City of Portland

Stormwater Management Manual

Revision 4
August 1, 2008

2008 Stormwater Management Manual

Quick Start Guide

1. Which Design Approach should I use?

See Section 2.2 for Simplified, Presumptive and Performance Approach Requirements (page 2-15).

2. What is my site's infiltration rate?

See Appendix F2 for infiltration testing requirements.

3. What category of the Stormwater Hierarchy can I achieve?

See Section 1.3.1 for infiltration and disharge requirements (page 1-8).

4. What documents do I need to submit for permitting?

See Appendix D for all Stormwater Manual forms and submittal guidance.

5. Where is the new Presumptive Approach Calculator (PAC)?

Go to http://www.portlandonline.com/bes/index.cfm?c=47958

Other requirements apply. Please see Section 1.3.5 for a complete summary of stormwater management requirements and Section 2.1 for a complete list of steps in the design and permit process.

STORMWATER MANAGEMENT MANUAL

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ENVIRONMENTAL SERVICES
CITY OF PORTLAND

Copies of this manual may be purchased from:
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INTRODUCTION

This *Stormwater Management Manual* (SWMM) is a technical document that outlines the City of Portland's stormwater management requirements. The requirements defined in this manual apply to all development and redevelopment projects within the City of Portland on both private and public property.

The City of Portland's approach to stormwater management emphasizes the use of vegetated surface facilities to treat and infiltrate stormwater on the property where the stormwater runoff is created. Infiltrating stormwater onsite with vegetated surface facilities is a multi-objective strategy that provides a number of benefits, including but not limited to pollution reduction, volume and peak flow reduction, and groundwater recharge. These benefits play a critical role in protecting stormwater infrastructure and improving watershed health. The SWMM complements and supports the City's *Portland Watershed Management Plan*, *System Plan*, Revegetation Program, Greenstreets Program, and other City standards and practices.

Summary of Changes in the 2008 Revised SWMM

The SWMM was initially adopted in 1999 and was most recently revised in 2004. For this 2008 revision, the entire 2004 SWMM was edited and reorganized to clarify the requirements, eliminate duplication, and improve the overall presentation of the information. The overall structure of Chapters 1 through 4 remains the same as in the 2004 SWMM. Several appendices were renamed and reordered.

Chapter 1 provides the stormwater infiltration, discharge, flow control, and pollution reduction **requirements and related policies** that all development and redevelopment projects in the City of Portland must comply with.

> ***Chapter 1 changes:*** *Emphasis was placed on clarifying the stormwater hierarchy and updating the underground injection control (UIC) requirements. The chapter includes several new graphics and a new section on LEED stormwater credits.*

Chapter 2 provides the **design guidelines and specifications for stormwater management facilities** required in order to meet the City's requirements. Projects may choose the **Simplified Approach**, the **Presumptive Approach,** or the **Performance Approach** to select and design stormwater facilities.

> ***Chapter 2 changes:*** *Chapter 2 is still the largest chapter, and was reorganized into three main sections.*

- *The first section emphasizes the importance of good site design and outlines the technical steps necessary to move through the permit process.*

- *The second section places new attention on the existing sizing methodologies (the Simplified, Presumptive, and Performance Approaches). Changes include reducing the project size allowed under the Simplified Approach, providing a new calculator for the Presumptive Approach (which allows applicants to take existing infiltration rates into account in a more consistent way), and expanding the application of the Performance Approach to accommodate projects with unique circumstances or innovative solutions.*

- *The third section outlines the importance of the landscape requirements; restructures and streamlines the facilities nomenclature; and updates the design guidelines for each facility with the most up-to-date information available, including new information on culverts and outfalls. New typical details were developed for each facility type and were consolidated into Appendix G.*

Chapter 3 provides the **operations and maintenance requirements** that all projects must comply with.

> ***Chapter 3 changes:*** *Chapter 3 includes updated technical information for maintaining each facility and clarification of the requirements on private vs. public property.*

Chapter 4 provides the **source control requirements** that all projects must comply with if they are classified as high risk because of certain site characteristics or activities.

> ***Chapter 4 changes:*** *Chapter 4 was reorganized to clarify the source control requirements and updated with the latest technical information available.*

The **Definitions** section defines the technical terms and acronyms used in the manual.

