institute 1990),

  $l(s) = FQt_m/wd = F(V_h/V_t)d$

  For other dimensions, including the length of the forebay, the length of the afterbay, and the overall length, L; refer to Figure 8.26.

- Calculate $V = l(s)wd = FQt_m$, and $A_h = wl(s)$

  V = minimum hydraulic design volume, in cubic feet.

  A_h = minimum horizontal area of the separator, in square feet.

Maintenance

Without intense maintenance, oil-water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels. See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

Coalescing Plate Separator Bay (Ecology BMP T11.11)

Coalescing Plate Design Criteria

Calculate the projected (horizontal) surface area of plates needed using the following equation:

$$A_h = Q/V_t = Q/[0.00386 * ((S_w - S_o)/(\mu_w))]$$

Where:

Q = design flow rate (ft^3/min)

V_t = Rise rate of the oil droplet

A_h = horizontal surface area of the plates (ft^2; 0.00386 is unit conversion constant)

S_w = specific gravity of water at the design temperature

S_o = specific gravity of oil at the design temperature

μ_w = absolute viscosity of the water (poise).

The above equation is based on an oil droplet diameter of 60 microns.

- Plate spacing should be a minimum of three-fourths of an inch (perpendicular distance between plates) or as determined by the manufacturer. (ASCE and WEF 1998; U.S. Army Corps of Engineers 1994; Jaisinghani and Springer 1979).
- Select a plate angle between 45 to 60 degrees 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 coalescing plate separator. The Reynolds Number through the separator bay should be less than 500 (laminar flow).

- Include forebay for floatables and afterbay for collection of effluent (ASCE and WEF 1998).
- The sediment-retaining baffle must be upstream of the plate pack at a minimum height of 18 inches.
- Design plates for ease of removal, and cleaning with high-pressure rinse or equivalent.

Maintenance

Without intense maintenance, oil-water separators may not be sufficiently effective in achieving oil and TPH removal down to required levels. See Core Requirement #9 in Chapter 2; Chapter 3, Section 3.3.3; and Chapter 10 for information on maintenance requirements.

8.11 Manufactured Treatment Devices

8.11.1 Background

This section addresses manufactured treatment devices that have not been evaluated in sufficient detail to be acceptable for general usage in new development or redevelopment situations.

The City Stormwater Design Manual (SDM) is based on the 2019 Ecology Manual. BMPs listed in the 2019 Ecology Manual are presumed to provide adequate runoff treatment (see Chapter 1, Section 1.7.4), but in many situations traditional BMPs such as wet ponds and biofiltration swales may not be appropriate or optimal (due to size and space restraints, or inability to remove target pollutants). Because of this, the stormwater treatment industry emerged to develop new stormwater treatment devices.

Manufactured treatment devices are emerging technologies that are new to the stormwater treatment marketplace. These devices include both permanent and construction site treatment technologies.

8.11.2 Evaluation of Manufactured Treatment Devices

Ecology has established the TAPE program to evaluate the capabilities of manufactured treatment devices. Manufactured treatment devices that have been evaluated by TAPE are approved at some level of use designation under specified conditions. Their use is restricted in accordance with their evaluation as explained in Volume V, Section 10.3 of the 2019 Ecology Manual. The recommendations for use of individual manufactured treatment devices may change as we collect more data on their performance. Updated recommendations on their use are posted to Ecology's TAPE web page: <https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Stormwater-permittee-guidance-resources/Emerging-stormwater-treatment-technologies>.

8.11.3 Applicability and Restrictions

The City has chosen to allow application of new technologies to be used to meet the requirements of this manual when they reach General Use Level Designation (GULD). The Director of Public Works has the authority to add additional requirements or conditions to these technologies, beyond those required by Ecology. **Note that the City will not accept ownership of GULD BMPs without prior approval.**

Additional general guidelines regarding the applicability and restrictions of manufactured treatment devices are as follows:

- In most retrofit situations where the requirements of this manual are not triggered, manufactured treatment devices may be used, with prior approval by the City. The assumption is that a manufactured treatment device is better than nothing.

- The City may, in some circumstances, allow use of technologies receiving Conditional Use Level Designation (CULD). Any application of CULD technologies will be required to sign a maintenance agreement with the City, stating that they will be responsible for maintaining these structures at all times, in accordance with the manufacturer’s requirements or as outlined for the specific CULD BMP by the City. This includes single-family residential applications. In addition, all property owners using these technologies will be responsible for upgrade/replacement of their systems in perpetuity. This includes upgrading or replacing these systems when problems arise, standards change, or the technology is ultimately rejected by the Board of External Reviewers (BER) or the City.

- The City may allow pilot level applications of new technologies in order for manufacturers to obtain data to help fulfill the requirements of the TAPE approval process. These projects must be approved in advance by the Director of Public Works, have an approved monitoring plan from the BER or Ecology, and provide a financial bond to provide cleanup and replacement in the event of failure.

Chapter 8 References

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Appendix 8A – Geotextile Specifications

Table 8A.1. Geotextile Property Requirements for Underground Drainage.[a]

		Low Survivability	Moderate Survivability
Geotextile Property	**Test Method**	**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

[a] 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 8A.2. Geotextile Property Requirements for Underground Drainage Filtration.[a]

Geotextile Property	Test Method	Class A	Class B	Class C
AOS[b]	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.

[a] 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).

[b] AOS = Apparent Opening Size (measure of diameter of the pores in the geotextile).

Table 8A.3. Geotextile Strength Property Requirements for Impermeable Liner Protection.

Geotextile Property	Test Method	Geotextile Property Requirements[a]
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 xenon arc device

[a] 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 A.1 and A.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 in Table A.3 should be used to specify survivability properties for the liner protection application. Table A.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 A.1 and A.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 stormwater 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 percent 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 percent or more). Tensile strength should be on the order of 200 lbs grab (ASTM D4632) or more.

From Allen (1999).

Reference for Tables A.1 and A.2: Section 9-33.2, Geotextile Properties, *WSDOT Standard Specifications for Road, Bridge, and Municipal Construction*.

Appendix 8B – Wellhead Protection and Critical Aquifer Recharge Area Maps

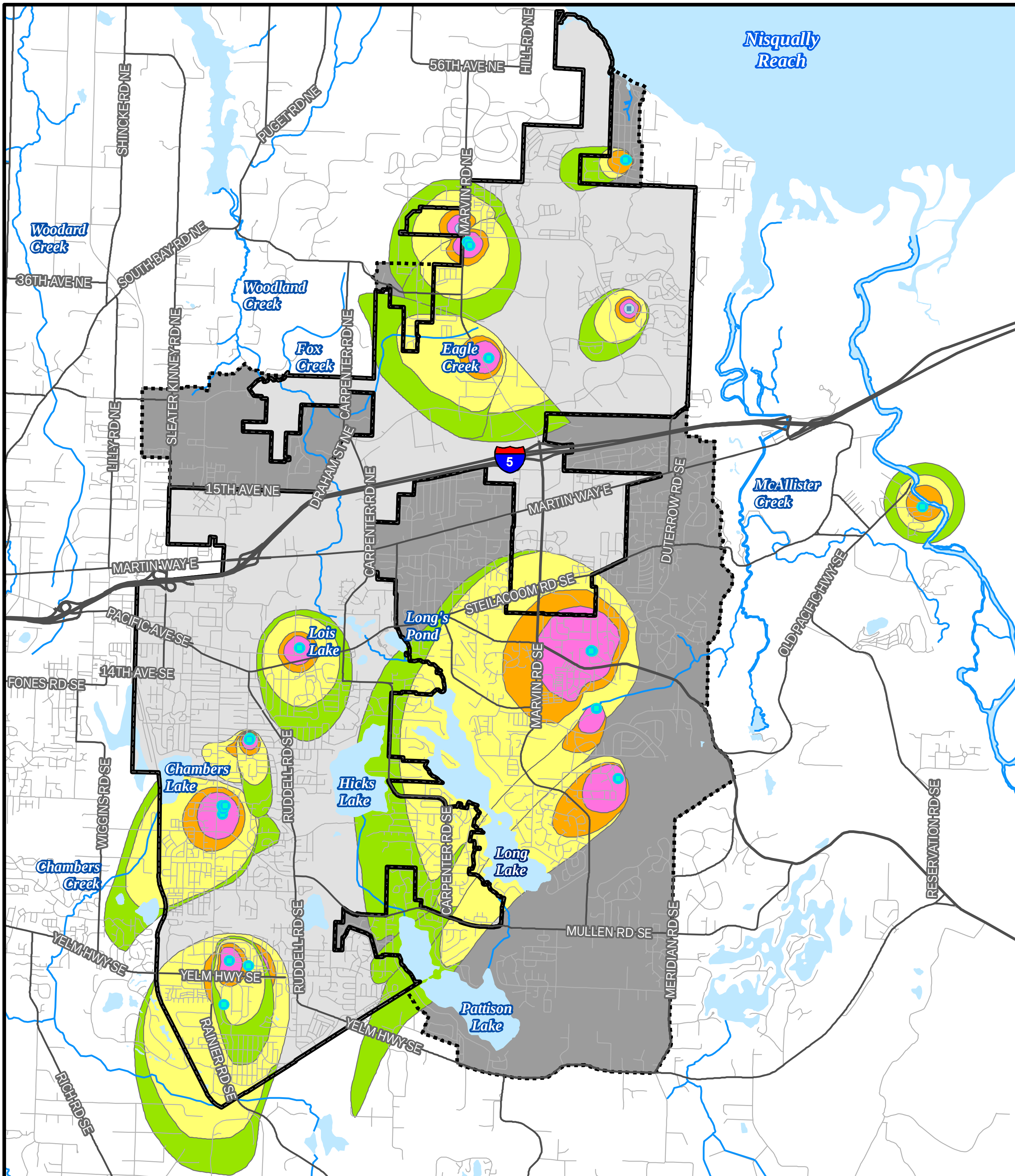

Figure 8B.1
Wellhead Protection Areas

N

0 3,125 6,250 12,500
Feet

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Legend

- Lacey City Limits
- Urban Growth Management Area (UGMA)
- River
- Waterbody

Production Wells

- Future
- Active

Wellhead Protection Areas (2021)

- 6-month
- 1-year
- 5-year
- 10-year

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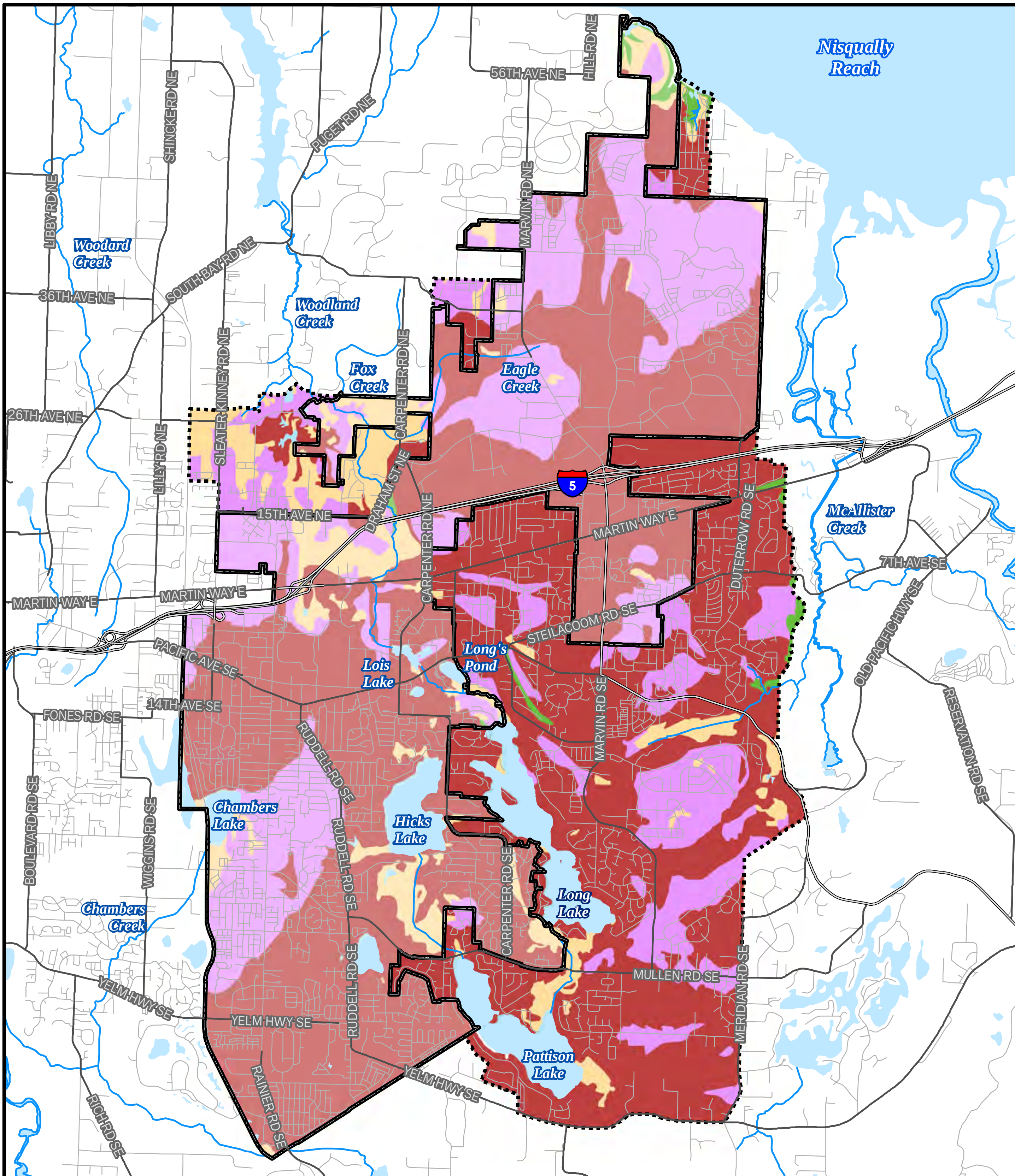

Figure 8B.2. Critical Aquifer Recharge Areas

N

0 3,000 6,000 12,000

Feet

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Legend

- Lacey City Limits
- Urban Growth Management Area (UGMA)
- River
- Waterbody

Critical Aquifer Recharge Area (CARA)

- Category I
- Category II
- Category III
- Category IV

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Chapter 9 – Source Control for Developed Sites

Table of Contents

Figures

Chapter 9 – Source Control for Developed Sites

9.1 Introduction

9.1.1 What is the Purpose of this Chapter?

Minimum Requirement #3, Source Control of Pollution, of the Western Washington National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Stormwater Permit states the following:

"All known, available and reasonable source control BMPs [best management practices] must be required for all projects approved by the [City of Lacey]. Source control BMPs must be selected in accordance with [Volume III], and designed and maintained in accordance with Volume IV of the [Department of Ecology's] Stormwater Management Manual for Western Washington [2019 Ecology Manual]."

This chapter is designed to help businesses, homeowners, and public agencies in the City of Lacey (City) implement source control BMPs to prevent pollutants from contaminating stormwater runoff and entering our lakes, streams, and Puget Sound. The purpose of source control BMPs is to prevent stormwater from coming in contact with pollutants *post*development, at the pollutant source. Source control can be a cost-effective means of reducing pollutants in stormwater, and therefore must be a primary consideration for all projects.

9.1.2 Ecology's *Stormwater Management Manual for Western Washington Standards*, Adopted

Source control BMPs must be selected from, designed, and maintained in accordance with Volumes III and IV of the 2019 Ecology Manual. The City hereby adopts the following requirements of Volumes III and IV of the 2019 Ecology Manual:

- Volume III, Section 1.1 of the 2019 Ecology Manual describes the process for selecting source control BMPs.
- Volume IV contains the following sections, which provide applicable (mandatory) and recommended BMPs grouped by types of activities that have the potential to produce pollution.
    - Section 1: Source Control BMPs Applicable to All Sites
    - Section 2: Cleaning or Washing Source Control BMPs
    - Section 3: Roads, Ditches, and Parking Lot Source Control BMPs
    - Section 4: Soil Erosion, Sediment Control, and Landscaping Source Control BMPs

- Section 5: Storage and Stockpiling Source Control BMPs
- Section 6: Transfer of Liquid or Solid Materials Source Control BMPs
- Section 7: Other Source Control BMPs

Volume IV of the 2019 Ecology Manual also includes the following appendices, hereby adopted by the City in accordance with the NPDES Phase II Municipal Stormwater Permit requirements:

- Appendix IV-A: Urban Land Uses and Pollutant Generating Sources

  This appendix identifies pollutant-generating sources at various land uses, i.e., manufacturing, transportation, communication, wholesale, retail, and service land uses.

- Appendix IV-B: Management of Street Waste Solids and Liquids

  This appendix addresses what to do with waste generated from stormwater maintenance activities such as street sweeping, catch basin cleaning, and flow control and runoff treatment BMP maintenance.

For the purposes of this chapter, the following references in Volume IV of the 2019 Ecology Manual shall be revised as follows:

- "local jurisdiction" and "local government" shall refer to "the City of Lacey"
- "local health department" shall refer to the "Thurston County Public Health and Social Services Department"
- "local sewer authority" shall refer to the "City of Lacey Wastewater Utility," or the "LOTT Clean Water Alliance." The City manages the collection and conveyance of wastewater to the LOTT Clean Water Alliance Wastewater Treatment Plant. Note that "local sewer authority" may apply to either or both entity(ies), depending on the nature of the discharge and requirement.
- "local permitting authority" shall refer to the "City of Lacey Department of Community and Economic Development"
- "local water utility" shall refer to the "City of Lacey Water Utility"
- "local Conservation District" shall refer to the "Thurston Conservation District"
- "local fire department" shall refer to "Lacey Fire District 3"

The remaining sections of this chapter are provided as City-specific guidance.

9.1.3 How Does this Chapter Apply to Businesses and Properties?

Because of the provisions of the federal Clean Water Act and Coastal Zone Management Act, as well as the NPDES permit, the implementation of BMPs applies to all businesses, residences, and public agencies in the City. It includes all permanent and temporary activities at public facilities, commercial and industrial facilities, agriculture and livestock farms, and residential dwellings. Anyone involved in a particular activity, whether as an employee, supervisor, manager, landlord, tenant, or homeowner, must take part in implementing appropriate BMPs.

Every person/business in the City of Lacey is required to use BMPs. Select BMPs from this chapter and Volume IV of the 2019 Ecology Manual. The BMPs required by this chapter and Volume IV of the 2019 Ecology Manual include Applicable (mandatory) and Recommended BMPs. Please note that in some instances there are required BMPs that are mandated by various federal, state, or City laws. Recommended BMPs are encouraged to further protect our water quality. For instance, if only one BMP is mandatory, it can be coupled with another recommended BMP to prevent pollution from ever getting into stormwater in the first place.

Operators under Ecology's Industrial Stormwater General Permit (ISGP), Boatyard General Permit, or Sand and Gravel General Permit should use this chapter and Volume IV of the 2019 Ecology Manual to identify required and suggested 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 shall use this chapter and Volume IV of the 2019 Ecology Manual in developing their SWPPPs.

Runoff treatment may also be required for certain types of businesses, based on the information provided in in Chapter 2, Section 2.2.6 (Core Requirement #6: Runoff Treatment) and in Chapter 8. Chapter 8 contains detailed information about runoff treatment BMPs.

Refer to the Lacey Municipal Code (LMC), and Volume I, Sections 2.4, 2.6, 2.7, and 2.15 of the 2019 Ecology Manual for information on other federal, state, or City stormwater-related programs and requirements. Businesses already implementing BMPs in accordance with these requirements usually do not have to implement additional BMPs. Businesses required to obtain a general or individual NPDES permit for stormwater discharges must comply with the requirements of that permit and are exempt from implementing additional BMPs.

If you are covered under the related requirements in the LMC, the City assumes that you are implementing the appropriate BMPs. If the City finds that you have not implemented your BMPs, or that the BMPs that you have implemented are not effectively addressing the discharge of contaminants, then you may be required to implement additional BMPs to meet requirements. *Everyone* must implement BMPs, but how each business goes about it, and through which government program, may differ from business to business.

9.2 Source Control BMP Selection

All Applicable (mandatory) BMPs listed in Volume IV, Section 1 of the 2019 Ecology Manual for the activities present are required by the City, while those described as Recommended are optional.

Use the Stormwater Pollution Source Control Checklist and Worksheet in Appendix 9A to document those activities/potential pollutant sources that will be present at a proposed project. Use the Stormwater Pollution Source Control Checklist to identify all of the activities that will occur at a proposed project site. Use the Stormwater Pollution Source Control Worksheet to document all of the source control BMPs (both required and optional) to be used at the site.

The completed Stormwater Pollution Source Control Checklist and Worksheet in Appendix 9A shall be submitted with the permit application. Any required BMPs shall be listed on the Stormwater Pollution Source Control Worksheet and identified on stormwater site plans submitted for City review.