> ***Definition Changes:*** *The definitions were revised to add new terms, delete unused terms, and update existing terms as necessary.*

Appendix A includes the **City Code** and **policies** that direct the Bureau of Environmental Services to implement and revise the SWMM. It includes related administrative rules and design guidelines.

> ***Appendix A changes:*** *The City Code is under revision at the time of this publication; a link is provided to the City Auditor's website, which will provide the most up-to-date information. The drainage reserve information previously found in Chapter 1 was completely revised and placed in Appendix A. Two new sections were added to Appendix A, including design guidelines for culverts and outfalls and a section on retrofits.*

Appendix B includes the **vendor submittal guidelines** for stormwater treatment technologies.

Appendix B changes: *None.*

Appendix C provides the technical support documentation for the **Santa Barbara Urban Hydrograph (SBUH) method,** including the Simplified Approach and Presumptive Approach sizing methodologies.

> ***Appendix C changes:*** *The SBUH information, previously included in Appendices C and D, was consolidated into Appendix C, and two new elements were added: the Presumptive Approach Calculator (PAC) and the accompanying PAC User's Manual.*

Appendix D is a new appendix that includes **submittal guidance** and all the **forms** necessary for permitting stormwater management plans.

> ***Appendix D changes:*** *This is a new appendix that houses all the SWMM forms (which have all been revised and reformatted). It includes the submittal guidance needed to navigate the land use, zoning, building, public works, and source control permitting processes. The revised administrative review and appeal processes were taken out of Chapters 1 and 4 and placed in Appendix D. Revisions include clarification of special circumstances and an update to the offsite management fee.*

Appendix E documents the **pollution reduction methodologies** used to formulate Portland's water quality treatment requirements.

> ***Appendix E changes:*** *None.*

Appendix F provides additional **landscape technical specifications**, including depth to groundwater and infiltration testing procedures, stormwater facility soil specifications, and plant lists.

> ***Appendix F changes:*** *Much of the landscape information previously included in Appendix F was revised and moved to the second section of Chapter 2. Appendix F now includes new technical specifications, including improved testing protocols, a new soil specification, and new and easier-to-reference plant lists.*

Appendix G includes **typical construction details** for the stormwater facilities included in this manual.

> ***Appendix G changes:*** *Appendix G is a new section that houses the revised facility drawings that were moved from Chapter 2. These files are available as both .pdf and CAD.dwg files on the 2008 Stormwater Management Manual CD and BES's website.*

Appendix H includes six case studies that illustrate how to design and permit a range of typical development proposals.

Appendix H changes: *This is a new appendix. The case studies were moved from the beginning of the manual and revised.*

Looking Ahead

At the request of the City's Stormwater Advisory Committee, the Bureau of Environmental Services (BES) has developed a draft work plan for the next *Stormwater Management Manual* revision (scheduled for 2011). It includes tasks to review and revise the current pollution prevention and flow control standards. In addition, BES is committed to gathering ongoing input from City staff, the development community, and other stakeholders that will be considered in the 2011 revision process. To request more information about the draft work plan or provide suggestions for the next revision, please send an email to StormwaterManual@bes.ci.portland.or.us.

Chapter 1 REQUIREMENTS AND POLICIES

This chapter outlines the City of Portland's stormwater management requirements and the related regulations and policies. It includes:

1.1 PURPOSE OF THE STORMWATER MANAGEMENT MANUAL

As the City of Portland is developed, impervious surfaces create increased amounts of stormwater runoff during rainfall events, disrupting the natural hydrologic cycle. Without stormwater management, these conditions erode stream channels and prevent groundwater recharge. Parking lots, roadways, rooftops, and other impervious surfaces increase the pollution levels and temperature of stormwater that is transported to streams, rivers, and groundwater resources. Implementing the requirements in this manual will help protect Portland's water resources, which in turn will provide great benefit to human health, fish and wildlife habitat, recreational resources, and drinking water.

Stormwater management is also critical in terms of protecting Portland's sanitary and stormwater infrastructure. Increased runoff contributes to combined sewer overflows (CSOs) and basement sewer backups. Implementing onsite infiltration and flow control measures will conserve the existing and future conveyance capacity of storm sewers and combined sewers.