Note that satisfaction of the source control requirements of this section does not fulfill the requirements of any applicable state NPDES ISGP.

9.3 General Principles of Pollution Prevention

This section describes the basic pollution prevention principles that every business and homeowner must consider. Most of these are common sense “housekeeping” types of solutions. With collective action by individuals and businesses throughout the region in implementing each of these principles, the improvement in water quality could be substantial. Although most of these principles are aimed at commercial or industrial activities, many items apply to individual residents as well.

The following principles must be reflected in the Drainage Control Plan – Maintenance and Source Control Manual (Chapter 3, Section 3.3.3).

1. **Avoid the activity or reduce its occurrence**

    - Is there a substitute process or a different material available to get the job done?

    - Can a larger run of a process be performed at one time, thus reducing the number of times per week or month it needs to be repeated?

      Examples:

      - Schedule delivery of raw materials close to the time of use instead of stockpiling and exposing them to the weather.

      - Avoid one solvent-washing step altogether.

    - Apply lawn care chemicals following directions and only as needed to avoid excessive fertilization.
    - Do not apply herbicides right before it rains.

- Contact Ecology or the Thurston County Department of Public Health and Social Services for pollution prevention assistance.

2. **Move activities under shelter**

   Sometimes it is fairly easy to move an activity indoors out of the weather. The benefits of this are twofold:

   - Preventing runoff contamination
   - Providing for easier, more controlled cleanup if a spill occurs.

     Example:

     - Unloading and storing barrels of chemicals inside a garage area instead of outside.

   Please be aware that moving storage areas indoors may require installation of fire suppression equipment or other building modifications as required by the International Building Code (IBC), the International Fire Code, or City ordinances.

3. **Clean up spills quickly**

   - Promptly contain and clean up solid and liquid pollutant leaks and spills on any exposed soil, vegetation, or paved area.
   - Use commercial spill kits or readily available absorbents such as kitty litter.
   - Promptly repair or replace all leaking connections, pipes, hoses, valves, etc., which can contaminate stormwater.

4. **Use less material**

   Don’t buy or use more material than you really need. This helps keep potential disposal, storage, and pollution problems to a minimum and can save money.

5. **Use the least toxic materials available**

   Investigate the use of materials that are less toxic than what is used now.

   Example:

   - A caustic-type detergent or a solvent could be replaced with a more environmentally friendly product. Such a change might allow the site to discharge process water to the sanitary sewer instead of paying for expensive disposal (contact the City of Lacey Wastewater Utility or the LOTT Clean Water Alliance to find out about allowable sanitary sewer discharges and pretreatment permits). Wash water with biodegradable soap is not allowed to enter the stormwater drainage system.

6. **Create and maintain vegetated areas near activity locations**

   Vegetation of various kinds can:

   - Filter pollutants out of stormwater
   - Provide erosion control

     Example:

     - Stormwater can be routed through vegetated areas (e.g., parking lot islands) located near the pollution-generating activity. By converting parking lot islands to depressions instead of mounded landscaped areas, they can be used to treat runoff from the parking lot or a nearby roof.

7. **Locate activities as far as possible from groundwater drainage paths**

   Activities located as far as possible from known drainage paths, ditches, streams, other water bodies, and storm drains will be less likely to pollute, since it will take longer for material to reach the drainage feature. This gives more time to react to a spill, or if it is a "housekeeping" issue, may protect the local waters long enough for you to clean up the area around the activity.

   Don't forget that groundwater protection is important throughout the region, no matter where the activity is located, so the actions taken on your site on a day-to-day basis are always important, even in dry weather.

8. Maintain stormwater drainage systems

Pollutants can concentrate over time in stormwater drainage structures such as catch basins, ditches, and storm drains. When a large storm event occurs, it can mobilize these pollutants and carry them to receiving waters. Maintenance actions can include:

- Develop and implement maintenance practices, inspections, and schedules for treatment facilities (e.g., detention ponds, oil-water separators, vegetated swales).
- Clean oils, debris, sludge, etc., from all BMP systems regularly, including catch basins, settling/detention basins, oil-water separators, boomed areas, and conveyance systems, to prevent the contamination of stormwater.
- Promptly repair or replace all substantially cracked or otherwise damaged paved secondary containment, high-intensity parking, and any other drainage areas that are subjected to pollutant material leaks or spills.
- Repair or replace all leaking connections, pipes, hoses, valves, etc., which can contaminate stormwater.

Requirements for cleaning stormwater BMPs are discussed in Volume IV of the 2019 Ecology Manual, specifically BMP S417: BMPs for Maintenance of Stormwater Drainage and Treatment Systems. Maintenance standards can be found in Chapter 10.

9. Reduce, reuse, and recycle as much as possible

Always look for ways to recycle instead of just disposing. This can save money as well as keep both hazardous and non-hazardous materials out of the landfills. Learn more about other businesses that have made process changes allowing recycling of chemicals by calling Ecology at 1-800-RECYCLE and reviewing information on the following website: <http://1800recycle.wa.gov>

Another unique recycling opportunity for businesses is available through the Industrial Materials Exchange (IMEX). This free service acts as a waste or surplus “matchmaker,” helping one company’s waste become another company’s asset. For instance, waste vegetable oil can become biofuel for another business. Go to the Industrial Materials Exchange website to list your potentially usable solid or chemical waste: <https://www.hazwastehelp.org/IMEX/index.aspx>

10. Be an advocate for stormwater pollution prevention

Help friends, neighbors, and business associates find ways to reduce stormwater pollution in their activities. Most people want clean water and do not pollute intentionally. Share your ideas and the BMPs in this chapter to get them thinking about how their everyday activities affect water quality.

11. Report problems

We all must do our part to protect water, fish, wildlife, and our own health by implementing proper BMPs, and reporting water quality problems that we observe. In the City, call the Department of Public Works at (360) 491-5644 to report dumping to sewers and to report spills and other incidents involving storm drains or ditches. For larger spills, contact Ecology's Southwest Regional Office at (360) 407-6300.

12. Provide oversight and training

- Assign one or more individuals at your place of business to be responsible for stormwater pollution control. Hold regular meetings to review the overall operation of BMPs.
- Establish responsibilities for inspections, operations and maintenance (O&M), documentation, and availability for emergency situations.
- Train all team members in the operation, maintenance, and inspection of BMPs and reporting procedures.

13. Dust control

- Sweep paved material handling and storage areas regularly as needed, to collect and dispose of dust and debris that could contaminate stormwater.
- Do not hose down pollutants from any area to the ground, storm drain, conveyance ditch, or receiving water.

14. Eliminate illicit connections

An illicit connection is formally defined in the City's NPDES Municipal Stormwater Permit and in Section 14.29.010 LMC, but generally includes any connection to the City stormwater system that is not intended, permitted, or used for collecting and conveying stormwater. A common problem with the stormwater drainage system for most communities is the existence of illicit connections of wastewater to the stormwater drainage system. Wastewater other than stormwater runoff, such as wash water, must be discharged to a wastewater collection system, and may not be discharged to a stormwater drainage system (the stormwater drainage system does not drain to a wastewater treatment plant).

Businesses and residences may have internal building drains, sump overflows, process wastewater discharges, and even sanitary sewer and septic system pipes that were incorrectly connected to the stormwater drainage system in the past.

All businesses and residences must examine their plumbing systems to determine if illicit connections exist. Any time it is found that toilets, sinks, appliances, showers and bathtubs, floor drains, industrial process waters, and/or other indoor activities are connected to the stormwater drainage system, these connections must be immediately rerouted to the sanitary or septic system, holding tanks, or a process treatment system.

15. Dispose of waste properly

Every business and residence in the City must dispose of solid and liquid wastes and contaminated stormwater properly. There are generally four options for disposal depending on the type of materials. These options include:

- Sanitary sewer and septic systems
- Recycling facilities
- Municipal solid waste disposal facilities
- Hazardous waste treatment, storage, and disposal facilities

The Thurston County Waste and Recovery Center (WARC) can accept a wide variety of materials including recyclables, garbage, and household hazardous waste. More information can on the types of materials accepted can be found on Thurston County's website: <www.co.thurston.wa.us/solidwaste/garbage/garbage-warc.html>

9.4 Local Amendments to Source Control BMPs

Refer to Volume IV of the 2019 Ecology Manual for source control BMPs. The following BMPs have local amendments:

- S409: BMPs for Fueling at Dedicated Stations
- S427: BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers

9.4.1 S409: BMPs for Fueling at Dedicated Stations

This BMP applies to businesses and public agencies that operate a facility used for the transfer of fuels from a stationary pumping station to vehicles or equipment. This type of fueling station includes aboveground or underground fuel storage facilities, which may be permanent or temporary. Fueling stations include facilities such as, but not limited to, commercial gasoline stations, 24-hour convenience stores, car washes, warehouses, manufacturing establishments, maintenance yards, port facilities, marinas and boatyards, construction sites, and private fleet fueling stations.

Description of Pollutant Sources

Typically, stormwater contamination at fueling stations is caused by leaks or spills of fuels, lubrication oils, radiator coolants, fuel additives, and vehicle wash water. These materials contain organic compounds, oils and greases, and metals that can be harmful to humans and aquatic life. These pollutants must not be discharged to the drainage system or directly into receiving water.

A spill can be a one-time event, a continuous leak, or frequent small spills. All types must be addressed.

Required BMP Elements

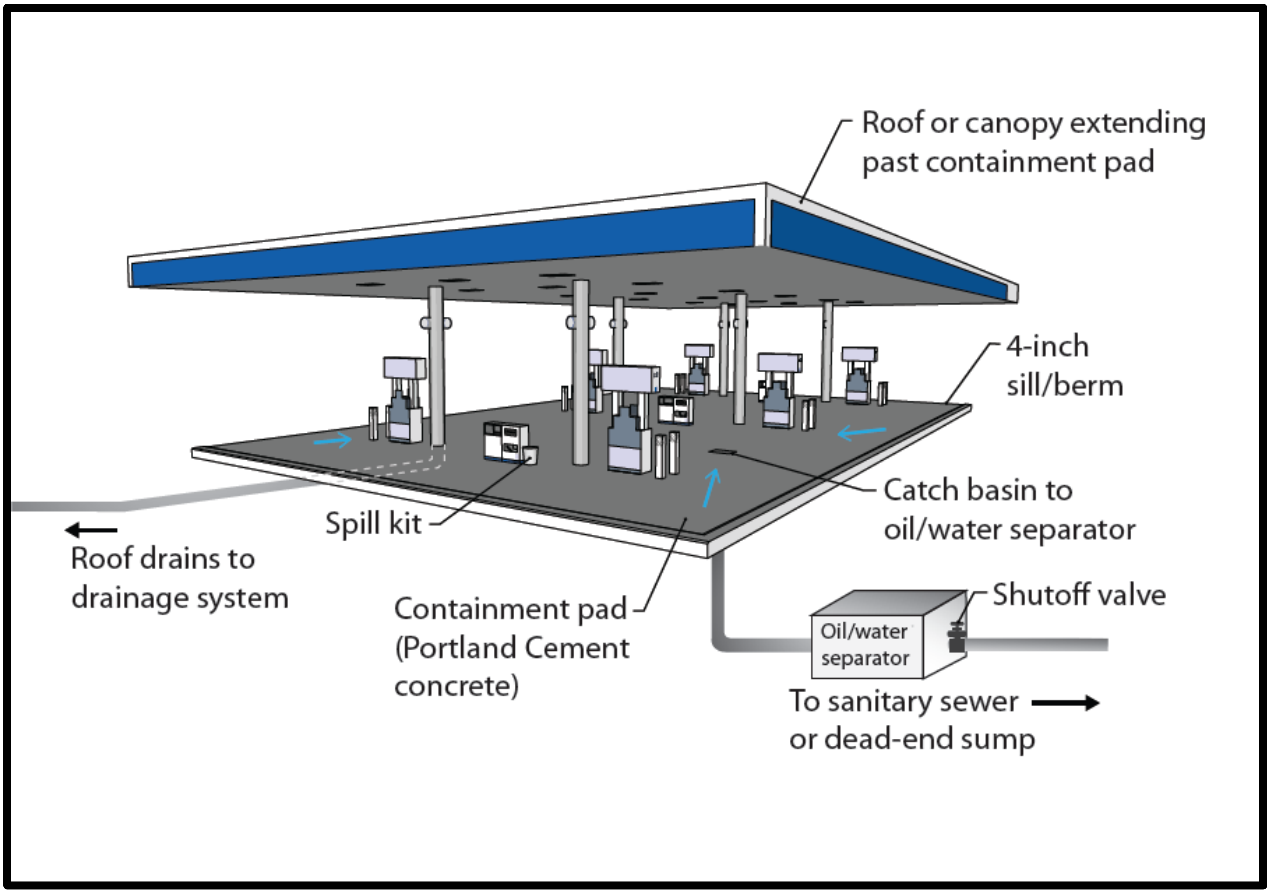
All BMPs related to fueling at dedicated stations must be consistent with the requirements of the Fire Code as adopted and amended per Chapter 14.07 LMC. The water quality requirements presented in this manual are separate from, and in addition to, the requirements of the Fire Code. These water quality requirements relate to fuel storage tanks, fuel dispensing equipment, area lighting, spill control and secondary containment, signage, maintenance, and operations. For current requirements, refer to Chapter 14.07 LMC.

New or substantially altered stations* require the following (refer to Figure 9.1):

*Substantial alteration of fueling stations includes replacing the canopy or relocating, replacing, or adding one or more fuel dispensers in such a way that the Portland cement concrete (or equivalent) paving in the fueling area is modified. Addition of fuel tanks to a site also triggers implementation of source control BMPs.

- Construct fueling stations on an impervious concrete pad under a roof to keep out rainfall and to prevent stormwater run-on. Pave the fueling island and containment pad with Portland cement concrete or equivalent. Asphalt is not considered an equivalent material.

- Design the fueling island (Figure 9.2) to minimize stormwater contamination, to control spills, and to collect and direct contaminated stormwater and/or wastewater to a pretreatment facility that will achieve the performance goal per Chapter 8. The fueling island must be designed in compliance with all applicable codes.



Source: City of Seattle

Figure 9.1. Fueling Island Schematic.

Source: City of Seattle

Figure 9.2. Roof at Fueling Island to Prevent Stormwater Run-On.

- The fueling island spill containment pad must be designed with the following:
    - A sill/berm (or equivalent control) raised to a minimum of 4 inches to contain spilled liquids and to prevent the run-on of stormwater from the surrounding area. Raised sills are not required at open-grate trenches that connect to an approved drainage control system.
    - A concrete containment pad around the fueling island that is sloped toward the fuel containment pad drains. The slope of the drains must not be less than 1 percent. Drains from the fueling island containment pad must discharge to the sanitary sewer or a dead-end sump. Provide drainage using trench drains and/or catch basins to collect spilled liquids and any contaminated stormwater runoff from the fuel island containment pad and convey it to either (1) the sanitary sewer—if approved by the City and LOTT Clean Water Alliance—through an approved pretreatment system such as an oil-water separator, or (2) a dead-end sump so that it can be held for proper off-site disposal.

- For discharges to the sanitary sewer, a catch basin must be installed upstream of the oil-water separator.

- If a dead-end sump is used, it must be easily inspected.

- Collected runoff from the fuel island containment pad discharged to the sanitary sewer must comply with the LMC. Comply with pretreatment regulations prohibiting discharges that could cause a fire or explosion (WAC, Section 173-216-060).

- The minimum spill retention volume of the oil-water separator or dead-end sump (i.e., volume of spilled fuel contained before the structure overflows) must be sized as follows:

  - For a covered fuel pad: 15 minutes for the flow rate of the dispensing mechanism with the highest through-put rate

  - For an uncovered area or an area that receives run-on from an uncovered area: the 15-minute peak flow rate of the 6-month, 24-hour storm event (or 91 percent of the total runoff volume for the simulation period if using continuous simulation modeling) over the surface of the containment pad, plus the volume required for a covered fuel pad.

The minimum volume of the spill containment sump must be 50 gallons with an adequate grit sedimentation volume. The spill retention/containment volume of the oil-water separator must retain the required spill volume when the oil-water separator is full of water. Dead-end sumps must not be used when the fuel containment area is uncovered or will receive run-on from other areas unless approved by the Public Works Director.

Note: To calculate the fuel containment capacity, determine the volume of fuel retention on the basis of the retained water volume in the bottom of the oil-water separator bottom and the density of fuel. Fuel containment will be above the static water level into the normal headspace of the oil-water separator (i.e., floating on top of the retained water volume) when the automatic shutoff valve is closed. Subtract the retained water volume in the oil-water separator from the overall volume of the oil-water separator to determine the spill retention volume.

- For further requirements and guidance related to the storage of fuel-contaminated stormwater, refer to S428: BMPs for Storage of Liquids in Permanent Aboveground Tanks in the 2019 Ecology Manual.

- For discharges to the sanitary sewer or combined sewer, an automatic shutoff valve is required at the discharge point of the oil-water separator. The valve at the discharge point must be closed in the event of a spill. When an oil-stop valve or resin plug valve is used, it must be engineered to be at least as protective as an automatic shutoff valve.

- Construct a roof or canopy over the fueling island to prevent precipitation from falling directly onto the spill containment pad (Figure 9.2). The roof or canopy must:
  - 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.
  - Roofs and canopies 10 feet or less in height must have a minimum overhang of 3 feet on each side. The overhang must be measured relative to the berm or other hydraulic grade break.
  - Roofs or canopies greater than 10 feet in height must have a minimum overhang of 5 feet on each side.
- Convey runoff collected in roof or canopy drains to a drainage system or receiving water outside the fueling containment area. This will prevent the mixing of uncontaminated runoff from the roof with contaminated runoff from the fueling island.
- A roof or canopy may not be practical at fueling stations that regularly fuel vehicles 10 feet in height or more, particularly at industrial or transportation sites. Additional BMPs or equivalent measures are required. At these types of fueling facilities, the following BMPs apply, as well as all of the other required BMPs and fire prevention requirements (Chapter 14.07 LMC and Uniform Fire Code).
- The concrete fueling pad must be equipped with an emergency spill control device that includes a shutoff valve for drainage from the fueling area.
- The shutoff valve must be closed in the event of a spill. An automatic shutoff valve is required to minimize the time lapse between spill and containment.

Obtain all necessary permits for installing, altering, or repairing side sewers. Restrictions on certain types of discharges may require pretreatment before they enter the sanitary sewer.

The following BMPs or equivalent measures are required for all fueling stations:

- Implement source control BMPs applicable to all sites (refer to Volume IV in the 2019 Ecology Manual).
- Train employees on the proper use of fuel dispensers.
- Do not use dispersants to clean up spills or sheens.
- Post signs related to the operation of fuel dispensers in accordance with Chapter 14.07 LMC. For example, post “No Topping Off” signs near fuel

dispensers (topping off gasoline tanks results in spillage and vents gasoline fumes to the air).

- Ensure that the person conducting the fuel transfer is present at the fueling dispenser/fueling pump during fuel transfer, particularly at unattended or self-service stations. Post "Stay with Vehicle during Fueling" signage near fuel dispensers.
- Ensure that the automatic shutoff on the fuel nozzle is functioning properly.
- Ensure that at least one designated trained person is available either on site or on call at all times to implement spill prevention and cleanup promptly and properly. If the fueling station is unattended, the spill plan must be visible to all customers using the station, and the spill kit must also be accessible and fully stocked at all times.
- Keep suitable cleanup materials, such as dry adsorbent materials, on site to enable employees to promptly clean up spills.
- 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. Cover nearby inlets/catch basins during the filling process and use drip pans under all hose connections.

9.4.2 S427: BMPs for Storage of Liquid, Food Waste, or Dangerous Waste Containers

Description of Pollutant Sources

The BMPs specified below apply to container(s) located outside a building. Use these BMPs when temporarily storing potential pollution generating materials or wastes. These BMPs do not apply when Ecology has permitted the business to store the wastes (see Volume I, Section 2.15 of the 2019 Ecology Manual). Leaks and spills of pollutant materials during handling and storage are the primary sources of pollutants. Oil and grease, acid/alkali pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD) are potential pollutant constituents.

Pollutant Control Approach

Store containers in impervious containment under a roof or in a building. For storage areas on-site for less than 30 days, consider using a portable temporary secondary system like that shown in Secondary Containment System figure in Volume IV of the 2019 Ecology Manual in lieu of a permanent system as described above.

Applicable Operational BMPs

- Place tight-fitting lids on all containers.

- Label all containers appropriately. Store containers so that the labels are clearly visible.

- 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.

- Store empty drums containing residues to prevent stormwater from entering drum closures. Cover or tilt drums to prevent stormwater from accumulating on the top of empty drums and around drum closures.

- Store containers that do not contain free liquids in a designated sloped area with the containers elevated or otherwise protected from stormwater run-on. Comply with Title 14 LMC.