Strategies for meeting the requirements in this manual depend on a number of site factors, including infiltration capacity, available infrastructure, proposed development plans, and the drainage basin the proposed development is in. The applicant's ability to effectively use the design standards in this manual depends on a demonstrated understanding of the development site's ecology and of the upstream and downstream impacts resulting from stormwater management improvements. The standards addressed in this manual are intended to make site-specific improvements to properties across the City and to comprehensively manage stormwater by watershed.

Stormwater management is critical to maintaining and enhancing the City's livability and improving watershed health. The *Stormwater Management Manual* allows the City of Portland to protect both watershed resources and infrastructure investments with every land improvement. As each development and redevelopment project meets the requirements of this manual, it will contribute to achieving these important citywide goals.

Regulatory Mandates

In response to the impacts of urbanization on water quality, Congress passed the Clean Water Act of 1972 (amended in 1987), which prohibits the discharge of pollutants into waters of the United States unless the discharge is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. The permit requirements, published in 1990, require large (Phase I) cities such as Portland to obtain an NPDES permit for their municipal separate storm sewer system (MS4) discharges.

Compliance with the NPDES MS4 permit requires the cities to establish a comprehensive stormwater management program, including establishing controls on post-development stormwater runoff and source controls for industrial facilities that contribute substantial pollutant loading to the MS4 system. Portland established this citywide regulatory program in 1999, which includes water quality and flow control design standards for onsite stormwater management facilities. The program focuses on low-impact development practices, structural source control devices, and maintenance and operational best management practices (BMPs) designed to improve stormwater quality. The source control requirements included in this manual are designed to meet the NPDES Industrial Stormwater Discharge Permit requirements for those facilities required to have permit coverage. Within this regulatory context, developers and municipal agencies are required to implement controls that reduce pollution carried in runoff. This *Stormwater Management Manual* is part of Portland's NPDES MS4 stormwater management program to improve the quality of Portland's waters.

In addition, the federal Safe Drinking Water Act (SDWA) of 1974 provides a comprehensive framework to ensure the quality and safety of drinking water supplies. Within the state of Oregon, the Department of Environmental Quality (DEQ) regulates stormwater discharges to underground injection control (UIC) systems under the SDWA. UICs are used to infiltrate stormwater runoff from both public and private properties. DEQ issued a water pollution control facility (WPCF) permit to the City in 2005 for approximately 9,000 public UICs used to discharge stormwater runoff from publicly owned streets. As part of the compliance, the City was required to establish a comprehensive UIC management plan that includes structural, non-structural, and institutional controls to ensure the protection of groundwater as a drinking water resource. This *Stormwater Management Manual* assists with the implementation of Portland's UIC management plan.

The purpose of this manual is to respond to these regulatory mandates by providing stormwater management principles and techniques that help preserve or mimic the natural hydrologic cycle, minimize sewer system problems, and improve water quality. The manual provides developers and design professionals with specific requirements for reducing the impacts of stormwater from new development and redevelopment.

Relationship to the Sewer and Drainage Facilities Design Manual

Both the *Stormwater Management Manual* and the *Sewer and Drainage Facilities Design Manual* (Environmental Services, August 2006) are under the authority of the Bureau of Environmental Services (BES) and adopted by City Council as an administrative rule. They are complementary documents that share features related to hydrology and hydraulic design of drainage facilities.

The *Sewer and Drainage Facilities Design Manual* is the primary reference for designing public sewers. It is referenced for the design of pipelines, drainage channels, and other public facilities that convey and dispose of sanitary sewage, stormwater, and combined sewage flows. The *Stormwater Management Manual* should not be used to design any public sewer conveyance facility presented in the *Sewer and Drainage Facilities Design Manual*.

The content of the two manuals may overlap while addressing different aspects of system infrastructure design. Designers must reference both manuals when working in the City of Portland to determine the appropriate standards that apply to a project. Before finalizing any design, it is the responsibility of the project engineer to contact the City to resolve any conflicts between the documents.