- Secure drums when stored in an area where unauthorized persons may gain access in a manner that prevents accidental spillage, pilferage, or any unauthorized use (see Locking System for Drum Lid figure in Volume IV of the 2019 Ecology Manual).

- If the material is a Dangerous Waste, the business owner must comply with any additional requirements as specified in Volume I, Section 2.15 of the 2019 Ecology Manual.

- Storage of reactive, ignitable, and flammable chemicals or materials must comply with the stricter of Titles 14 and 16 LMC.

- Have spill kits or cleanup materials near container storage areas.

- Clean up all spills immediately.

- Cover dumpsters to prevent the entry of stormwater. Keep dumpster lids closed.

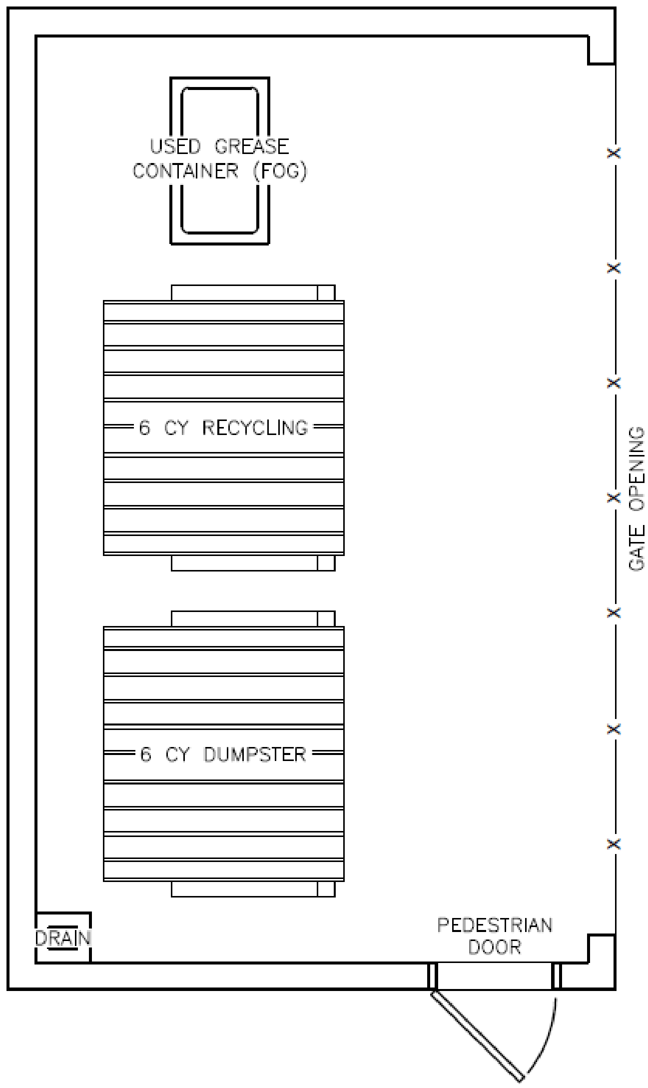
- Replace or repair leaking garbage dumpsters, or install waterproof liners.

- Drain dumpsters and/or dumpster pads to sanitary sewer.

- When collection trucks directly pick up roll-containers, ensure a filet is on both sides of the curb to facilitate moving the dumpster.

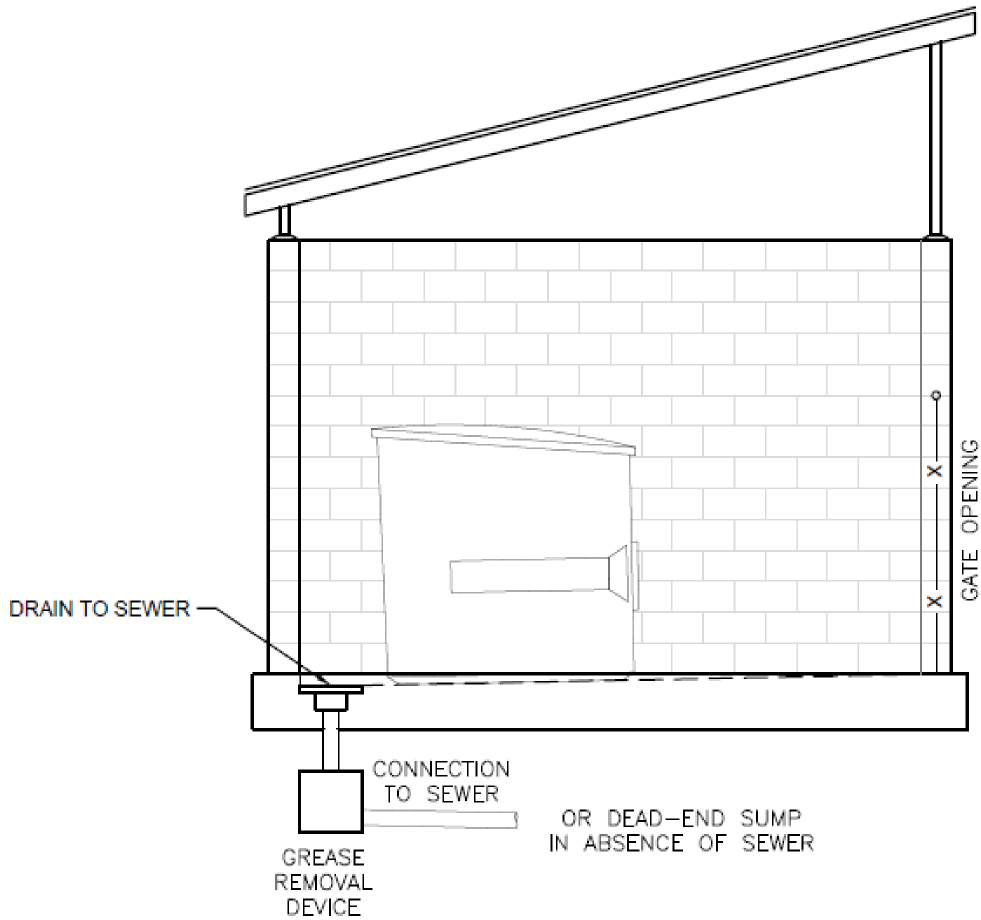
Applicable Structural Source Control BMPs

- Keep containers with Dangerous Waste, food waste, or other potential pollutant liquids inside a building unless this is impracticable due to site constraints or 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 Figures 9.3 and 9.4). The secondary containment shall be sloped to drain into a dead-end sump for the collection of leaks and small spills.



Source: Kitsap County

Figure 9.3. Example of a Covered, Bermed, and Plumbed Area – Plan View.



Source: Kitsap County

Figure 9.4. Example of a Covered, Bermed, and Plumbed Area – Side View.

- For liquid materials, surround the containers with a dike as illustrated in Covered and Bermed Containment Area figure in Volume IV of the 2019 Ecology Manual. 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.

- Where material is temporarily stored in drums, a containment system can be used as illustrated, in lieu of the above system (see Secondary Containment System figure in Volume IV of the 2019 Ecology Manual).

- 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 Mounted Container with Drip Pan figure in Volume IV of the 2019 Ecology Manual).

Applicable Treatment BMP

Note: This treatment BMP is for contaminated stormwater from drum storage areas.

- To discharge contaminated stormwater, pump it from a dead-end sump or catchment and dispose of appropriately.

Appendix 9A – Stormwater Pollution Source Control Checklist and Worksheet

CITY OF LACEY STORMWATER POLLUTION SOURCE CONTROL CHECKLIST

Project Name:____

Check all activities that will occur at a proposed site. Only activities common in the City of Lacey are included in this checklist. Other activities may apply to your site. Fill in the blank rows included under each activity grouping if needed based on the complete list of site-specific activities provided in Table 9A.1.

Source Control BMPs Applicable to All Sites		
BMP #	**BMP Name**	
S410	Correcting Illicit Discharges to Storm Drains	
S453	Formation of a Pollution Prevention Team	
S454	Preventive Maintenance/Good Housekeeping	
S455	Spill Prevention and Cleanup	
S456	Employee Training	
S457	Inspections	
S458	Record Keeping	
Source Control BMPs for Specific Activities		
BMP #	**BMP Name**	**Activity Conducted on the Site?**
Cleaning or Washing Source Control BMPs		
S431	Washing and Steam Cleaning Vehicles/Equipment/Building Structures	□ Yes □ No
______	____	□ Yes □ No
Roads, Ditches, and Parking Lot Source Control BMPs		
S415	Maintenance of Public and Private Utility Corridors and Facilities	□ Yes □ No
S416	Maintenance of Roadside Ditches	□ Yes □ No
S417	Maintenance of Stormwater Drainage and Treatment Systems	□ Yes □ No
S421	Parking and Storage of Vehicles and Equipment	□ Yes □ No
S430	Urban Streets	□ Yes □ No
______	____	□ Yes □ No
Soil Erosion, Sediment Control, and Landscaping Source Control BMPs		
S407	Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots	□ Yes □ No
S408	Dust Control at Manufacturing Areas	□ Yes □ No
S411	Landscaping and Lawn/Vegetation Management	□ Yes □ No
S425	Soil Erosion and Sediment Control at Industrial Sites	□ Yes □ No
S435	Pesticides and an Integrated Pest Management Program	□ Yes □ No

BMP #	BMP Name	Activity Conducted on the Site?
Soil Erosion, Sediment Control, and Landscaping Source Control BMPs (continued)		
S444	Storage of Dry Pesticides and Fertilizers	☐ Yes ☐ No
S449	Nurseries and Greenhouses	☐ Yes ☐ No
S450	Irrigation	☐ Yes ☐ No
______	____	☐ Yes ☐ No
Storage and Stockpiling Source Control BMPs		
S427	Storage of Liquids, Food Waste, or Dangerous Waste Containers	☐ Yes ☐ No
S428	Storage of Liquids in Permanent Aboveground Tanks	☐ Yes ☐ No
S429	Storage or Transfer (Outside) of Solid Raw Materials, Byproducts or Finished Products	☐ Yes ☐ No
______	____	☐ Yes ☐ No
Transfer of Liquid or Solid Materials Source Control BMPs		
S409	Fueling at Dedicated Stations	☐ Yes ☐ No
S412	Loading and Unloading Areas for Liquid or Solid Material	☐ Yes ☐ No
S419	Mobile Fueling of Vehicles and Heavy Equipment	☐ Yes ☐ No
S426	Spills of Oil and Hazardous Substances	☐ Yes ☐ No
______	____	☐ Yes ☐ No
Other Source Control BMPs		
S404	Commercial Printing Operations	☐ Yes ☐ No
S414	Maintenance and Repair of Vehicles and Equipment	☐ Yes ☐ No
S418	Manufacturing Activities – Outside	☐ Yes ☐ No
S420	Painting/Finishing/Coating of Vehicles/Boats/Buildings/ Equipment	☐ Yes ☐ No
S423	Recyclers and Scrap Yards	☐ Yes ☐ No
S424	Roof/Building Drains at Manufacturing and Commercial Buildings	☐ Yes ☐ No
S432	Wood Treatment Areas	☐ Yes ☐ No
S433	Pools, Spas, Hot Tubs, and Fountains	☐ Yes ☐ No
S438	Construction Demolition	☐ Yes ☐ No
S443	Fertilizer Application	☐ Yes ☐ No
S447	Roof Vents	☐ Yes ☐ No
S451	Building, Repair, Remodeling, Painting, and Construction	☐ Yes ☐ No
______	____	☐ Yes ☐ No

Table 9A.1. All Site-Specific Source Control BMPs.	
BMP #	**BMP Name**
Cleaning or Washing Source Control BMPs	
S431	Washing and Steam Cleaning Vehicles/Equipment/Building Structures
S434	Dock Washing
S441	Potable Water Line Flushing, Water Tank Maintenance, and Hydrant Testing
Roads, Ditches, and Parking Lot Source Control BMPs	
S405	Deicing and Anti-Icing Operations for Airports
S406	Streets and Highways
S415	Maintenance of Public and Private Utility Corridors and Facilities
S416	Maintenance of Roadside Ditches
S417	Maintenance of Stormwater Drainage and Treatment Systems
S421	Parking and Storage of Vehicles and Equipment
S430	Urban Streets
Soil Erosion, Sediment Control, and Landscaping Source Control BMPs	
S407	Dust Control at Disturbed Land Areas and Unpaved Roadways and Parking Lots
S408	Dust Control at Manufacturing Areas
S411	Landscaping and Lawn/Vegetation Management
S425	Soil Erosion and Sediment Control at Industrial Sites
S435	Pesticides and an Integrated Pest Management Program
S444	Storage of Dry Pesticides and Fertilizers
S449	Nurseries and Greenhouses
S450	Irrigation
Storage and Stockpiling Source Control BMPs	
S427	Storage of Liquids, Food Waste, or Dangerous Waste Containers
S428	Storage of Liquids in Permanent Aboveground Tanks
S429	Storage or Transfer (Outside) of Solid Raw Materials, Byproducts or Finished Products
S445	Temporary Fruit Storage
Transfer of Liquid or Solid Materials Source Control BMPs	
S409	Fueling at Dedicated Stations
S412	Loading and Unloading Areas for Liquid or Solid Material
S419	Mobile Fueling of Vehicles and Heavy Equipment
S426	Spills of Oil and Hazardous Substances
S439	In-Water and Over-Water Fueling

Other Source Control BMPs	
S401	Building, Repair, and Maintenance of Boats and Ships
S402	Commercial Animal Handling Areas
S403	Commercial Composting
S404	Commercial Printing Operations
S413	Log Sorting and Handling
S414	Maintenance and Repair of Vehicles and Equipment
S418	Manufacturing Activities – Outside
S420	Painting/Finishing/Coating of Vehicles/Boats/Buildings/Equipment
S422	Railroad Yards
S423	Recyclers and Scrap Yards
S424	Roof/Building Drains at Manufacturing and Commercial Buildings
S432	Wood Treatment Areas
S433	Pools, Spas, Hot Tubs, and Fountains
S436	Color Events
S438	Construction Demolition
S440	Pet Waste
S442	Labeling Storm Drain Inlets On Your Property
S443	Fertilizer Application
S446	Well, Utility, Directional and Geotechnical Drilling
S447	Roof Vents
S451	Building, Repair, Remodeling, Painting, and Construction
S452	Goose Waste

CITY OF LACEY STORMWATER POLLUTION SOURCE CONTROL WORKSHEET

List all source control BMPs to be used at site. Use one worksheet for each activity from the checklist.

Project:______________________________ Activity:_________________________________

OPERATIONAL BMPs
STRUCTURAL BMPs
TREATMENT BMPs

Chapter 10 – Stormwater BMP Maintenance

Table of Contents

Chapter 10 – Stormwater BMP Maintenance

10.1 Purpose, Content, and Organization

This chapter contains best management practice (BMP)-specific maintenance standards, which are intended to be observable conditions for determining whether maintenance actions are required for compliance with Core Requirement #9: Operation and Maintenance. This information is also available on the City of Lacey's (City) website in a recordable format.

All stormwater BMPs need to be maintained. Regular maintenance ensures proper functioning and keeps the BMP aesthetically appealing. The stormwater BMP maintenance guidance provided in this chapter was designed to help explain how stormwater BMPs work and provide user-friendly guidance on how to maintain BMPs to keep them functional and up to standards.

As a BMP owner (typically the parcel owner or homeowner's association) is responsible for regularly maintaining privately-owned stormwater BMPs such as ponds, infiltration systems, rain gardens, catch basins, and pipes. (The City maintains stormwater BMPs located in the public right-of-way.)

Most large development sites (typically projects larger than one single-family property) will have developed a detailed Maintenance and Source Control Manual as part of the site development (refer to Drainage Control Plan Maintenance and Source Control Manual requirements in Chapter 3, Section 3.3.3 of this manual). The City requires that the Maintenance and Source Control Manual is transferred with the property to the new owner(s) and responsible parties. The Maintenance and Source Control Manual will provide extensive information on the project, the stormwater BMPs on the site, maintenance responsibilities, and maintenance activities that may include or reference the maintenance checklists found in this appendix. Be sure to locate the Maintenance and Source Control Manual for your project and follow the information presented therein. If a Maintenance and Source Control Manual for the property is not available, please contact the City check if a copy is available and/or to request a copy.

The remainder of this chapter is divided into three major sections:

- **Section 10.2** describes how to use the maintenance checklists that are included in Appendices 10A, 10B, and 10C.
- **Section 10.3** describes general stormwater BMP inspection and maintenance procedures.
- **Section 10.4** provides descriptions and photos of the most common stormwater BMP types, along with general maintenance actions to keep those BMPs functioning.

For sites that do not have a Maintenance and Source Control Manual (typically smaller, single-family sites), the following instructions and helpful tips for successful BMP inspections and maintenance are provided.

10.2 Maintenance Standards Checklists

The maintenance standards checklists in Appendices 10A, 10B, and 10C are used when inspecting and maintaining privately-owned stormwater BMPs. If a particular checklist is missing, or if additional BMPs have not been identified or addressed in this guide, please contact the property's site developer, design engineer, or the City.

The checklists are in table format for ease of use and brevity. Each checklist describes the part of the feature to check, how often to check, what to check for, and the desired outcome after maintenance is performed. Annual reporting forms are included in Appendix 10D to summarize BMP inspection findings, BMP conditions, and maintenance accomplished, for annual reporting to the City.

Although it is not intended for the inspection to involve anything too difficult or strenuous, there are a few tools that will make the job easier and safer. These tools include:

- Gloves
- A flashlight (to look into catch basins, manholes or pipes)
- A long pole or broom handle (see below)
- A pry bar or lifting tool for pulling manhole and grate covers
- Standard yard tools, such as a rake and a shovel
- Measuring tool
- A listing of resources is also included at the end of this chapter (see Chapter 10 Resources) and includes phone numbers of the agencies referred to in the tables.

10.2.1 Safety Warning:

For your safety and per OSHA regulations, you should never stick your head or any part of your body into a manhole or other type of confined space. When looking into a manhole or catch basin, stand above it, and use the flashlight to help you see. Use a pole or broom handle that is long enough when you are checking sediment depths in confined spaces. Always properly replace grates and lids.

NO PART OF YOUR BODY SHOULD BREAK THE PLANE OF THE OPEN HOLE.

10.2.2 Checklist Instructions

The maintenance standards checklists in Appendices 10A, 10B, and 10C cover most of the needs for the components of the drainage system, as well as for some components that may not be applicable (ignore those checklists that don't apply to the property's drainage system). Let City staff know if there are any components of the property's drainage system that are unrecognizable or missing from these pages.

Refer to Chapter 14.27 LMC for additional stormwater maintenance requirements, including required maintenance frequency.

Using photocopies of these checklists and the annual reporting form (Appendix 10D), check off the problems that are observed each time an inspection is performed. Add comments regarding problems found and actions taken on the annual reporting form (Appendix 10D). Keep the completed forms for future reference.

The City is available at (360) 491-5600 for technical guidance. Please do not hesitate to call, especially when unsure whether a situation may be a problem.

10.3 Stormwater BMP Inspection and Maintenance Procedures

Stormwater BMPs play an important role in managing the 4 feet of rainfall received in Lacey in an average year. The term "stormwater BMP" refers to any landscaped or structural feature that collects, conveys, cleans, or infiltrates runoff water. There are many types of stormwater BMPs, ranging from simple swales and ponds to more complicated filter systems and flow control devices. On-site stormwater BMPs work together to control runoff water, reduce flooding, and prevent pollution.

Owners of commercial property, multifamily residential property, or single-family residential properties with privately-owned drainage and stormwater BMPs are required by City code to maintain their BMPs to established standards for full functionality (Chapter 14.25 LMC). BMP owners are responsible for performing inspections of stormwater BMPs, and for performing any maintenance identified by the inspections.

Basic maintenance work may be performed by the owner or property manager, although some tasks are best left to an experienced contractor. The inspection of stormwater BMPs and any required maintenance work must be completed and reported annually to the City of Lacey Public Works Department by the date specified on the *Stormwater BMPs Inspection and Maintenance Annual Reporting Form* obtainable on the City's website at <https://cityoflacey.org/privately-owned-stormwater-facilities/>).

Again, note that most large development sites will also have a Maintenance and Source Control Manual that was prepared as part of the site development, and should have been provided to the property owners. Look to your site's Maintenance and Source Control Manual for information on the project, the BMPs on the site, maintenance responsibilities, projected costs for maintenance, and maintenance activities.

Where a Maintenance and Source Control Manual is not available, the following steps are provided as general guidance:

Step 1. Identify

The first step is BMP identification to understand what types of stormwater BMPs are on the property. Look on the site plan of the property and note the main BMP types indicated (such as rain gardens and infiltration trenches), along with related drainage components (such as catch basins, pipes, and debris barriers). Locate the various BMPs on the ground.

Note that most drainage systems consist of components for four main purposes: stormwater collection (e.g., catch basins), conveyance (e.g., pipes and swales), runoff treatment (e.g., wet ponds) and flow control (via infiltration and/or surface discharge).

To assist in identifying components, refer to the definitions and illustrations on the pages that follow.

Step 2. Inspect

For all BMP components that have been identified, conduct an inspection. The inspection can be performed by the owner and/or with co-owners, or a property manager or vendor can perform the inspection. Refer to the Stormwater BMP Maintenance Checklists (Appendices 10A, 10B, and 10C), which describe the maintenance standards for each component, and also identify and describe defects and their remedies.

For each BMP, note on the Inspection and Maintenance Checklist the condition of the BMP (good, fair, or poor), and any problems or other observations.

Step 3. Maintain

For all BMP components, if the inspection indicates maintenance is needed, have the work performed by competent personnel. Basic maintenance tasks may be performed by the property owner(s) or property manager, but difficult or potentially dangerous tasks should be performed by a qualified vendor. Be safe! Use caution when inspecting and working on or near BMPs and stay out of confined spaces such as catch basins and manholes.

Note the action taken and the date and record this information on the *Stormwater Facilities Inspection and Maintenance Annual Reporting Form* (Appendix 10D). Mark the check boxes on the Inspection and Maintenance Checklist corresponding to the maintenance accomplished on each BMP.

Step 4. Submit

Submit the completed *Stormwater Facilities Inspection and Maintenance Annual Reporting Form* (Appendix 10D) by August 15 each year to: Lacey Water Resources, 420 College Street SE, Lacey, WA 98503. The completed checklist may be mailed, e-mailed (if available) or delivered in person to Lacey City Hall.

10.4 Common Stormwater BMPs: Identification and Actions

A brief description, purpose, and common maintenance actions are described for each of the following BMPs:

- Detention Pond
- Infiltration Basin ("Dry Pond")
- Biofiltration Swale
- Wet Pond
- Stormwater Wetland
- Bioretention Cell
- Rain Garden
- Permeable Pavement
- Downspout, Sheet Flow, and Concentrated Flow Dispersion
- Downspout Infiltration
- Detention Tank
- Ditch
- Culvert
- Catch Basin
- Debris Barriers and Trash Racks.

Please refer to the Stormwater BMP Maintenance Standards (Appendices 10A, 10B, and 10C) for further details.

10.4.1 Detention Pond

Description

A detention pond is a shallow bowl-like depression in the land, with an area to collect and temporarily store stormwater. The pond is generally lined with grass and there is typically a pipe for inflow and a control structure at the outflow.

Purpose

A detention pond is intended to store (or "detain") stormwater to reduce runoff volumes during storms. The outflow structure releases the detained water to the downstream system or surface water at a slow, controlled rate.

Maintenance Actions To Keep Detention Ponds Functioning

- Remove litter, sediment, yard debris, and problem vegetation such as Scotch broom.
- Maintain a healthy grass cover to prevent erosion and weed growth.
- Repair erosion and replace rock riprap at pipe ends.
- Inspect pond berms for any structural deficiencies.

10.4.2 Infiltration Basin ("Dry Pond")

Description

A shallow bowl-like depression in the land, with a broad, flat bottom area to collect, temporarily store, and infiltrate stormwater.

Purpose

An infiltration basin is designed to receive treated water and allow it to infiltrate into the soil. The infiltration basin is usually lined with grass and drains "dry" between rain events. Some playfields (as in photo above, left) double as infiltration basins by design.

Maintenance Actions To Keep Infiltration Basins Functioning

- Remove litter, yard debris, and problem vegetation such as Scotch broom.
- Maintain a healthy grass cover to prevent erosion and weed growth.
- Repair erosion and replace rock riprap at pipe ends.
- Avoid activities within the basin that could cause erosion or soil compaction.
- Avoid using herbicides or pesticides within the basin area.
- Aerate the soil in the bottom area as needed to preserve and enhance infiltration.

10.4.3 Biofiltration Swale

Description

A longitudinally sloped, wide, shallow, vegetation-lined channel with gently sloping sides and a flat bottom.

Purpose

Biofiltration swales are designed to remove pollutants by means of sedimentation, filtration, soil sorption, and/or plant uptake. Some water also infiltrates into the soil as it slowly flows along the swale.

Maintenance Actions To Keep Swales Functioning

- Remove debris, litter, and flow obstructions from the swale.
- Mow the swale and maintain healthy grass cover.
- Prevent dirt, rocks, and weeds from accumulating, but avoid use of herbicides (remove manually).
- Do not fill-in the swale with rocks, bark, etc.
- Aerate the soil to preserve infiltration capacity.

10.4.4 Wet Pond

Description

A constructed pond with an impermeable liner to maintain a permanent pool of water.


Purpose

Wet ponds provide for runoff treatment by settling and retention of sediment particles and other pollutants. The cleaner surface water is then conveyed to a nearby infiltration BMP (such as a "dry detention pond") or surface discharge. A wet pond provides a basic level of treatment and is common in many neighborhoods.

Maintenance Actions To Keep Wet Ponds Functioning

- Remove litter and yard debris from within and around the pond.
- Check inflow and outflow systems and remove any obstructions.
- Remove excess vegetation such as cattails from within the pond.
- Remove noxious weeds, but do not use herbicides (contact City for advice).

10.4.5 Stormwater Wetland

Description

A created wetland with a permanent pool of water, similar to a wet pond but generally shallower and with aquatic emergent plants.

Purpose

Aquatic emergent plants in stormwater wetlands provide for a higher level of runoff treatment of collected stormwater through biological processes.

Maintenance Actions To Keep Stormwater Wetlands Functioning

- Remove litter and yard debris from within and around the wetland.
- Check inflow and outflow systems and remove any obstructions.
- Remove excess vegetation such as cattails from within the wetland.
- Remove noxious weeds, but do not use herbicides (contact City for advice).

10.4.6 Bioretention Cell

Description

A shallow stormwater system with a designed soil mix and plants. Bioretention is a low impact development (LID) practice that is integrated into a site to retain stormwater near its source.

Purpose

Bioretention cells are designed to mimic a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. They also provide runoff treatment through sedimentation, filtration, adsorption, and phytoremediation. Bioretention cells function by storing stormwater as surface ponding before it filters through the underlying amended soil.

Maintenance Actions To Keep Bioretention Cells Functioning

- Remove litter, weeds and fallen leaves. Do not use herbicides or pesticides.
- Check inflow and outflow systems and remove any obstructions.
- Repair erosion, cover bare spots with organic mulch.
- Perform plant maintenance as needed, such as pruning branches.
- Remove dead vegetation and replace dead plants with same varieties.

10.4.7 Rain Garden

Description

Non-engineered, shallow, landscaped depressions with compost amended native soils and adapted plants that collect, absorb, and filter stormwater runoff from roof tops, driveways, patios, and other hard surfaces.

Purpose

Rain gardens are sized to pond and temporarily store stormwater runoff and allow stormwater to pass through the amended soil profile.

Maintenance Actions To Keep Rain Gardens Functioning

- Remove litter, weeds and fallen leaves. Do not use herbicides or pesticides.
- Check inflow and outflow systems and remove any obstructions.
- Repair erosion, cover bare spots with organic mulch.
- Perform plant maintenance as needed, such as pruning branches.
- Remove dead vegetation and replace dead plants with same varieties.

10.4.8 Permeable Pavement

Description

Permeable pavement (including pervious asphalt, pervious concrete, and permeable pavers) looks very much like ordinary pavement but includes additional "void" spaces where water can pass through.

Purpose

Permeable pavement is designed to allow water to drain through the wearing course, be held in a storage reservoir bed (made up of aggregate rock, or drain rock), and then infiltrate into the native soils.

Maintenance Actions To Keep Permeable Pavement Functioning

- Clean surface to remove trash, sediment, vegetation, and other accumulated debris.
- Check inflow and outflow systems and underdrains and remove any obstructions.
- Use vacuum to remove fine sediments.
- If pavers are used, check for damaged or missing pavers, and replace as needed.
- If paving grids are used, check for loss of soil, grass, and/or gravel material and replace as needed.

10.4.9 Downspout, Sheet Flow, and Concentrated Flow Dispersion

Description

A gravel trench or splash block followed by a vegetated flow path (or dispersion area) used to disperse flow and reduce runoff from impervious surfaces.

Purpose

Dispersion attenuates peak runoff flows by slowing the runoff entering into the conveyance system, allowing some infiltration, and providing some water quality benefits.

Maintenance Actions To Keep Downspout, Sheet Flow, and Concentrated Flow Dispersion Functioning

- Ensure that vegetation is not blocking flow and perform plant maintenance as needed.
- Remove and replace dead vegetation to ensure that runoff is received in a well-vegetated area.
- Avoid activity in dispersion area to avoid compaction.
- Check for erosion of the dispersion trench or dispersal area and replace and restore gravel and/or soil.

10.4.10 Downspout Infiltration

Description

Downspout infiltration includes infiltration trenches or drywells. Infiltration trenches and drywells are backfilled with washed drain rock, allowing for temporary storage of stormwater runoff in the voids of the drain rock material. Stored runoff gradually infiltrates into the surrounding soil.

Purpose

Downspout infiltration is intended only for use in infiltrating runoff from roof surfaces.

Maintenance Actions To Keep Downspout Infiltration Functioning

- Remove litter, leaves, debris, and obstructions from the infiltration trench or drywell.

- Stabilize adjacent landscaped areas to avoid runoff from eroding and mobilizing soil into the surface inlet.

10.4.11 Detention Tank

Description

An underground storage BMP typically constructed with large diameter corrugated metal or HDPE pipe.

Purpose

A detention tank is intended to store (or “detain”) stormwater to reduce runoff volumes during storms. The outflow structure releases the detained water to the downstream system or surface water at a slow, controlled rate.

Maintenance Actions To Keep Detention Tanks Functioning

- Remove litter, leaves, debris, and obstructions from inlet and outlet.
- Check tank for cracks or leaks.
- Clean out any sediment or debris accumulated inside the tank.

10.4.12 Ditch

Description

A V-shaped channel, usually along the side of a road.

Purpose

The purpose of a ditch is to collect and convey runoff.

Maintenance Actions To Keep Ditches Functioning

- Remove debris, litter, and flow obstructions from the ditch.
- Do not fill-in the ditch – prevent dirt, rocks, and weeds from accumulating.
- Repair erosion on ditch side-slopes.

10.4.13 Culvert

Description

A pipe that continues conveyance flow from a ditch or swale under the ground surface, typically under driveways and cross-streets. Usually connects ("daylights") to another ditch, swale, or pond. The end of a pipe or culvert is often surrounded by rock "riprap" (as in photo below, right) to prevent soil erosion.

Purpose

The purpose of a culvert is to maintain flow from a ditch or swale.

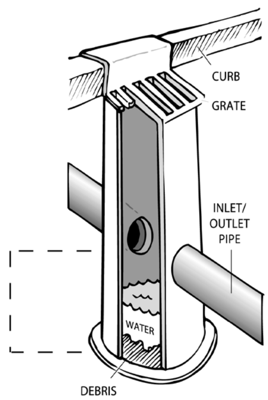
Maintenance Actions To Keep Culverts Functioning

- Remove debris, litter, and obstructions from the openings at the culvert ends.
- Remove soil, sod, and vegetation buildup from the culvert openings.
- Replace rock riprap at the culvert ends.
- Repair any damage to the culvert ends.

10.4.14 Catch Basin

Description

An underground concrete box structure with a slotted metal grate on top that collects runoff water from the ground surface. Typically located within pavement in parking lots and in the street gutter, usually next to a curb.



Purpose

Grate on top lets water in and keeps larger debris out. Sediment settles in the sump in the bottom (below the pipe openings) and must be removed periodically. Catch basins have an outlet pipe between the grate and the sump, to let the cleaner water flow out to a storm pond or other location. Some catch basins have both inflow and outflow pipes, to convey collected runoff water through.

Maintenance Actions To Keep Catch Basins Functioning

- Remove litter, leaves, debris, and obstructions from catch basin grates.
- Hire a professional to remove sediment buildup from sump if road is privately owned. Catch basins in the public right-of-way are maintained by the City.

10.4.15 Debris Barriers and Trash Racks

Description

A structural device with metal bars, to prevent debris from entering a pipe, spillway, or hydraulic structure.

Purpose

The purpose of a debris barrier or trash rack is to prevent trash, debris, and vegetation from clogging or plugging a closed pipe system.

Maintenance Actions To Keep Debris Barriers and Trash Racks Functioning

- Remove trash, debris, vegetation, and dirt from around the structure.
- Check inflow and outflow and remove any flow obstructions.
- Remove plants such as alder and willow that tend to grow near the pipe ends.
- Check for structural integrity; hire a professional to fix broken bars or racks.

Chapter 10 Resources

If you are unsure whether a problem exists, please contact the City at the number below and ask for technical assistance with your situation. Other resources are listed for your convenience and as references associated with the checklists.

Lacey Public Works Department
(360) 491-5600
< https://cityoflacey.org/privately-owned-stormwater-facilities/>.

City of Lacey Spill Response Team
(360) 491-5644
< https://cityoflacey.org/stormwater-utility-programs-activities/report-a-spill/>.

Thurston County Environmental Health
Hazardous Waste Disposal (oil, paint, pesticides, etc.)
(360) 754-4111
<http://www.co.thurston.wa.us/HEALTH/ehhw/index.html>.

Solid Waste Disposal (yard waste, construction waste, contaminated soils, etc.)
(360) 786-5136
< https://www.thurstoncountywa.gov/phss/Pages/eh-garbagedumping.aspx>.

WSU Thurston Co. Extension (Water Resource Educational Programs, Environmental Stewardship information)
(360) 786-5445
<https://extension.wsu.edu/thurston/nrs/waterresources/>.

Appendix 10A – Maintenance Standards Checklists for Group 1: Flow Control and Treatment BMPs

1a. Detention Ponds

Detention ponds are earthen excavations that are "dry" except during and after rains, when they contain stormwater temporarily. Detention ponds store water while releasing it gradually.

Detention Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Trash and Debris	Accumulated trash and debris. Dumping of yard wastes such as grass clippings and branches into pond. Presence of glass, plastic, metal, foam, or paper. In general, there should be no visual evidence of dumping.		No trash or debris present. Remove and properly dispose of all trash and debris.	
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public (such as Scotch broom or blackberry vines, poison oak, tansy ragwort, stinging nettles, or devil's club). Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation according to applicable regulations. *(Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	
	Contamination and Pollution	Presence of contaminants such as oil, gasoline, concrete slurries, paint, obnoxious color, odor, or sludge.		Locate the source of the pollution and remove contaminants or pollutants present. *Report and coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754-4111 and/or Dept. of Ecology Spill Response (800) 424-8802.*	

Detention Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General (continued)	Rodent Holes	If the BMP is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm. Water should not be able to flow through the rodent holes.		Remove rodents and repair the dam or berm. *(Coordinate with the Thurston County Health Department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*	
	Beaver Dam	Beaver dam results in an adverse change in the functioning of the BMP		Return BMP to design function. (*Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator.)*	
	Insects	Insects such as wasps and hornets interfering with maintenance activities, or mosquitoes becoming a nuisance.		Remove or remove insects. For mosquito control, eliminate stagnant water. *Apply insecticides in compliance with adopted integrated pest management policies.*	
	Overgrown Vegetation Around Pond	Tree grown and dense vegetated impedes inspection, maintenance access or interferes with maintenance activity with the BMP function or maintenance (i.e., slope mowing, silt removal, Vactoring, or equipment movements).		Prune or maintain trees and vegetation so they do not to hinder inspection or maintenance activities. If trees are not interfering with access or maintenance, do not remove.	
	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements).		Remove hazard trees.	
Side Slopes	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion or where any erosion is observed on a compacted berm embankment. Check all pond areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance. *If erosion is occurring on compacted berms, a professional engineer licensed in Washington State should be consulted to resolve source of erosion.*	

Detention Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Pond Storage Area	Sediment Accumulation	Accumulated sediment that exceeds 10 percent of the designed pond depth unless otherwise specified or affects inlets or outlets of the BMP.		Clean out sediment and aerate and/or re-seed the pond if deemed necessary to improve infiltration and control erosion. *(If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*	
	PVC Pond Liner	An indicator of a torn liner could be the pond no longer holds water. Check to see if the pond holds water during dry periods (during long dry periods the water may evaporate), and the liner is not exposed. Maintenance is needed if liner is visible and has more than three 0.25-inch holes.		Repair or replace liner as needed. Liner is fully covered.	
	Clay Liner	An indicator of a torn liner could be the pond no longer holds water. Check to see if the pond holds water during dry periods (during long dry periods the water may evaporate).		Repair or replace liner as needed.	
Dikes or Berms	Settlement	Any part of the dike or berm that has settled more than 4 inches lower than designed.		Build the dike or berm back to the design elevation. *If settlement is significant, a professional engineer licensed in Washington State should be consulted to determine the cause of the settlement.*	
	Seepage	Check for water flowing through the pond berm and ongoing erosion with potential for erosion to continue.		Repair berm to eliminate seepage and erosion. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*	

Detention Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Emergency Overflow Spillway	Rocks Missing	Check to see that the riprap protective area is intact. Maintenance is need if only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil at the top of outflow path of spillway.		Restore rocks and pad depth to design standards. (Riprap on inside slopes need not be replaced.) If any native soil is exposed, cover soil with rock riprap.	
	Tree Growth	Check emergency spillways for tree growth that creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.		Remove trees on emergency spillway. *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 professional engineer should be consulted for proper berm/spillway restoration.*	
	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion. Maintenance is needed where any erosion is observed on a compacted berm embankment. Check all pond areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance. *If erosion is occurring on compacted berms, a professional engineer licensed in Washington State should be consulted to resolve source of erosion.*	

1b. Infiltration Ponds, Trenches, and Galleries

Infiltration ponds, trenches, and galleries are earthen excavations or underground structures that are “dry” except during and after rains, when they contain stormwater temporarily. Infiltration ponds, trenches, and galleries store water while gradually percolating water into the ground.

Infiltration Ponds, Trenches, and Galleries					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Trash and Debris	Accumulated trash and debris. Dumping of yard wastes such as grass clippings and branches into pond. Presence of glass, plastic, metal, foam, or paper. In general, there should be no visual evidence of dumping.		No trash or debris present. Remove and properly dispose all trash and debris.	
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public (such as Scotch broom or blackberry vines, poison oak, tansy ragwort, stinging nettles, or devil’s club). Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. *(Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	
	Contamination and Pollution	Presence of contaminants such as oil, gasoline, concrete slurries, paint, obnoxious color, odor, or sludge.		Locate the source of the pollution and remove contaminants or pollutants present. *Report and coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.*	

Infiltration Ponds, Trenches, and Galleries					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General (continued)	Rodent Holes	If the BMP is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm. Water should not be able to flow through the rodent holes.		Remove rodents and repair the dam or berm. *(Coordinate with Thurston County Health Department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*	
	Beaver Dam	Beaver dam results in an adverse change in the functioning of the BMP.		Return BMP to design function. (*Contact WDFW Region 6 to identify the appropriate Nuisance Wildlife Control Operator.)*	
	Insects	Insects such as wasps and hornets interfering with maintenance activities, or mosquitoes becoming a nuisance.		Remove insects. For mosquito control, eliminate stagnant water. *Apply insecticides in compliance with adopted integrated pest management policies.*	
	Hazard Trees	If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements).		Remove hazard trees.	
	Tree Growth and Dense Vegetation	Tree growth and dense vegetation, which impedes inspection, maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, Vactoring, or equipment movements).		Trees and vegetation do not hinder inspection or maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood).	
Storage Area	Water Not Infiltrating	Check for water ponding in infiltration basin 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. (Maintenance is required if a percolation test pit or test of BMP indicates BMP is only working at 90 percent of its designed capabilities, or if 2 inches or more sediment is present, remove).		BMP infiltrates as designed. Sediment is removed and/or BMP is cleaned so that infiltration system works according to design.	
Filter Bags (if applicable)	Filled with Sediment and Debris	Maintenance is required if sediment and debris fill bag more than one-half full.		Replace filter bag or redesign system. Filter bag must be less than one-half full.	