1.2 APPLICABILITY

All development and redevelopment[1] proposals are subject to the requirements of the *Stormwater Management Manual* during a number of review and permit processes. These processes generally include land use reviews and zoning, site development, and building permits. Each development proposal will have a unique set of reviews and permits, based on what is proposed and the location. **Exhibit 1-1** provides a general overview of the development review process and shows when stormwater management requirements apply.

The thresholds for proposals that are subject to the requirements are:

- Properties that propose new offsite discharges or new connections to the public system are required to comply with stormwater requirements for the impervious area draining to the discharge point.
- Projects that develop or redevelop over 500 square feet of impervious surface.

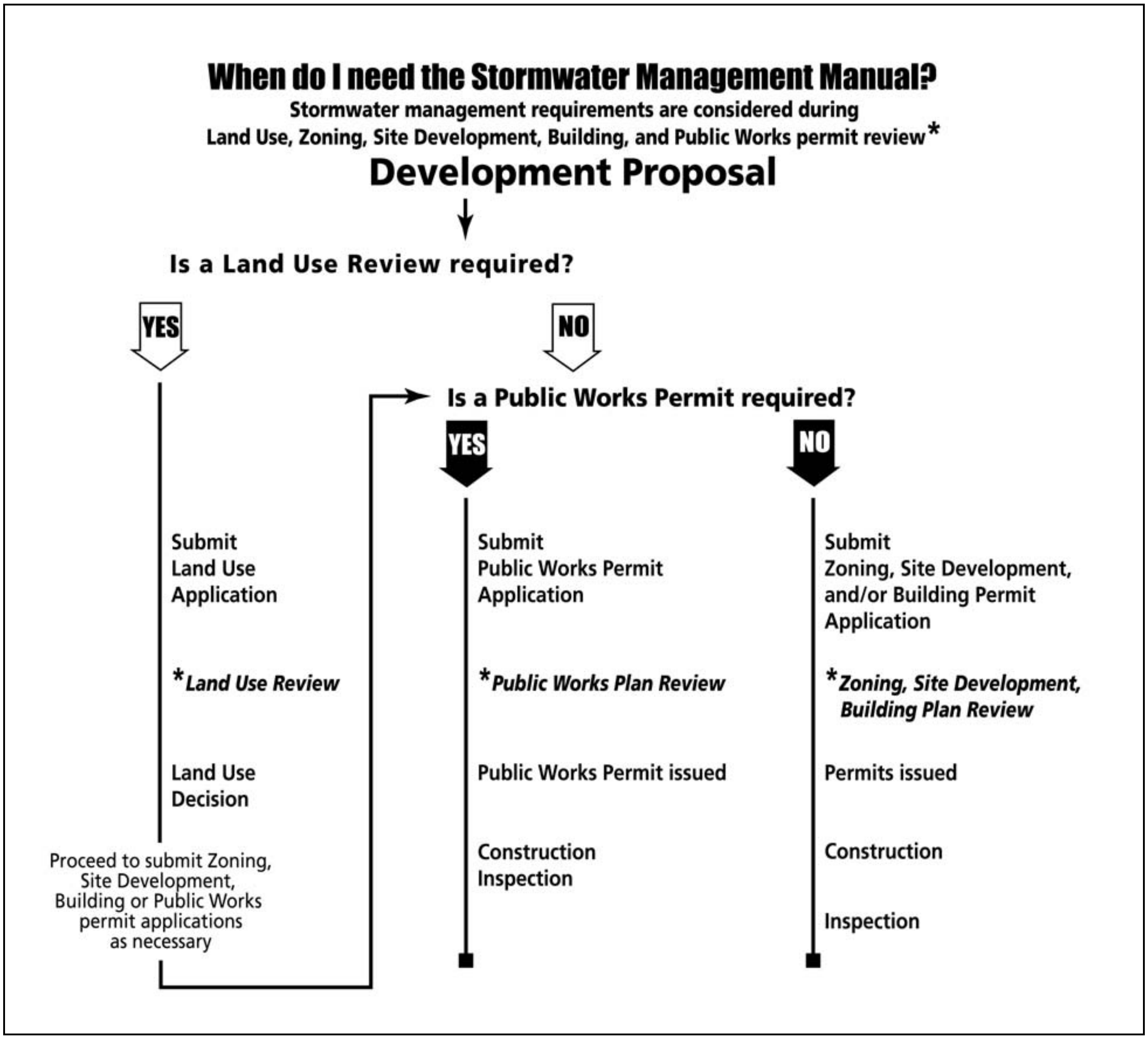
Proposals meeting these thresholds must comply with stormwater **infiltration and discharge** requirements, as specified in the stormwater hierarchy described in **Section 1.3.1,** the **flow control** requirements specified in **Section 1.3.2** and the **pollution reduction** requirements specified in **Section 1.3.3**. All projects must also comply with **Chapter 3** operations and maintenance requirements and **Chapter 4** source control requirements.