Infiltration Ponds, Trenches, and Galleries					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.		Replace gravel in rock filter if needed. Water must flow through filter.	
Trenches	Observation Well (use surface of trench if well is not present)	Water ponds at surface during storm events. Less than 90 percent of design infiltration rate.		Remove and replace/clean rock and geomembrane.	
Galleries	Chambers	Check inlet and outlets and interior of chambers for deficiencies, cracks, debris, and sediment.		Remove any debris and sediment and replace or restore chambers as needed.	
Ponds	Vegetation	Exceeds 18 inches.		Mow grass or groundcover to a height no greater than 6 inches.	
		Bare spots.		Revegetate and stabilize immediately. No bare spots should be present.	
Side Slopes	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion or where any erosion is observed on a compacted berm embankment. Check all pond areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance. *If erosion is occurring on compacted berms, a professional engineer licensed in Washington State should be consulted to resolve source of erosion.*	
Dikes or Berms	Settlement	Any part of the dike or berm that has settled more than 4 inches lower than designed.		Build the dike or berm back to the design elevation. *If settlement is significant, a professional engineer licensed in Washington State should be consulted to determine the cause of the settlement.*	
	Seepage	Check for water flowing through the pond berm and ongoing erosion with potential for erosion to continue.		Repair berm to eliminate seepage and erosion. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*	

Infiltration Ponds, Trenches, and Galleries					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Dikes or Berms (continued)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm, which could lead to failure of the berm.		Remove trees on berms. *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 professional engineer licensed in Washington State should be consulted for proper berm/spillway restoration.*	
Emergency Overflow Spillway	Rocks Missing	Check to see that the riprap protective area is intact. Maintenance is need if only one layer of rock exists above native soil in area 5 square feet or larger, or any exposure of native soil at the top of outflow path of spillway.		Restore rocks and pad depth to design standards. (Riprap on inside slopes need not be replaced.) If any native soil is exposed, cover soil with rock riprap.	
	Tree Growth	Check emergency spillways for tree growth that creates blockage problems and may cause failure of the berm due to uncontrolled overtopping.		Remove trees on emergency spillway. *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 professional engineer licensed in Washington State should be consulted for proper berm/spillway restoration.*	
	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion. Maintenance is needed where any erosion is observed on a compacted berm embankment. Check all pond areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance. *If erosion is occurring on compacted berms, a professional engineer licensed in Washington State should be consulted to resolve source of erosion.*	
	Screen Clogged or Missing	The bar screen over the outlet should be intact and clear of debris. Water should flow freely through the outlet pipe.		Replace screen if it is not attached. Remove any trash or debris and dispose of properly. Clean out the end pipe if necessary.	

Infiltration Ponds, Trenches, and Galleries					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Presettling Ponds and Vaults	BMP or Sump Filled with Sediment and/or Debris	6 inches or designed sediment trap depth of sediment.		Remove sediment. No sediment should be present in presettling pond or vault.	
	Inadequate Sediment Settling Area	Stormwater should not enter the infiltration area without some method of settling-out solids.		Add a sediment trapping area by constructing a sump or berm for settling of solids. This area should be separate from the rest of the BMP. Contact the City for guidance.	
Drain Rock	Water Ponding	If water enters the BMP from the surface, inspect to see if water is ponding at the surface during storm events. If buried drain rock, observe drawdown through observation port or cleanout.		Clear piping through BMP when ponding occurs. Replace rock material/sand reservoirs as necessary. Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill. No water ponding should be present on surface during storm events.	

For manufactured infiltration galleries, designers must review and apply the most current manufacturer guidelines and recommendations for BMP operation and maintenance.

1c. Detention Tanks and Vaults

These types of storage structures are usually underground and accessed via a manhole. DO NOT ENTER ANY TANK OR VAULT without proper training, certification, and equipment.

Detention Tanks and Vaults					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
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. Remove blockage or replace air vent if damaged.	
	Debris and Sediment	Accumulated sediment depth exceeds 10 percent of the diameter of the storage area for 50 percent of the length of storage vault or any point depth exceeds 15 percent of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 50 percent of the length of tank.)		No debris or sediment present. All sediment and debris removed from storage area.	
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into BMP. (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 percent 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 0.5 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.		Vault replaced or repaired to design specifications and is structurally sound.	

Detention Tanks and Vaults					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Storage Area (continued)	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 0.5 inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.		No cracks more than 0.25-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 access cover/lid is in place and secure.	
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 0.5 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	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.		Ladder meets design standards and allows maintenance persons safe access.	
Catch Basins	See “Catch Basins”	See “Catch Basins.”		See “Catch Basins.”	

1d. Wet Vaults

These types of storage structures are usually underground and accessed via a manhole. DO NOT ENTER ANY TANK OR VAULT without proper training, certification, and equipment.

Wet Vaults					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Vault	Trash and Debris	Accumulated trash and debris in vault, pipe or inlet/outlet (includes floatables and non-floatables).		No trash or debris present. Remove and properly dispose of all trash and debris.	
	Sediment Accumulation	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6 inches.		Remove sediment from vault. *(If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*	
	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 percentage 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 0.5 inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.		Vault repaired so no cracks exist wider than 0.25 inch at the joint of the inlet/outlet pipe.	
	Baffles	Baffles corroding, cracking warping and/or showing signs of failure as deemed 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.	

1e. Wet Ponds

Wet ponds are designed to improve water quality. They have a permanent pool of water, which slows incoming stormwater flows causing sediments and pollutants to settle-out. Wet ponds are typically deeper than other water quality BMPs, such as stormwater wetlands, and utilize the pool volume to reduce pollutant loads.

Wet Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Water Level	First cell is empty, doesn't hold water.		Line the first cell to maintain at least 4 feet of water. Second cell may drain, but the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.	
	Trash and Debris	Accumulated trash and debris. Dumping of yard wastes such as grass clippings and branches into pond. Presence of glass, plastic, metal, foam, or paper. In general, there should be no visual evidence of dumping.		No debris or sediment present. Remove and properly dispose of all trash and debris.	
	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 on Pond Bottom	Accumulated sediment on pond bottom that exceeds the depth of sediment zone plus 6 inches, usually in the first cell.		Sediment removed from pond bottom.(*If sediment contamination is a potential problem, sediment should be tested regularly to determine leaching potential prior to disposal.)*	
	Oil Sheen on Water	Visible and prevalent oil sheen.		Oil removed from water using oil-absorbent pads or Vactor truck. Locate and correct oil source. If chronic low levels of oil persist, plant wetland plants such as *Juncus effusus* (soft rush) which can uptake small concentrations of oil.	
	Erosion	Erosion of the pond's side slopes and/or scouring of 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.	

Wet Ponds					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General (continued)	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.	
	PVC Pond Liner	Check to see if liner is visible and has more than three 0.25-inch holes, is exposed and/or torn. An indicator of a torn liner could be the pond no longer holds water (during long dry periods the water may evaporate)		Repair or replace liner as needed. Note: wet ponds usually have liners.	
	Clay Liner	Check to see if pond is holding water (during long dry periods the water may evaporate).		Repair liner to design state.	
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public (such as Scotch broom or blackberry vines, poison oak, tansy ragwort, stinging nettles, or devil's club). Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. *(Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	
	Vegetation Not Growing or Overgrown Within Pond	Presence of invasive species or sparse/excessive growth of plants.		Remove invasive species and reestablish vegetation as designed.	

1f. Stormwater Wetlands

Stormwater wetlands are designed to improve water quality. They are designed with emergent aquatic plants to provide biological treatment and filtering of runoff water.

Stormwater Wetlands					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Trash and Debris	Accumulated trash and debris. Dumping of yard wastes such as grass clippings and branches into pond. Presence of glass, plastic, metal, foam, or paper. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.		No debris or sediment present. Remove and properly dispose all trash and debris.	
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public (such as Scotch broom or blackberry vines, poison oak, tansy ragwort, stinging nettles, or devil's club). Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. *(*Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. (*Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	
	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 emergent wetland plants such as Juncus effusus (soft rush) which can assist filtering small concentrations of oil.*	
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material or damaged.		No clogging or blockage in the inlet and outlet piping.	

Stormwater Wetlands					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General (continued)	Rodent Holes	If the BMP is constructed with a dam or berm, look for rodent holes or any evidence of water piping through the dam or berm. Water should not be able to flow through the rodent holes.		Remove rodents and repair the dam or berm. *(Coordinate with Thurston County Health Department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)*	
	Beaver Dams	Beaver dam results in an adverse change in the functioning of the BMP.		Return BMP to design function. *Evaluate using beaver deceiver and leveler devices. If beaver removal is necessary, contact WDFW Region 6 to coordinate with a Nuisance Wildlife Control Operator.*	
	Tree Growth and Hazard Trees	Tree growth that impedes maintenance access.		Remove hazard trees. Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., firewood or construction).	
	Tree Growth and Hazard Trees	If dead, diseased, or dying trees are identified, use a certified Arborist to determine the health of tree and whether removal is required.		Remove hazard trees.	
	Liner	Check to see if liner is visible and has more than three 0.25-inch holes, or if it is exposed and or torn. An indicator of a torn liner could be the wetland no longer holds water. (during long dry periods the water may evaporate).		Repair or replace liner as needed. Liner is fully covered.	
Forebay	Sediment Accumulation	Sediment accumulation in forebay exceeds the design depth of the sediment zone plus 6 inches.		Remove accumulated sediment from forebay bottom to the design depth of the sediment zone.	
Side Slopes of Wetland	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion. Check all wetland areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance.	
Side Slopes of Wetland	Erosion	Any erosion observed on a compacted berm embankment.		*If erosion is occurring on compacted berms a professional engineer should be consulted to resolve source of erosion.*	

Stormwater Wetlands					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Wetland Cell	Wetland Vegetation	20 percent or more of the stormwater wetland area has dead or dying vegetation, as measured by stem counts relative to the design plant coverage.		Plants in wetland cell surviving and not interfering with wetland function. Dead or dying vegetation is replaced by like species, unless recommended otherwise by the Wetlands Consultant and approved by the City. *(Watering, physical support, mulching, and weed removal may be required on a regular basis especially during the first 3 years.)*	
	Wetland Vegetation	Percent vegetated cover of stormwater wetland bottom area, excluding exotic and invasive species, is less than 50 percent after 2 years.		Exotic/invasive species removed. Additional plantings may be required.	
	Wetland Vegetation	Decaying vegetation produces foul odors.		Decaying vegetation is removed, preferably in late summer.	
	Wetland Vegetation	Wetland vegetation is blocking flow paths causing flow back-up and flooding.		Areas of blocking vegetation are cut back sufficient to allow design flows and prevent flooding.	
	Wetland Vegetation	Water quality monitoring indicates that wetland vegetation is contributing phosphorus and metals to downstream waters rather than sequestering them.		Water quality monitoring indicates improved water quality. To maximize removal of wetland pollutants, wetland vegetation must be periodically harvested, particularly with respect to phosphorus and metals removal. Harvesting should occur by mid-summer before plants begin to transfer phosphorus from the aboveground foliage to subsurface roots, or begin to lose metals that desorb during plant die off. Every 3 to 5 years the entire plant mass including roots should be harvested because the belowground biomass constitutes a significant reservoir (as much as half) of the nutrients and metals that are removed from stormwater by plants.	
	Sediment Accumulation	Sediment accumulation inhibits growth of wetland plants or reduces wetland volume (greater than 1 foot of sediment accumulation).		Wetland dredged to remove sediment accumulation.	

Stormwater Wetlands					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Wetland Berms (dikes)	Settlements	Any part of berm that 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.		Dike restored to the design elevation. *A professional engineer licensed in Washington State should be consulted to determine the source of the settlement.*	
	Seepage	Check for water flowing through the pond berm and ongoing erosion with potential for erosion to continue.		Repair berm to eliminate seepage and erosion. *Recommend a geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.*	
Wetland Berms Over 4 Feet in Height (dikes)	Tree Growth	Tree growth on berms over 4 feet in height may lead to piping through the berm, which could lead to failure of the berm.		Remove trees on berms. *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 professional engineer licensed in Washington State should be consulted for proper berm/spillway restoration.*	
Emergency Overflow/ Spillway	Obstruction	Tree growth or other blockage on emergency spillways may cause failure of the berm due to uncontrolled overtopping.		Remove obstruction on emergency spillway. *A professional engineer licensed in Washington State should be consulted for proper berm/spillway restoration.*	
	Rock Missing	Check to see that the riprap protective area is intact. Only one layer of rock exists above native soil in an area 5 square feet or larger, or any exposure of native soil at the top of out flow path of spillway.		Restore rocks and pad depth to design standards. (Riprap on inside slopes need not be replaced.)	

Stormwater Wetlands					
Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
Emergency Overflow/ Spillway (continued)	Erosion	Maintenance is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion. Maintenance is needed where any erosion is observed on a compacted berm embankment. Check all wetland areas, particularly around inlets and outlets, as well as at berms for signs of sliding or settling.		Try to determine what has caused the erosion and fix it. Stabilize slopes by using appropriate erosion control measure(s); e.g., reinforcing the slope with rock, planting grass, or compacting the soil. Contact the City for assistance. *If erosion is occurring on compacted berms a professional engineer licensed in Washington State should be consulted to resolve source of erosion.*	

1g. Basic and Compost-Amended Biofiltration Swale

A gently-sloped channel with gentle side slopes, lined with grass (and sometimes other vegetation) to slow the flow and allow for runoff treatment and infiltration.

Basic and Compost-Amended Biofiltration Swale

Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches or inhibits vegetation growth in 10 percent or more of swale.		Remove sediment deposits on grass treatment area of the biofiltration 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.		Swale must drain freely and not contain standing water between storms. 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	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.		Base flow removed from swale. Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.	
	Poor Vegetation Coverage	Grass is sparse or bare or eroded patches occur in more than 10 percent of the swale bottom.		Swale has no bare spots and grass is thick and healthy. 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 (higher than 10 inches); when nuisance weeds and other vegetation start 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.	

Basic and Compost-Amended Biofiltration Swale					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Swale	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 biofiltration swale.		No debris or sediment present. Remove trash and debris from biofiltration swale.	
	Erosion/ Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.		No eroded or scoured areas in biofiltration swale. Cause of erosion or scour addressed. 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.	
	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. (*Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	

1h. Wet and Continuous Inflow Biofiltration Swales

Similar to a basic biofiltration swale (previous pages), but with modifications due to saturated soil conditions (such as, specific plants that can tolerate wet conditions).

Wet and Continuous Inflow Biofiltration Swales					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Swale	Sediment Accumulation	Sediment depth exceeds 2 inches in 10 percent 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.		Wetland vegetation fully covers bottom of swale. Cause of lack of vigor of vegetation addressed. Replant as needed. Determine cause of lack of vigor of vegetation and correct. Replant as needed. Remove cattails 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	Any plastic, paper or other waste or debris.		No debris or sediment present. Remove trash and debris from wet biofiltration swale.	
	Erosion/ Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.		No eroded or scoured areas in biofiltration swale. Check design flows to ensure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as *Juncus effusus* (soft rush) in wet areas or snowberry (*Symphoricarpos albus*) in dryer areas.	

Wet and Continuous Inflow Biofiltration Swales					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Swale (continued)	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. *(Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	

1i. Filter Strip (Basic and CAVFS)

A basic filter strip is a flat grassy area that provides treatment of unconcentrated sheet flow runoff from adjacent pavement. Can provide enhanced treatment for metals in runoff water when soil is amended with organic compost and grass is sufficiently dense.

Filter Strip (basic and CAVFS)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
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 to 4 inches.	
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.		No trash or debris present. Remove trash and debris from filter.	
	Erosion/ Scouring	Eroded or scoured areas due to flow channelization, or higher flows.		No eroded or scoured areas, cause of erosion or scour addressed. 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.	

1j. Sand Filter (aboveground/open)

A typical open sand filter consists of a pretreatment system to remove sediments, a flow spreader, a sand bed, and underdrain piping. See also Sand Filter (belowground/closed).

Sand Filter (aboveground/open)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Aboveground (open sand filter)	Sediment and Silt Accumulation on top layer	Sediment and silt depth exceeds 0.5 inch over 10 percent of surface area of sand filter.		No sediment deposit on grass layer of sand filter that would impede permeability of the filter section. Silt scraped off during dry periods using steel rakes or other devices. Surface layer of the media striated.	
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.		No trash or debris present. 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 cleanouts and/or drainpipes.	
	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, flow through the overflow pipes occurs frequently, or hydraulic conductivity is less than 1 inch per hour.		Sand filter infiltrates as designed. 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 BMPs. (Consider 4- to 8-hour drawdown tests).		Low, continuous flows are limited to a small portion of the BMP by using a low wooden divider or slightly depressed sand surface.	
	Short Circuiting	Drawdown greater than 12 inches per hour. 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. No leaks in the cleanouts or underdrains.	
	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.	

Sand Filter (aboveground/open)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Aboveground (open sand filter) (continued)	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. Rills and gullies on the surface of the filter can indicate improper function of the inlet flow spreader.		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 percent or any other failure to the piping.		Pipe repaired or replaced.	

1k. Sand Filter (belowground/closed)

Similar to an open sand filter, but installed below grade within a vault.

Sand Filter (belowground/closed)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Vault	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 0.5 inch.		No sediment deposits on sand filter section that would impede permeability of the filter section. Silt scraped off during dry periods using steel rakes or other devices. Surface layer of the media striated.	
	Sediment Accumulation in Presettling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of sediment zone plus 6 inches.		No sediment deposits in first chamber of vault.	
	Trash and Debris	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.		No trash or debris present. 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.		No sediment or debris present. Any sediment and debris removed from cleanouts and/or drainpipes.	
	Clogged 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, and/or hydraulic conductivity is less than 1 inch per hour.		Sand filter infiltrates as designed. Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging and influent suspended solids loads (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material). *Other options include removal of thatch, aerating the filter surface, tilling the filter surface, replacing the top 4 inches of filter media, and inspecting geotextiles for clogging.*	
	Short Circuiting	Drawdown greater than 12 inches per hour. When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area. (Consider 4- to 8-hour drawdown tests.)		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. No leaks in the cleanouts or underdrains.	

Sand Filter (belowground/closed)					
Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
Vault (continued)	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.	
	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.	
	Ventilation	Ventilation area blocked or plugged.		Blocking material removed/cleared from ventilation area. A specified percentage of the vault surface area must provide venting to the vault interior (per design specifications).	
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 0.5 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.	
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab.	Cracks wider than 0.5 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 0.25 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.	
Pipes	Damaged Pipes	Inlet or outlet piping damaged or broken, in need of repair.		Pipe repaired and/or replaced.	

1I. Media Filter Drains

A filter treatment device that is typically sited along highway side slopes (conventional design) and medians (dual media filter drains), borrow ditches, or other linear depressions. Media filter drains have basic components: a gravel no-vegetation zone, a grass strip, the MFD mix bed, and a conveyance system for flows leaving the media filter drain mix.

Media Filter Drains					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
No Vegetation Zone Adjacent to Pavement	Erosion, Scour, or Vehicular Damage	No vegetation zone uneven or clogged so that flows are not uniformly distributed.		Area leveled and cleaned so that flows are spread evenly.	
	Sediment Accumulation on Edge of Pavement	Flows no longer sheet flowing off of roadway. Sediment accumulation on pavement edge exceeds top of pavement elevation.		No sediment accumulation on pavement edge that impedes sheet flow. Sediment deposits removed such that flows can sheet flow off of roadway.	
Vegetated Filter	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.		Sediment deposits removed, slope is re-leveled so that flows pass evenly through media filter drain.	
	Excessive Vegetation or Undesirable Species	When the grass becomes excessively tall (greater than 10 inches); when nuisance weeds and other vegetation starts to take over or shades out desirable vegetation growth characteristics. See also the Thurston County Noxious Weeds List.		Grass mowed and nuisance vegetation controlled such that flow not impeded. *Grass should be mowed to a height that encourages dense even herbaceous growth.*	
	Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows, or vehicular damage.		No eroded or scoured areas. *For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with suitable topsoil. 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.*	

Media Filter Drains					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Media Bed	Erosion, Scour, or Vehicular Damage	Eroded or scoured areas due to flow channelization, high flows, or vehicular damage.		No eroded or scoured areas. *For ruts or areas less than 12 inches wide, repair the damaged area by filling with suitable media. If bare areas are large, generally greater than 12 inches wide, the media bed should be re-graded.*	
	Sediment Accumulation on Media Bed	Sediment depth inhibits free infiltration of water.		Sediment accumulation does not impeded infiltration. Sediment deposits removed and slope is re-leveled so that flows pass freely through Media Bed.	
Underdrains	Sediment	Depth of sediment within perforated pipe exceeds 0.5 inch.		Depth of sediment within perforated pipe does not exceed 0.5 inch. Flush underdrains through access ports and collect flushed sediment.	
General	Trash and Debris Accumulation	Accumulated trash and debris. If there is less than the threshold, remove all trash and debris as part of the next scheduled maintenance.		No trash or debris present. Remove trash and debris from media filter.	
	Flows are Bypassing Media Filter Drain	Evidence of significant flows downslope (rills, sediment, vegetation damage, etc.) of media filter drain.		BMP functions as designed. Sediment deposits removed and slope is re-leveled so that flows pass evenly through media filter drain. If media filter drain is completely clogged, it may require a more extensive repair or replacement.	
	Media Filter Drain Mix Replacement	Water is seen on surface of the media filter drain mix from storms that are less than the 91st percentile 24-hour rain event (approximately 1.25 inches in 24 hours). Maintenance also needed on a 10-year cycle and during a preservation project.		No water ponded on surface after design storm. *Excavate and replace all of the media filter drain mix contained within the media filter drain.*	

1m. Bioretention Cells, Swales, and Planter Boxes

Bioretention areas are shallow stormwater systems with a designed soil mix and plants adapted to the local climate and soil moisture conditions. They are designed to mimic a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. Most routine maintenance procedures are typical landscape care activities.

Bioretention Cells, Swales, and Planter Boxes

Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
General	Trash	Trash and debris present.		No trash and debris present. Remove and properly dispose of all trash and debris.	
Concrete Sidewalls	Cracks or Failure in Concrete Planter Reservoir	Cracks wider than 0.5 inch or maintenance/inspection personnel determine that the planter is not structurally sound.		Concrete repaired or replaced.	
Rockery Sidewalls	Unstable Rockery	Rock walls are insecure.		Rockery sidewalls are stable (may require consultation with professional engineer licensed in Washington State, particularly for walls 4 feet or greater in height).	
Earthen Side Slopes and Berms	Failure in Earthen Reservoir (embankments, dikes, berms, and side slopes)	Erosion (gullies/rills) greater than 2 inches around inlets, outlet, and alongside slopes.		Source of erosion eliminated, and damaged area stabilized (regrade, rock, vegetation, erosion control blanket). For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures are in place until permanent repairs can be made.	
		Erosion of sides causes slope to become a hazard.		The hazard is eliminated, and slopes are stabilized.	
		Settlement greater than 3 inches (relative to undisturbed sections of berm).		The design height is restored with additional mulch.	
		Downstream face of berm or embankment wet, seeps or leaks evident.		Holes are plugged and berm is compacted. May require consultation with professional engineer licensed in Washington State, particularly for larger berms.	
		Any evidence of rodent holes or water piping around holes if BMP acts as dam or berm.		Rodents (see “Pests: Insects/Rodents”) removed and berm repaired/compacted.	

Bioretention Cells, Swales, and Planter Boxes					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Ponding Area	Sediment or Debris Accumulation	Accumulation of sediment or debris to extent that infiltration rate is reduced (see "Ponded water") or surface storage capacity significantly impacted.		Sediment cleaned out to restore BMP shape and depth. Damaged vegetation is replaced and mulched. Source of sediment identified and controlled (if feasible).	
	Leaf Accumulation	Accumulated leaves in BMP.		No leaves clogging outlet structure or impeding water flow.	
	Basin Inlet via Surface Flow	Soil is exposed or signs of erosion are visible.		Erosion sources repaired and controlled.	
Curb Cut Inlet	Sediment or Debris Accumulation	Sediment, vegetation, or debris partially or fully blocking inlet structure.		Curb cut is clear of debris. Source of the blockage is identified and action is taken to prevent future blockages.	
Splashblock Inlet	Water Not Properly Directed to BMP	Water is not being directed properly to the BMP and away from the inlet structure.		Blocks are reconfigured to direct water to BMP and away from structure.	
	Erosion	Water disrupts soil media.		Splashblock is reconfigure/repaired.	
Inlet/ Outlet Pipe	Damaged Pipe	Pipe is damaged.		Pipe is repaired/replaced. No cracks more than 0.25 inch wide at the joint of inlet/outlet pipes exist.	
	Clogged Pipe	Pipe is clogged.		Pipe is clear of roots or debris. Source of the blockage is identified, and action is taken to prevent future blockages.	
Inlets/ Outlet and Access Pathways	Blocked Access	Maintain access for inspections.		Vegetation is cleared within 1 foot of inlets and outlets. Access pathways are maintained.	
Ponding Area	Erosion	Water disrupts soil media.		No eroded or scoured areas in bioretention area. Cause of erosion or scour addressed. A cover of rock or cobbles or other erosion protection measure maintained (e.g., matting) to protect the ground where concentrated water enters or exits the BMP (e.g., a pipe, curb cut, or swale).	
Trash Rack	Trash or Debris Accumulation	Trash or debris present on trash rack.		No trash or debris on trash rack. Clean and dispose trash.	
	Damaged Trash Rack	Bar screen damaged or missing.		Barrier repaired or replaced to design standards.	

Bioretention Cells, Swales, and Planter Boxes					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Check Dams and Weirs	Sediment or Debris Accumulation	Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, weir, or orifice.		Blockage is cleared. Identify the source of the blockage and take actions to prevent future blockages.	
	Erosion	Erosion and/or undercutting is present.		No eroded or undercut areas in bioretention area. Cause of erosion or undercutting addressed. Check dam or weir is repaired.	
	Unlevel Top of Weir	Grade board or top of weir damaged or not level.		Weir restored to level position.	
Flow Spreader	Sediment Accumulation	Sediment blocks 35 percent or more of ports/notches or, sediment fills 35 percent or more of sediment trap.		Sediment removed and disposed of.	
	Damaged or Unlevel Grade Board/Baffle	Grade board/baffle damaged or not level.		Board/baffle removed and reinstalled to level position.	
Overflow/ Emergency Spillway	Sediment or Debris Accumulation	Overflow spillway is partially or fully plugged with sediment or debris.		No sediment or debris in overflow.	
	Erosion	Native soil is exposed, or other signs of erosion damage are present.		Erosion repaired and surface of spillway stabilized.	
	Missing Spillway Armament	Spillway armament is missing.		Armament replaced.	
Underdrain	Blocked Underdrain	Plant roots, sediment or debris reducing capacity of underdrain. Prolonged surface ponding (see “Bioretention Soil”).		Underdrains and orifice are free of sediment and debris.	
Bioretention Soil	Ponded Water	Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.		Cause of ponded water is identified and addressed: 1. Leaf or debris buildup is removed 2. Underdrain is clear 3. Other water inputs (e.g., groundwater, illicit connections) investigated 4. Contributing area verified If steps #1–4 do not solve the problem, imported bioretention soil is replaced and replanted.	

Bioretention Cells, Swales, and Planter Boxes					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Bioretention Soil (continued)	Protection of Soil	Maintenance requiring entrance into the BMP footprint.		Maintenance is performed without compacting bioretention soil media.	
Vegetation	Bottom Swale and Upland Slope Vegetation	Less than 75 percent of swale bottom is covered with healthy/surviving vegetation.		Plants are healthy and pest free. Cause of poor vegetation growth addressed. Bioretention area is replanted as necessary to obtain 75 percent survival rate or greater. Plant selection is appropriate for site growing conditions.	
Trees and Shrubs	Causing Problems for Operation of BMP	Large trees and shrubs interfere with operation of the basin or access for maintenance.		Trees and shrubs do not hinder BMP performance or maintenance activities. Prune or remove large trees and shrubs.	
	Dead Trees and Shrubs	Standing dead vegetation is present.		Trees and shrubs do not hinder BMP performance or maintenance activities. Dead vegetation is removed, and cause of dead vegetation is addressed. Specific plants with high mortality rate are replaced with more appropriate species.	
Trees and Shrubs Adjacent to Vehicle Travel Areas (or areas where visibility needs to be maintained)	Safety Issues	Vegetation causes some visibility (line of sight) or driver safety issues.		Appropriate height for sight clearance is maintained. Regular pruning maintains visual sight lines for safety or clearance along a walk or drive. Tree or shrub is removed or transplanted if presenting a continual safety hazard.	
Emergent Vegetation	Conveyance Blocked	Vegetation compromises conveyance.		Sedges and rushes are clear of dead foliage.	
Mulch	Lack of Mulch	Bare spots (without much cover) are present, or mulch covers less than 2 inches.		BMP has a maximum 3-inch layer of an appropriate type of mulch and mulch is kept away from woody stems.	
Vegetation	Accumulation of Clippings	Grass or other vegetation clippings accumulate to 2 inches or greater in depth.		Clippings removed.	
	Weeds	Weeds are present (unless on edge and providing erosion control).		Weed material removed and disposed of. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.	

Bioretention Cells, Swales, and Planter Boxes					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Noxious Weeds	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. *(Coordinate with Thurston County Health Department.)* Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. (Apply requirements of adopted integrated pest management policies for the use of herbicides.) *Complete eradication of noxious weeds may not be possible.*	
Excessive Vegetation	Adjacent BMPs Compromised	Low-lying vegetation growing beyond BMP edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil.		Vegetation does not impede function of adjacent BMPs or pose as safety hazard. Groundcovers and shrubs trimmed at BMP edge. Excessive leaf litter is removed.	
	Causes BMP to Not Function Properly	Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety.		Pruning and/or thinning vegetation maintains proper plant density and aesthetics. Plants that are weak, broken, or not true to form are removed or replaced in-kind. Appropriate plants are present.	
Irrigation (if any)	NA	Irrigation system present.		Manufacturer's instructions for O&M are met.	
Plant Watering	Plant Establishment	Plant establishment period (1–3 years).		Plants are watered as necessary during periods of no rain to ensure plant establishment.	
Summer Watering (after establishment)	Drought Period	Longer term period (3+ years).		Plants are watered as necessary during drought conditions and trees are watered up to 5 years after planting.	

Bioretention Cells, Swales, and Planter Boxes					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Spill Prevention and Response	Spill Prevention	Storage or use of potential contaminants in the vicinity of BMP.		Spill prevention measures are implemented whenever handling or storing potential contaminants.	
	Spill Response	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.		Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.)*	
Safety	Safety (slopes)	Erosion of sides causes slope to exceed 1:3 or otherwise becomes a hazard.		Actions taken to eliminate the hazard.	
	Safety (hydraulic structures)	Hydraulic structures (pipes, culverts, vaults, etc.) become a hazard to children playing in and around the BMP.		Actions taken to eliminate the hazard (such as covering and securing any openings).	
Aesthetics	Aesthetics	Damage/vandalism/debris accumulation.		BMP restored to original aesthetic conditions.	
	Edging	Grass is starting to encroach on swale.		Edging repaired.	
Pest Control	Pests: Insects/ Rodents	Pest of concern is present and impacting BMP function.		Pests removed and BMP returned to original functionality. Do not use pesticides or *Bacillus thuringiensis israelensis (Bti).*	
	Mosquitoes	Standing water remains in the basin for more than three days following storms.		All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present.	

1n. Rain Gardens

Rain gardens are shallow stormwater systems with compost amended soil or imported rain garden or bioretention soil and plants adapted to the local climate and soil moisture conditions. They are similar in function to bioretention cells, but have less onerous design requirements and are generally applicable to smaller sites.

Rain Gardens					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
BMP – General Requirements	Mosquitoes	Standing water remains for more than three days following storms.		All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present. Rain garden drains freely and there is no standing water between storms. Cause of the standing water is addressed (see “Ponded Water”).	
Footprint Area	Trash	Trash and debris present.		No trash or debris present. Remove and properly dispose of all trash and debris.	
	Debris Accumulation	Accumulated leaves in BMP.		No leaves clogging outlet structure or impeding water flow.	
Earthen Side Slopes and Berms	Erosion	Persistent soil erosion on slopes.		No eroded or scoured areas. Cause of erosion or scour is addressed.	
Rockery Sidewalls	Unstable Rockery	Rockery side walls are insecure.		Rockery sidewalls are stable (may require consultation with engineer, particularly for walls 4 feet or greater in height).	
Rain Garden Bottom Area	Sediment Accumulation	Visible sediment deposition in the rain garden that reduces drawdown time of water in the rain garden.		No sediment accumulation in rain garden, Source of sediment addressed.	
Mulch	Lack of Mulch	Bare spots (without mulch cover) are present or mulch depth less than 2 inches.		BMP has a minimum 2- to 3-inch layer of an appropriate type of mulch and is kept away from woody stems.	
Splashblock Inlet	Water Not Properly Directed to Rain Garden	Water is not being directed properly to the rain garden and away from the inlet structure. Water splashes adjacent buildings.		Blocks are reconfigured to direct water to rain garden and away from structure.	

Rain Gardens					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Pipe Inlet/ Outlet	Erosion	Rock or cobble is removed or missing, and concentrated flows are contacting soil.		No eroded or scoured areas. Cause of erosion or scour is addressed. Cover of rock or cobbles protects the ground where concentrated water flows into the rain garden from a pipe or swale.	
	Accumulated Debris	Accumulated leaves, sediment, debris or vegetation at curb cuts, inlet or outlet pipe.		Blockage is cleared.	
	Damaged Pipe	Pipe is damaged		Pipe is repaired/replaced.	
	Clogged Pipe	Pipe is clogged.		Pipe is clear of roots and debris.	
Access	Blocked Access	Maintain access for inspections.		Vegetation is cleared or transplanted within 1 foot of inlets and outlets.	
Ponded Water	Ponded Water	Excessive ponding water: Ponded water remains in the rain garden more than 48 hours after the end of a storm.		Rain garden drains freely and there is no standing water in the rain garden between storms. Leaf litter/debris/sediment is removed.	
Overflow	Blocked Overflow	Capacity reduced by sediment or debris.		No sediment or debris in overflow.	
Vegetation	Blocking Site Distances and Sidewalks	Vegetation inhibits sight distances and sidewalks.		Sidewalks and sight distances along roadways and sidewalks are kept clear.	
	Vegetation Blocking Pipes	Vegetation is crowding inlets and outlets.		Inlets and outlets in the rain garden are clear of vegetation.	
	Unhealthy Vegetation	Yellowing: possible Nitrogen (N) deficiency Poor growth: possible Phosphorous (P) deficiency. Poor flowering, spotting or curled leaves, or weak roots or stems: possible Potassium (K) deficiency.		Plants are healthy and appropriate for site conditions.	
	Weeds	Presence of weeds.		Weeds are removed (manual methods preferred) and mulch is applied.	
Summer Watering (years 1–3)	Plant Establishment	Tree, shrubs, and groundcovers in first 3 years of establishment period.		Plants are watered during plant establishment period (years 1–3).	

Rain Gardens					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Summer Watering (after establishment)	Drought Conditions	Vegetation requires supplemental water.		Plants are watered during drought conditions or more often if necessary during post-establishment period (after 3 years).	

1o. Trees

When designed in accordance with this manual, trees can provide flow control via interception, transpiration, and increased infiltration. Most routine maintenance procedures are typical landscape care activities.

Trees					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Tree	Excess or Unhealthy Growth	Health of tree at risk, or tree in conflict with other infrastructure.		Tree pruned according to industry standards to promote tree health and longevity.	
	NA	Young tree (i.e., within first 3 years).		Tree provided with supplemental irrigation and fertilization (as needed) during first three growing seasons.	
	NA	Evidence of pest activity affecting tree health.		Pest management activities implemented to reduce or eliminate pest activity, and to restore tree health.	
	Dead or Declining	Dead, damaged or declining.		Tree is replaced per planting plan or acceptable substitute.	

1p. Permeable Pavement

Permeable pavement is a stormwater infiltration BMP that is designed to accommodate pedestrian, bicycle, and auto traffic while allowing infiltration and storage of stormwater. Permeable pavement includes porous asphalt; pervious concrete; permeable pavers and aggregate pavers; and grid systems.

Permeable Pavement					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
All Pavement Types	Leaf and Debris Accumulation	Fallen leaves or debris.		Removed/disposed.	
	All Pavement Types	Sediment or debris accumulation between paver blocks, on surface of pavement, or in grid voids.		Sediment at surface does not inhibit infiltration. Remove/dispose of sediment.	
BMP – General Requirements	Unstable Adjacent Area	Runoff from adjacent pervious areas deposits soil, mulch, or sediment on paving.		No deposited soil or other materials on permeable pavement or other adjacent surfacing. All exposed soils that may erode to pavement surface mulched and/or planted.	
	Wearing Course Covered by Adjacent Vegetation	Vegetation growing beyond BMP edge onto sidewalks, paths, and street edge.		Vegetation does not impede function of adjacent BMPs or pose as safety hazard. Groundcovers and shrubs trimmed to avoid overreaching the sidewalks, paths and street edge.	
Porous Asphalt or Pervious Cement Concrete	NA	None. Maintenance to prevent clogging with fine sediment.		Conventional street sweepers equipped with vacuums, water, and brushes or pressure washer used to restore permeability. Vacuum or pressure wash the pavement two to three times annually.	
	NA	None. Maintenance to prevent clogging with fine sediment.		Use of sand and sealant application prohibited. Protect from construction runoff.	
	Cracks	Major cracks or trip hazards.		Potholes or small cracks filled with patching mixes. Large cracks and settlement addressed by cutting and replacing the pavement section.	
	NA	Utility cuts.		Any damage or change due to utility cuts replaced in kind.	
Interlocking Concrete Paver Blocks	Missing or Damaged Paver Block	Interlocking paver block missing or damaged.		Individual damaged paver blocks removed and replaced or repaired per manufacturer's recommendations.	

Permeable Pavement					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Interlocking Concrete Paver Blocks (continued)	Settlement	Settlement of surface. When deviation from original grade impedes function.		Original grade re-established. May require resetting.	
	Void Material is Missing or Low	Loss of aggregate material between paver blocks.		Refill per manufacturer's recommendations.	
Open-Celled Paving Grid with Gravel	Loss of Aggregate Material in Paving Grid	Loss of aggregate material in grid.		Aggregate gravel level maintained at the same level as the plastic rings or no more than 0.25 inch above the top of rings. Refill per manufacturer's recommendations.	
Open-Celled Paving Grid with Grass	Lack of Grass Coverage	Loss of soil and/or grass material in grid.		Refill and/or replant per manufacturer's recommendations. Growing medium restored, BMP aerated and reseeded or planted, and vegetated area amended as needed.	
Inlet/Outlet Pipe	Pipe is Damaged	Pipe is damaged.		Pipe is repaired/replaced.	
	Pipe is Clogged	Pipe is clogged.		Roots or debris is removed.	
	Erosion	Native soil exposed or other signs of erosion damage present.		No eroded or scoured areas Cause of erosion or scour is addressed.	
Underdrain Pipe	Blocked Underdrain	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period).		Underdrains and orifice free of sediment and debris. Jet clean or rotary cut debris/roots from underdrain(s). If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.	
Spill Prevention and Response	NA	Storage or use of potential contaminants in the vicinity of BMP.		Spill prevention measures exercised whenever handling or storing potential contaminants.	

Permeable Pavement					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Spill Prevention and Response (continued)	Release of Pollutants	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.		Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. *(Coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.)*	

1q. Vegetated Roofs

Vegetated roofs are areas of living vegetation installed on top of buildings, or other above-grade impervious surfaces. Design components vary depending on the vegetated roof type and site constraints, but may include a waterproofing material, a root barrier, a drainage layer, a separation fabric, a growth medium (soil), and vegetation.

Vegetated Roofs					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Soil/ Growth Medium	Water is Not Infiltrating Properly	Water does not permeate growth media (runs off soil surface).		BMP infiltrates as designed. Aerate or replace media until stormwater infiltrates freely through growth media.	
	Water is Not Infiltrating Properly	Growth medium thickness is less than design thickness (due to erosion and plant uptake).		BMP infiltrates as designed. Supplement growth medium to design thickness.	
	Water is Not Infiltrating Properly	Fallen leaves or debris are present.		No leaves or debris present.	
	Erosion/ Scouring	Areas of potential erosion are visible.		Steps taken to repair or prevent erosion. Fill, hand tamp, or lightly compact, and stabilize with additional soil substrate/growth medium and additional plants.	
Erosion Control Measures	Erosion/ Scouring	Mat or other erosion control is damaged or depleted during plant establishment period.		Erosion control measures repaired/replaced until 90 percent vegetation coverage attained. Avoid application of mulch on extensive vegetated roofs.	
System Structural Components	Deteriorating Flashing, Gravel Stops, Utilities, or Other Structures on Roof	Flashing, utilities or other structures on roof are deteriorating (can serve as source of metal pollution in vegetated roof runoff).		Structural components inspected for deterioration or failure. Repair/replace as necessary.	
Roof Drain	Sediment, Vegetation, or Debris Accumulation	Sediment, vegetation, or debris blocks 20 percent or more of inlet structure.		Blockages cleared. Problems that led to blockage identified and corrected.	
	Damaged Inlet Pipe	Inlet pipe is in poor condition.		Repaired/replaced.	
	Clogged Inlet Pipe	Pipe is clogged.		Roots or debris removed.	

Vegetated Roofs					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Vegetation	Plant Coverage	Healthy vegetative coverage falls below 90 percent (unless design specifications stipulate less than 90 percent coverage).		Bare areas planted with vegetation If necessary, install erosion control measures until percent coverage goal is attained.	
Vegetation (sedums)	NA	Extensive roof with low density sedum population.		Sedums are mulch mowed, creating cuttings from existing plants to encourage colonization.	
Vegetation	Poisonous Vegetation and Noxious Weeds	Any poisonous or nuisance vegetation which may constitute a hazard to the public. Any evidence of noxious weeds as defined in the Thurston County Noxious Weeds List.		Eliminate danger of poisonous vegetation where maintenance personnel or the public might normally be. Completely remove invasive, noxious, or nonnative vegetation in accordance with applicable regulations. *(Coordinate with Thurston County Health Department.)*. Do not spray chemicals on vegetation without guidance or City approval. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality. *(Coordinate with Thurston County Health Department.) Complete eradication of noxious weeds may not be possible.*	
	Presence of Weeds	Weeds are present.		Weed material removed and disposed of, with roots manually removed with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate. It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality.	

Vegetated Roofs					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Vegetation (extensive vegetated roof)	Under Fertilization	Poor plant establishment and possible nutrient deficiency in growth medium.		Organic debris allowed to replenish and maintain long-term nutrient balance and growth medium structure. Conduct annual soil test 2 to 3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Minimum amount slow-release fertilizer necessary to achieve successful plant establishment is applied. Apply fertilizer only after acquiring required approval from BMP owner and operator. Note that extensive vegetated roofs are designed to require zero to minimal fertilization after establishment (excess fertilization can contribute to nutrient export).	
Vegetation (intensive vegetated roof)	Under Fertilization	Fertilization may be necessary during establishment period or for plant health and survivability after establishment.		Annual soil test conducted 2 to 3 weeks prior to the spring growth flush to assess need for fertilizer. Utilize test results to adjust fertilizer type and quantity appropriately. Apply minimum amount slow-release fertilizer necessary to achieve successful plant establishment. Apply fertilizer only after acquiring required approval from BMP owner and operator. Intensive vegetated roofs may require more fertilization than extensive vegetated roofs.	
Vegetation (trees and shrubs on an intensive vegetated roof)	NA	Pruning as needed.		All pruning of mature trees performed by or under the direct guidance of an ISA certified arborist.	
Irrigation system (if any)	NA	Irrigation system is not working, or routine maintenance is needed.		Manufacturer’s instructions for O&M have been followed.	

Vegetated Roofs					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Vegetation (extensive vegetated roof)	NA	Summer watering – Plant establishment period (1 to 2 years).		Watered weekly during periods of no rain to ensure plant establishment (30 to 50 gallons per 100 square feet).	
	NA	Summer watering – Longer term period (2+ years).		Watered during drought conditions or more often if necessary to maintain plant cover (30 to 50 gallons per 100 square feet).	
	NA	Plant establishment period (1 to 2 years).		Watered deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist. Use soaker hoses or spot water with a shower type wand when irrigation system not present.	
Vegetation (intensive vegetated roof)	NA	Longer term period (2+ years).		Watered during drought conditions or more often if necessary to maintain plant cover.	
Spill Prevention and Response	NA	Storage or use of potential contaminants in the vicinity of BMP.		Spill prevention measures exercised whenever handling or storing potential contaminants.	
	Release of Pollutants	Any evidence of contaminants such as oil, gasoline, concrete slurries, paint, etc.		Spills are cleaned up as soon as possible to prevent contamination of stormwater. No contaminants or pollutants present. (Coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.)	
Training and Documentation	NA	Training/written guidance is required for proper O&M.		Property owners and tenants provided with proper training and a copy of the Maintenance and Source Control Manual.	
Safety	NA	Insufficient egress/ingress routes and fall protection.		Egress and ingress routes maintained to design standards and fire codes. Ensure appropriate fall protection.	
Aesthetics	Poor Aesthetics	Damage/vandalism/debris accumulation.		BMP restored to original aesthetic conditions.	

Vegetated Roofs					
Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
Pest Control	Mosquitoes	Standing water remains for more than three days following storms.		Standing water removed. Cause of the standing water identified, and appropriate actions taken to address the problem (e.g., aerate or replace medium, unplug drainage).	

1r. Downspout, Sheet Flow, Concentrated Flow Dispersion

Dispersion BMP components vary depending on the type of BMP used, but can consistent of a gravel filled trench, splashblock, transition zone, vegetated flow path, berms, and/or slotted drains. Dispersion BMPs reduce peak flows by slowing stormwater runoff entering into the conveyance system, allowing for some infiltration, and providing some water quality benefits.

Downspout, Sheet Flow, Concentrated Flow Dispersion					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Splashblock	Water Directed Toward Building	Water is being directed towards building structure.		Water directed away from building structure.	
	Water Causing Erosion	Water disrupts soil media.		Blocks are reconfigured/repaired, and media is restored.	
Transition Zone	Erosion	Adjacent soil erosion; uneven surface creating concentrated flow discharge; or less than 2 feet of width.		No eroded or scoured areas. Cause of erosion or scour is addressed.	
Dispersion Trench	Concentrated Flow	Visual evidence of water discharging at concentrated points along trench (normal condition is a “sheet flow” from edge of trench; intent is to prevent erosion damage).		No debris on trench surface. Notched grade board or other distributor type is aligned to prevent erosion. Trench is rebuilt to standards, if necessary.	
Surface of Trench	Accumulated Debris	Accumulated trash, debris, or sediment on drain rock surface impedes sheet flow from BMP.		No trash or debris present. Removed and properly dispose of all trash and debris.	
	Vegetation Impeding Flow	Vegetation/moss present on drain rock surface impedes sheet flow from BMP.		Freely draining drain rock surface.	
Pipe(s) to Trench	Accumulated Debris in Drains	Accumulation of trash, debris, or sediment in roof drains, gutters, driveway drains, area drains, etc.		No trash or debris in roof drains, gutters, driveway drains, or area drains.	
	Accumulated Debris in Inlet Pipe	Pipe from sump to trench or drywell has accumulated sediment or is plugged.		No sediment or debris in inlet/outlet pipe screen or inlet/outlet pipe.	
	Damaged Pipes	Cracked, collapsed, broken, or misaligned drain pipes.		No cracks more than 0.25-inch wide at the joint of the inlet/outlet pipe.	
Sump	Accumulated Sediment	Sediment in the sump.		Sump contains no sediment.	

Downspout, Sheet Flow, Concentrated Flow Dispersion					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Access Lid	Hard to Open	Cannot be easily opened.		Access lid is repaired or replaced.	
	Buried	Buried.		Access lid functions as designed (refer to record drawings for design intent).	
	Missing Cover	Cover missing.		Cover is replaced.	
Rock Pad	Inadequate Rock Cover	Only one layer of rock exists above native soil in area 6 square feet or larger, or any exposure of native soil.		Rock pad is repaired/replaced to meet design standards.	
	Erosion	Soil erosion in or adjacent to rock pad.		Rock pad is repaired/replaced to meet design standards.	
Dispersal Area	Erosion	Erosion (gullies/rills) greater than 2 inches deep in dispersal area.		No eroded or scoured areas. Cause of erosion or scour is addressed.	
	Accumulated Sediment	Accumulated sediment or debris to extent that blocks or channelizes flow path.		No excess sediment or debris in dispersal area. Sediment source is addressed (if feasible).	
Ponded Water	Ponded Water	Standing surface water in dispersion area remains for more than 3 days after the end of a storm event.		System freely drains and there is no standing water in dispersion area between storms. The cause of the standing water (e.g., grade depressions, compacted soil) is addressed.	
Vegetation	Plant Survival	Dispersal area vegetation in establishment period (1 to 2 years, or additional 3rd year) during extreme dry weather).		Vegetation is healthy and watered weekly during periods of no rain to ensure plant establishment.	
	Lack of Vegetation Allowing Erosion	Poor vegetation cover such that erosion is occurring.		Vegetation is healthy and watered. No eroded or scoured areas are present. Cause of erosion or scour is addressed. Plant species are appropriate for the soil and moisture conditions.	
	Vegetation Blocking Flow	Vegetation inhibits dispersed flow along flow path.		Vegetation is trimmed, weeded, or replanted to restore dispersed flow path.	
	Presence of Noxious Weeds	Any noxious or nuisance vegetation which may constitute a hazard to county personnel or the public.		Noxious and nuisance vegetation removed according to applicable regulations. No danger of noxious vegetation where county personnel or the public might normally be.	

Downspout, Sheet Flow, Concentrated Flow Dispersion					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Pest Control	Mosquito Infestation	Standing water remains for more than three days following storms.		All inlets, overflows and other openings are protected with mosquito screens. No mosquito infestation present.	
Rodents	Presence of Rodents	Rodent holes or mounds disturb dispersion flow paths.		Rodents removed; holes are filled; and flow path is revegetated.	

1s. Downspout Infiltration

Downspout infiltration systems are trench or drywell designs intended only for use in infiltrating runoff from roof downspout drains.

Downspout Infiltration					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Rock Trench/Well	Inflow Disruption	Accumulated trash, debris, or sediment on drain rock surface impeding sheet flow into BMP.		Sheet flow re-established. Material removed and disposed of in accordance with applicable solid waste requirements.	
	Inflow Disruption	Vegetation/moss present on drain rock surface impeding sheet flow into BMP.		Material removed and sheet flow re-established.	
	Inflow Disruption	Water ponding at surface, or standing water in subgrade observation port.		Inflow to BMP is consistent, and no ponding is observed. Inlet piping is clear and/or rock or sand reservoirs have been replaced.	
Inlet/Outlet Pipe Conveyance	Conveyance Blockage	Accumulation of trash, debris, or sediment in roof drains, gutters, driveways drains, area drains, etc.		Conveyance systems are clear of debris and free-flowing.	
	Conveyance Blockage	Pipes to or from sump, trench, or drywell have accumulated sediment or is plugged.		Pipe systems are clear of debris and free-flowing.	
	Conveyance Damage	Pipes to or from sump, trench, or drywell is cracked, broken, or misaligned.		Pipe systems are undamaged and free-flowing.	
Roof Downspout	Splash Pad Malfunction	Splash pad missing or damaged.		Splash pad installed and functioning correctly	
	Overflow	Water overflows from the gutter or downspout during rain.		First try cleaning out the gutter and downspouts. If this doesn't solve the problem, a larger drywell may be needed. Contact the City before changing the design or upgrading to a larger drywell.	
Storage Sump	Sediment in Sump	Excess sediment accumulate in sump.		Material removed and disposed of in accordance with applicable solid waste requirements.	
	Access Lid Problems	Access lid cannot be opened or is missing.		Access lid is functioning as designed. Refer to record drawings to confirm type, function, and required components.	

Downspout Infiltration					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Roof	Moss	Moss and algae are taking over the shadier parts of the shingles.		Disconnect the flexible part of the downspout that leads to the drywell. Then perform moss removal as desired. Use baking soda instead of highly toxic pesticides or chlorine bleach.	

1t. Cisterns

Cisterns are designed to collect stormwater runoff from non-polluting surfaces (typically roofs), and to make use of the collected water. Reuse of the runoff can be for irrigation, potable, and non-potable uses, but requires different levels of storage and runoff treatment depending on the intended use.

Cisterns					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Roof/Gutter	Debris Accumulation in Cistern	Debris has accumulated.		No debris in cistern. Remove and properly dispose of all debris.	
	Debris Accumulation in Gutter	Debris has accumulated.		No debris in cistern or gutters. Remove and properly dispose of all debris.	
Screens at the Top of Downspout and Cistern Inlet	Debris Accumulation in Cistern	Screen has deteriorated.		Screen is in place and functions as designed.	
	NA	None. Preventive maintenance.		No debris in cistern or accumulated on screen. Remove and properly dispose of all debris.	
Low Flow Orifice	Cistern Overflows are too Frequent	Debris or other obstruction of orifice.		Low flow orifice is clean.	
Overflow Pipe	Overflow Pipe	Pipe is damaged.		Overflow pipe is watertight and does not leak. Repair/replace.	
	Overflow Pipe	Pipe is clogged.		Debris removed. Overflow pipe can convey overflow to point of discharge.	
Cistern	Accumulated Debris And/or Sediment	More than 6 inches of accumulation in bottom of cistern.		Accumulated debris and/or sediment removed.	
Training and Documentation	NA	Training/written guidance is required for proper O&M.		Property owners and tenants are provided with proper training and a copy of the Maintenance and Source Control Manual.	
Access and Safety	NA	Access to cistern required for maintenance or cleaning.		Any opening that could allow the entry of people is marked: “DANGER—CONFINED SPACE”.	
Pest Control	Mosquito Infestation	Standing water remains for more than 3 days following storms.		All inlets, overflows, and other openings are protected with mosquito screens. No mosquito infestation present.	

1u. Fencing/Shrubbery Screen/Other Landscaping

Fencing, shrubbery screening, and landscaping provide flow control via interception, transpiration, and increased infiltration as well as slope protection. Most routine maintenance procedures are typical landscape care activities.

Fencing/Shrubbery Screen/Other Landscaping					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Missing or Broken Parts/Dead Shrubbery	Any defect in the fence or screen that permits easy entry to a BMP.		Fence is mended or shrubs replaced to form a solid barrier to entry.	
	Erosion	Erosion has resulted in an opening under a fence that allows entry by people or pets.		Soil under fence replaced so that no opening exceeds 4 inches in height.	
	Unruly Vegetation	Shrubbery is growing out of control or is infested with weeds. See also Thurston County Noxious Weeds List.		Shrubbery is trimmed and weeded to provide appealing aesthetics. Do not use chemicals to control weeds.	
Fences	Damaged Parts	Posts out of plumb more than 6 inches.		Posts plumb to within 1.5 inches of plumb.	
		Top rails bent more than 6 inches.		Top rail free of bends greater than 1 inch.	
		Any part of fence (including posts, top rails, and fabric) more than 1 foot out of design alignment.		Fence is aligned and meets design standards.	
		Missing or loose tension wire.		Tension wire in place and holding fabric.	
		Missing or loose barbed wire that is sagging more than 2.5 inches between posts.		Barbed wire in place with less than 0.75-inch sag between posts.	
		Extension arm missing, broken, or bent out of shape more than 1.5 inches.		Extension arm in place with no bends larger than 0.75 inch.	
	Deteriorated Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.		Structurally adequate posts or parts with a uniform protective coating.	
	Openings in Fabric	Openings in fabric are such that an 8-inch-diameter ball could fit through.		No openings in fabric.	

1v. Manufactured Media Filters

Manufactured media filters are installed below grade and usually consist of a two-chambered vault that include a presettling basin and a filter bed with sand or filter media. This filter is accessed through a manhole. DO NOT ENTER ANY TANK OR VAULT without proper training, certification and equipment.

Manufactured Media Filters					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Media Filter Vault	Sediment Accumulation on Top of Filter Cartridges	Sediment accumulation exceeds 0.25 inches on top of cartridges.		No sediment deposits on top of cartridges. Sediment on cartridges likely indicates that cartridges are plugged and require maintenance.	
	Sediment Accumulation	Sediment accumulation in vault exceeds 6 inches. Look for other indicators of clogged cartridges or overflow.		No sediment accumulation in vault. *Sediment in vault should be removed. Cartridges should be checked and replaced or serviced as needed.*	
	Trash and Floatable Debris Accumulation	Trash and floatable debris accumulation in vault.		No trash or other floatable debris in filter vault.	
	Filter Cartridges Submerged	Filter vault does not drain within 24 hours following storm. Look for evidence of submergence due to backwater or excessive hydrocarbon loading.		Filter media checked and replaced if needed. *If cartridges are plugged with oil additional treatment or source control BMP may be needed.*	
Forebay	Sediment Accumulation	Sediment accumulation exceeds 6 inches or 33 percent (one third) of the available sump.		Sediment accumulation less than 6 inches.	
	Trash and Floatable Debris Accumulation	Trash and/or floatable debris accumulation.		No trash or other floatable debris accumulation in forebay. Trash and/or floatable debris should be removed during inspections. *Significant oil accumulation may indicate the need for additional treatment or source control.*	
Drain Pipes/ Cleanouts	Sediment in Drain Pipes/ Cleanouts	Accumulated sediment that exceeds 20 percent of the diameter.		No sediment or debris in drainpipes or cleanouts. Sediment and debris removed.	
Belowground Vault	Access Cover Damaged/ Not working	One maintenance person cannot remove lid after applying 80 pounds of lift, corrosion of deformation of cover.		Cover repaired to proper working specifications or replaced.	

Manufactured Media Filters					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Belowground Vault (continued)	Damaged Pipes	Any part of the pipes are crushed or damaged due to corrosion and/or settlement.		Pipe repaired or replaced.	
	Vault Structure has Cracks in Wall, Bottom, and Damage to Frame and/or Top Slab	Cracks wider than 0.5 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 repaired or replaced so that vaults meets design specifications and is structurally sound.	
		Cracks wider than 0.5 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 0.25 inch at the joint of 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 design specifications.	
	Ladder Rungs Unsafe	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.		Ladder meets design standards and allows maintenance persons safe access.	
Belowground Cartridge Type	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.	

Designers must also review the most current manufacturer guidelines for any updates or additions to the following operation and maintenance requirements.

1w. Proprietary or Manufactured Products

As with other stormwater BMPs in this appendix, proper maintenance of proprietary products such as media filters or vegetation-based treatment technologies is critical to proper BMP performance. Regular maintenance ensures proper functioning and keeps the BMP aesthetically appealing. Many of the same inspection and maintenance procedures outlined for the BMPs described in this appendix also apply to proprietary technologies.

Designers must review and apply the most current manufacturer guidelines and recommendations for BMP operation and maintenance.

The City will inspect proprietary products in accordance with the applicable inspection standards to ensure that maintenance is performed properly.

Appendix 10B – Maintenance Standards Checklists for Group 2: Structures and Pretreatment

2a. Control Structures and Flow Restrictors

Flow control devices are usually placed within manholes, which may be locked. They typically consist of two pipes, one placed above the other. The lower pipe will typically have a cover and a small hole drilled in it to allow for slow release of water. The upper pipe is usually larger to provide an outlet for higher flows and emergency overflows.

Control Structures and Flow Restrictors					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Structure	Trash and Debris (includes sediment)	Material exceeds 25 percent of sump depth or 1 foot below orifice plate.		No trash or debris present. Control structure orifice is not blocked. Remove and properly dispose of all trash and debris.	
	Structural Damage	Structure is not securely attached to manhole wall.		Securely attach structure to wall and outlet pipe.	
		Structure is not in upright position (more than 10 percent from plumb)		Restore structure to correct position.	
		Connections to outlet pipe are not watertight and show signs of rust.		Pipe connections are water tight; structure repaired or replaced and works as designed.	
		Any holes in structure (other than designed holes).		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 percent 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, displaced, or bent orifice plate.		Plate is in place and works as designed.	
	Obstructions	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.	

Control Structures and Flow Restrictors					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.		Manhole access cover/lid is in place and secure.	
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 0.5 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	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.		Ladder meets design standards and allows maintenance persons safe access.	
Catch Basin	See “Catch Basins”	See “Catch Basins.”		See “Catch Basins.”	

2b. Catch Basins

These structures are typically located in the streets. The City is responsible for routine maintenance of the pipes and structures in the public rights-of-way, while the property owner or homeowners association is responsible for maintenance of pipes and catch basins in private areas and for keeping the grates clear of debris in all areas.

Catch Basins					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Trash and Debris	Trash, leaves or debris which is located immediately in front of the catch basin opening or is blocking inflow capacity of the basin by more than 10 percent.		Remove trash, leaves and debris located directly in front of catch basin or on grate.	
		Trash or debris (in basin) that exceeds 60 percent of the sump depth as measured from 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 of clearance from the debris surface to the invert of the lowest pipe.		No trash or debris present. Remove and properly dispose of all trash and debris.	
		Trash or debris in any inlet or outlet pipe blocking more than 33 percent (one-third) of its height.		Inlet and outlet pipes free of trash or debris. Remove and properly dispose of all trash and debris.	
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).		Remove dead animals, etc., present within the catch basin.	
	Sediment	Sediment (in basin) exceeds 60 percent of sump depth as measured from the bottom of basin to invert of lowest pipe into or out of basin, but in no case less than a minimum of 6 inches of clearance from the sediment surface to the invert of 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 0.25 inch (intent is to make sure no material is running into basin).		Top slab is free of holes and cracks.	

Catch Basins					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General (continued)	Structure Damage to Frame and/or Top Slab (continued)	Frame not sitting flush on top slab, i.e., separation of more than 0.75 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 determines structure is unsound.		Basin replaced or repaired to design standard	
		Grout fillet has separated or cracked wider than 0.5 inch and longer than 1 foot at the joint of any inlet/outlet pipe, or any evidence of soil entering basin.		Pipe regrouted and secure at basin wall.	
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.		Replaced or repair to design standards.	
	Vegetation	Vegetation growing across and blocking more than 10 percent of the basin opening.		Remove vegetation blocking opening to basin.	
		Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.		No vegetation or root growth present.	
	Contamination and Pollution	Presence of contaminants such as oil, gasoline, concrete slurries, paint, obnoxious color, odor, or sludge.		Locate the source of the pollution and remove contaminants or pollutants present. *Report and coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.*	
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 in place and secured.	
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 0.5 inch of thread.		Mechanism opens with proper tools.	

Catch Basins					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Catch Basin Cover (continued)	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	Maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks. Ladder must be fixed or secured immediately.		Ladder meets design standards and allows maintenance persons safe access.	
Metal Grates (if applicable)	Grate Opening Unsafe	Grate with opening wider than 0.875 (7/8) inch.		Grate opening meets design standards.	
	Trash and Debris	Trash and debris that is blocking more than 20 percent of grate surface inletting capacity.		Grate free of trash and debris. Remove and properly dispose of all trash and debris.	
	Damaged or Missing	Grate missing or broken member(s) of the grate.		Grate is in place and meets design standards.	

2c. Debris Barriers (trash racks)

A metallic screen or similar structural device used to prevent debris from entering a pipe, spillway or other hydraulic structure.

Debris Barriers (trash racks)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Trash and Debris	Trash or debris that is plugging more than 20 percent of the openings in the barrier.		Barrier cleared to receive 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 0.75 inch.	
		Bars are missing or entire barrier missing.		Bars in place according to design.	
		Bars are loose and rust is causing 50 percent 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.	

2d. Energy Dissipators

Typically a rock splash pad at a pipe end or other discharge location, to reduce the velocity and energy of flowing water and prevent erosion. Other means of energy dissipation include drop manholes, stilling basins, and check dams.

Energy Dissipators					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
External					
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area 5 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 percent of the design depth.		Pipe cleaned/flushed so 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. Water discharges from feature by sheet flow.	
	Perforations Plugged	Over half of perforations in pipe are plugged with debris and sediment.		Perforated pipe cleaned or replaced. Perforations freely discharge flow.	
	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.		BMP rebuilt or redesigned to standards. No flow discharges from distributor catch basin.	
	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 50 percent of original size or any concentrated worn spot exceeding 1 square foot, which would make structure unsound.		Structure replaced to design standards. Structure in no danger of failing.	

Energy Dissipators					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Manhole/ Chamber (continued)	Trash and Debris	Trash or debris (in basin) that exceeds 60 percent of the sump depth as measured from 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-inch clearance from the debris surface to the invert of the lowest pipe.		No trash or debris present. Remove and properly dispose of all trash and debris.	
		Trash or debris in any inlet or outlet pipe blocking more than 33 percent of its height.		Inlet and outlet pipes free of trash or debris. Remove and properly dispose of all trash and debris.	
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).		Remove dead animals, etc., present within the catch basin.	
	Sediment	Sediment (in basin) exceeds 60 percent of sump depth as measured from the bottom of basin to invert of lowest pipe into or out of basin, but in no case less than a minimum of 6-inch clearance from the sediment surface to the invert of 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 0.25 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 0.75 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 determines structure is unsound.		Basin replaced or repaired to design standard	
		Grout fillet has separated or cracked wider than 0.5 inch and longer than 1 foot at the joint of any inlet/outlet pipe, or any evidence of soil entering basin.		Pipe regrouted and secure at basin wall.	
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.		Replaced or repair to design standards.	

Energy Dissipators					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Manhole/ Chamber (continued)	Contamination and Pollution	Presence of contaminants such as oil, gasoline, concrete slurries, paint, obnoxious color, odor, or sludge.		Locate the source of the pollution and remove contaminants or pollutants present. *Report and coordinate source control, removal, and/or cleanup with City of Lacey Spill Response Team (360) 491-5644, Moderate Risk Waste Program at Thurston County Environmental Health (360) 754–4111, and/or Dept. of Ecology Spill Response (800) 424-8802.*	
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 in place and secured.	
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 0.5 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.	

2e. Baffle Oil/Water Separators (API type)

An underground vault or tank designed to separate oil from runoff water via baffles.

Baffle Oil/Water Separators (API type)					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Dirty Discharge Water	Inspect discharge water for obvious signs of poor water quality.		Effluent discharge from vault should be clear without thick visible sheen.	
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6 inches in depth.		Remove sediment deposits 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.		No trash or debris present. Remove and properly dispose of all trash and debris from vault and inlet/outlet piping.	
	Oil Accumulation	Oil accumulations at the surface of the water or 6 inches of sludge in the sump.		Extract oil from vault by Vactoring. Disposal must be in accordance with state and local rules and regulations. No visible oil depth on water.	
Structure	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 – Cracks in Walls or Bottom, Damage to Frame and/or Top Slab	Maintenance person determines structure is unsound.		Vault replaced or repairs made so that vault meets design specifications and is structurally sound.	
		Grout fillet has separated or cracked wider than 0.5 inch at the joint of any inlet/outlet pipe, or any evidence of soil entering basin.		Top slab is free of holes and cracks.	
	Baffles	Baffles corroding, cracking, warping and/or show signs of failure as determined by maintenance/inspection person.		Baffles repaired or replaced to specifications.	
	Access Ladder Damaged	Ladder is corroded or deteriorated, not securely attached to structure wall, missing rungs, cracks, or misaligned.		Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection.	

An oil/water separator vault is a confined space. Visual inspections should be performed aboveground. If entry is required, it should be performed by qualified personnel.

2f. Coalescing Plate Oil/Water Separators

An underground vault or tank designed to separate oil from runoff water via gravity.

Coalescing Plate Oil/Water Separators					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
General	Dirty Discharge Water	Inspect 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.		Remove sediment deposits on vault bottom and plate media that would impede flow through the vault and reduce separation efficiency.	
	Trash and Debris	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.		No trash or debris present. Remove and properly dispose of all trash and debris from vault and inlet/outlet piping.	
	Oil Accumulation	Oil accumulation at the water surface.		Oil is extracted from vault using Vactoring methods. Dispose of in accordance with state and local rules and regulations. Coalescing plates are cleaned by thoroughly rinsing and flushing. Direct wash-down effluent to the sanitary sewer system where permitted. There should be no visible oil depth on water.	
Structure	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 or 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. Damage to Frame and/or Top Slab	Cracks wider than 0.5 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.	

Coalescing Plate Oil/Water Separators					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Structure (continued)	Vault Structure Damage – Includes Cracks. Damage to Frame and/or Top Slab	Cracks wider than 0.5 inch at the joint of any inlet/outlet pipe or soil particles entering through the cracks.		Vault repaired so that no cracks exist wider than 0.25 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.		Replace or repair ladder so it meets specifications and is safe to use as determined by inspection.	

2g. Catch Basin Inserts

A structure within a catch basin, with a filter containing a pollutant-removal medium. Generally considered as an alternative to oil-water separators, these are not commonly used for permanent installations, as they tend to be maintenance-intensive.

Catch Basin Inserts					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
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.		No trash or debris present. Runoff freely flows into catch basin. Remove and properly dispose of all trash and debris removed from insert unit.	
	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.	

Appendix 10C – Maintenance Standards Checklists for Group 3: Miscellaneous BMPs and Features

3a. Conveyance Pipes, Culverts, Ditches, and Swales

These features contain and direct the flow of water from one location to another.

Conveyance Pipes, Culverts, Ditches, and Swales					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Pipes	Sediment, Debris, and Vegetation	Accumulated sediment should not exceed 20 percent of the diameter of the pipe. Vegetation should not reduce free movement of water through pipes. Ensure that the protective coating is not damaged or rusted. Dents should not significantly impede flow. Pipe should not have major cracks or flaws allowing water to leak out.		Clean out pipes of all sediment and debris. Remove all vegetation so that water flows freely through pipes. Repair or replace pipe.	
Open Ditches	Trash and Debris	There should not be any yard waste or litter in the ditch.		No trash or debris present. Remove and properly dispose of all trash and debris.	
	Sediment Buildup	Accumulated sediment should not exceed 20 percent of the depth of the ditch.		Clean out ditch of all sediment and debris.	
Open Ditches and Swales	Overgrowth of Vegetation	Check for vegetation (e.g., weedy shrubs or saplings) that reduces the free movement of water through ditches or swales.		Clear blocking vegetation so that water moves freely through the ditches. Grassy vegetation should be left alone.	
	Erosion	Check around inlets and outlets for signs of erosion. Check slopes for signs of sloughing or settling. Action is needed where eroded damage is over 2 inches deep and where there is potential for continued erosion.		Eliminate causes of erosion. Stabilize slopes by using the appropriate erosion control procedure (e.g., compact the soil, plant grass, reinforce with rock).	
	Missing Rocks	Native soil beneath the rock splash pad, check dam, or lining should not be visible.		Replace rocks to design standard.	
Swales	Vegetation	Grass cover is sparse and weedy, or areas are overgrown with woody vegetation.		Aerate soils and re-seed and mulch bare areas. Keep grass less than 8 inches high. Remove woody growth, re-contour and re-seed as necessary.	

Conveyance Pipes, Culverts, Ditches, and Swales					
Drainage System Feature	**Problem or Defect**	**Conditions To Check For**	**√ Check**	**What To Do for Desired Condition**	**√ Done**
Swales (continued)	Homeowner Conversion	Swale has been filled in or blocked by shed, woodpile, shrubbery, etc.		Speak with the homeowner and request that the swale area be restored. Contact the City to report the problem if not rectified voluntarily.	
	Swale Does Not Drain	Water stands in the swale, or flow velocity is very slow. Stagnation occurs.		A survey may be needed to check grades. Grades should be in 1 to 5 percent range if possible. If grade is less than 1 percent, underdrains may need to be installed.	

3b. Access Roads and Easements

These features provide access to stormwater BMPs for inspection and/or maintenance.

Access Roads and Easements					
Drainage System Feature	Problem or Defect	Conditions To Check For	√ Check	What To Do for Desired Condition	√ Done
General	Access	Check to determine if there is adequate access to your stormwater BMPs for maintenance vehicles.		If there is not adequate access, check with the City to determine whether an easement exists. If so, a maintenance road may need to be constructed there.	
Access Road	Blocked Roadway	Debris that could damage vehicle tires (glass or metal).		Clear all potentially damaging material.	
	Blocked Roadway	Any obstructions that reduce clearance above and along the road to less than the required width (minimum of 15 feet).		Clear above and along roadway so there is enough clearance.	
Road Surface	Bad Road Conditions	Check for potholes, ruts, mushy spots, or woody debris that limits access by maintenance vehicles.		Add gravel or remove wood as necessary.	
Shoulders and Ditches	Erosion	Check for erosion along roadway.		Repair erosion with additional soil or gravel.	

Appendix 10D – Inspection and Maintenance Annual Reporting Forms

STORMWATER FACILITIES INSPECTION & MAINTENANCE ANNUAL REPORTING FORM for COMMERCIAL BUSINESSES

Name of Business ______________________ Date Form Completed ______________

Main Streets where Stormwater Facilities are Located ______________________

Name of Person Completing this Form ______________________ Title (such as Owner, Property Manager, etc.) ______________________

Contact Phone Number ______________________ Email Address (please print clearly) ______________________

Instructions for completing this form:

1. Identify your business' stormwater facilities and inventory them in Part 1 below.
   Use your site plan or the descriptions in the Stormwater Facilities Maintenance Guide, available online at **www.ci.lacey.wa.us/PSF**
2. Inspect your facilities and check for any damage or other potential problems.
   Refer to the appropriate checklists in the Stormwater Facilities Maintenance Guide.
3. Maintain your facilities as needed, as described in the Maintenance Guide.
   Do it yourself or with others, form a work party, or hire a qualified contractor.
4. Summarize the current condition of facilities and recent maintenance work, in Part 2.
   In the table, check all applicable boxes, circle conditions and write-in any other info.
5. Submit this completed form to the City of Lacey each year by AUGUST 31st.

   Mailing Address: City of Lacey
   ATTN: Commercial Stormwater Maintenance
   1200 College Street SE, Lacey, WA 98503

* * * * * * * * * * * *

PART 1: **FACILITIES INVENTORY**

Check the boxes to indicate which facility types you have at your business, and how many.

Facility Type	Number Within Your Neighborhood				
Wet Ponds/Constructed Wetlands	☐ None	☐ One	☐ Two or more		
Infiltration Basins ("dry ponds")	☐ None	☐ One	☐ Two or more		
Bio-Swales	☐ None	☐ One	☐ Two or more		
Bioretention Cells ("rain gardens")......	☐ None	☐ One	☐ Two or more		
Treatment Vaults	☐ None	☐ One	☐ Two or more		
Dispersion Trenches	☐ None	☐ One	☐ Two or more		
Oil-Water Separators	☐ None	☐ One	☐ Two or more		
Catch Basins (private only, not in public road)	☐ None	☐ One	☐ Two	☐ 3	☐ 4+

Other Drainage Features: ______________________

PART 2: **FACILITIES MAINTENANCE**

IDENTIFY	INSPECT	MAINTAIN	OBSERVE
Facility Type *& Features*	Current Condition (**G**ood, **F**air, **P**oor)	Inspection and Maintenance Accomplished	Problems Noted
Wet Pond or Constructed Wetland			☐ No Problems Noted
Inflow System	G F P	☐ Pipe-End Area Cleared	☐ Pipe Damage
Slopes, Erosion	G F P	☐ Erosion Repaired	☐ Erosion
Trash & Yard Debris	G F P	☐ Trash/Debris Removed	☐ Dumping of waste/debris
Cattails/Vegetation	G F P	☐ Cattails/Veg. Removed	☐ Excess cattails/plants
Impermeable Liner	G F P	☐ Liner completely covered	☐ Water Level fluctuates
Outflow System	G F P	☐ Grate or Weir Cleared	☐ Other:
Detention Pond/Infiltration Basin ("Dry Pond")			☐ No Problems Noted
Inflow System	G F P	☐ Pipe-End Area Cleared	☐ Pipe Damage
Erosion Protection	G F P	☐ RipRap Restored/Replaced	☐ Invasive plant growth
Grassy Bottom Area	G F P	☐ Mowed ☐ Reseeded	☐ Not draining well
Slopes, Erosion	G F P	☐ Erosion Repaired	☐ Erosion ☐ Moles
Trash & Yard Debris	G F P	☐ Trash/Debris Removed	☐ Dumping of waste/debris
Vegetation on slopes	G F P	☐ Problem Plants Removed	☐ Other:
Bio-Swale			☐ No Problems Noted
Grass, Vegetation	G F P	☐ Mowed ☐ Weeded	☐ Erosion ☐ Moles
Side Slopes	G F P	☐ Trash/Debris Removed	☐ Other:
Bioretention Cells (Community RainGardens)			☐ No Problems Noted
Inflow	G F P	☐ Inflow Path Cleared	☐ Erosion
Mulch and Soil	G F P	☐ Added new mulch	☐ Plants not healthy
Plants	G F P	☐ Pruned, weeded	☐ Other:
Overflow Grate	G F P	☐ Grate Area Cleared	
Dispersion Trench			☐ No Problems Noted
Inflow System	G F P	☐ Grate/Pipe Cleared	☐ Pipe Damage
Drainrock	G F P	☐ Rock Restored/Replaced	☐ Invasive weed growth
Outflow System	G F P	☐ Outflow Clear & Level	☐ Erosion
Trash and Invasives	G F P	☐ Trash/Weeds Removed	☐ Other:
Catch Basins (NOT within public roads)			☐ No Problems Noted
Grate	G F P	☐ Grates Cleared-off	☐ Grate Damage
Sump	G F P	☐ Sumps Cleaned-out	☐ Structure Damage
Pipe Outlet	G F P	☐ Pipe Outlet Cleared	☐ Pipe Damage
			☐ Other:

Who performs the maintenance of your stormwater facilities? Check all that apply:

☐ Self /Other Owners ☐ Maintenance Contractor ☐ Other:________________________

Notes:____

____

Thank you! *If you want City staff to contact you for technical assistance, please check this box:* ☐

City of Lacey Commercial Stormwater Inspector: Jack Froschauer (360) 413-4382 JFroscha@ci.lacey.wa.us

STORMWATER FACILITIES
INSPECTION & MAINTENANCE
ANNUAL REPORTING FORM
for RESIDENTIAL NEIGHBORHOODS

____ ____________
Name of Home Owner Association or Neighborhood Date Form Completed

____
Main Streets where Stormwater Facilities are Located

______________________________ ____________________
Name of Person Completing this Form Title (such as Owner, HOA President, etc.)

________________________ ____________________________
Contact Phone Number Email Address (please print clearly)

Instructions for completing this form:

1. Identify your neighborhood's stormwater facilities and inventory them in Part 1 below.
   Use your site plan or the descriptions in the Stormwater Facilities Maintenance Guide, available online at www.ci.lacey.wa.us\PrivateStormFacilities
2. Inspect your facilities and check for any damage or other potential problems.
   Refer to the appropriate checklists in the Stormwater Facilities Maintenance Guide.
3. Maintain your facilities as needed, as described in the Maintenance Guide.
   Do it yourself or with others, form a work party, or hire a qualified contractor.
4. Summarize the current condition of facilities and recent maintenance work, in Part 2.
   In the table, check all applicable boxes, circle conditions and write-in any other info.
5. Submit this completed form to the City of Lacey each year by AUGUST 31st.

   Mailing Address: Stormwater Maintenance Program
   Lacey Water Resources
   420 College Street SE, Lacey, WA 98503

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PART 1: **FACILITIES INVENTORY**

Check the boxes to indicate which facility types you have in your community, and how many.

Facility Type	Number Within Your Neighborhood				
Wet Ponds/Constructed Wetlands	☐ None	☐ One	☐ Two or more		
Infiltration Basins ("dry ponds")	☐ None	☐ One	☐ Two or more		
Bio-Swales	☐ None	☐ One	☐ Two or more		
Bioretention Cells ("rain gardens")......	☐ None	☐ One	☐ Two or more		
Treatment Vaults	☐ None	☐ One	☐ Two or more		
Dispersion Trenches	☐ None	☐ One	☐ Two or more		
Oil-Water Separators	☐ None	☐ One	☐ Two or more		
Catch Basins (private only, not in public road)	☐ None	☐ One	☐ Two	☐ 3	☐ 4+

Other Drainage Features:____________________________________

PART 2: **FACILITIES MAINTENANCE**

IDENTIFY	INSPECT	MAINTAIN	OBSERVE
Facility Type *& Features*	Current Condition (**G**ood, **F**air, **P**oor)	Inspection and Maintenance Accomplished	Problems Noted
Wet Pond or Constructed Wetland			☐ No Problems Noted
Inflow System	G F P	☐ Pipe-End Area Cleared	☐ Pipe Damage
Slopes, Erosion	G F P	☐ Erosion Repaired	☐ Erosion
Trash & Yard Debris	G F P	☐ Trash/Debris Removed	☐ Dumping of waste/debris
Cattails/Vegetation	G F P	☐ Cattails/Veg. Removed	☐ Excess cattails/plants
Impermeable Liner	G F P	☐ Liner completely covered	☐ Water Level fluctuates
Outflow System	G F P	☐ Grate or Weir Cleared	☐ Other:
Detention Pond/Infiltration Basin ("Dry Pond")			☐ No Problems Noted
Inflow System	G F P	☐ Pipe-End Area Cleared	☐ Pipe Damage
Erosion Protection	G F P	☐ RipRap Restored/Replaced	☐ Invasive plant growth
Grassy Bottom Area	G F P	☐ Mowed ☐ Reseeded	☐ Not draining well
Slopes, Erosion	G F P	☐ Erosion Repaired	☐ Erosion ☐ Moles
Trash & Yard Debris	G F P	☐ Trash/Debris Removed	☐ Dumping of waste/debris
Vegetation on slopes	G F P	☐ Problem Plants Removed	☐ Other:
Bio-Swale			☐ No Problems Noted
Grass, Vegetation	G F P	☐ Mowed ☐ Weeded	☐ Erosion ☐ Moles
Side Slopes	G F P	☐ Trash/Debris Removed	☐ Other:
Bioretention Cells (Community RainGardens)			☐ No Problems Noted
Inflow	G F P	☐ Inflow Path Cleared	☐ Erosion
Mulch and Soil	G F P	☐ Added new mulch	☐ Plants not healthy
Plants	G F P	☐ Pruned, weeded	☐ Other:
Overflow Grate	G F P	☐ Grate Area Cleared	
Dispersion Trench			☐ No Problems Noted
Inflow System	G F P	☐ Grate/Pipe Cleared	☐ Pipe Damage
Drainrock	G F P	☐ Rock Restored/Replaced	☐ Invasive weed growth
Outflow System	G F P	☐ Outflow Clear & Level	☐ Erosion
Trash and Invasives	G F P	☐ Trash/Weeds Removed	☐ Other:
Catch Basins (NOT within public roads)			☐ No Problems Noted
Grate	G F P	☐ Grates Cleared-off	☐ Grate Damage
Sump	G F P	☐ Sumps Cleaned-out	☐ Structure Damage
Pipe Outlet	G F P	☐ Pipe Outlet Cleared	☐ Pipe Damage
			☐ Other:

Who performs the maintenance of your stormwater facilities? Check all that apply:

☐ Self /Other Owners ☐ Maintenance Contractor ☐ Other:______________________

Notes:____

Thank you! *If you want City staff to contact you for technical assistance, please check this box:* ☐