The Bureau of Development Services (BDS) administers the land use review process and permits for private improvements. Public works permits are required for public infrastructure improvements, which are generally located in the public right-of-way and are administered by the City's service bureaus, including Transportation, Environmental Services (BES), and Water.

For more information about the City of Portland's development review and permit processes, refer to: http://www.portlandonline.com/bds/index.cfm?c=35891. For more information about the City of Portland's public works permit process, refer to http://www.portlandonline.com/index.cfm?c=43826.

[1] See the **Definitions** (which follow Chapter 4) for a definition of development, redevelopment, and other terms used in this manual.

Exhibit 1-1: Stormwater Management Requirements in the Development Review Process



Projects on Private and Public Property

Stormwater management requirements apply projects on both private and public property, including all streets, alleys, driveways, and sidewalks. Stormwater that is generated from private property must be managed on private property, in privately maintained facilities. Stormwater that is generated from public property must be managed on public property, in publicly maintained facilities.

<u>Exceptions</u>
An applicant may propose to construct a "shared facility" that is designed to manage stormwater from private and public property. A shared facility may be in the right-of-way or on private property. This may be considered if one the following criteria is met:

1. Public street improvements require the construction of a public stormwater management facility, and there is an opportunity for a private facility to accept public runoff that cannot be managed effectively in the right-of-way.

2. The applicant clearly demonstrates that private stormwater management facilities cannot be constructed on private property (for example, when minimum zoning requirements cannot be met), and there is sufficient area in the right-of-way to construct a facility that can manage stormwater from both the street and the private property.

Both BES and City Council must approve an agreement for a shared facility. In addition, the private property owner must share in the ongoing operations and maintenance costs of the facility in proportion to the property's stormwater contribution.

<u>Sidewalks and Driveways</u>
Applicants are required to size stormwater facilities in the right-of-way to manage stormwater from all the impervious area within the right-of-way, including sidewalks and driveway aprons. Where it is not feasible for sidewalks to drain into a stormwater facility in the right-of-way, applicants are encouraged to use street trees as an impervious area reduction technique (see **Section 2.3.3** for specifications).

Stormwater facilities in the right-of-way are **not** sized to treat stormwater from private driveways. Stormwater from private driveways must be managed on private property. Applicants are encouraged to use vegetated filter strips to manage driveway runoff where possible (see **Section 2.3.3** for specifications). Under the appropriate site conditions, applicants may also consider pervious pavement for driveways. In any case, it is not expected that a separate stormwater facility will be constructed to serve only a sidewalk or residential driveway under 500 square feet.

Stormwater Management Retrofits

Stormwater retrofits help the City incrementally provide stormwater management for existing development. **Appendix A.5** summarizes the regulations within this manual that apply to both voluntary and non-voluntary stormwater retrofits.

1.3 STORMWATER MANAGEMENT REQUIREMENTS

Section 1.3.1 addresses the infiltration and discharge requirements, **Section 1.3.2** the flow control requirements and **Section 1.3.3** the pollution reduction requirements. **Section 1.3.4** outlines the requirements that apply in the Columbia South Shore area and **Section 1.3.5** provides a summary of all stormwater management requirements.

Vegetated Facilities Meet Multiple Requirements

While it is necessary to describe each stormwater requirement separately, the response to meet the requirements need not be separate. Traditional stormwater management tended to respond to each concern independently (e.g., filters reduced pollution, storage tanks provided detention and pipes conveyed and discharged the stormwater). The City's current stormwater management approach relies on the use of vegetated surface infiltration facilities to comprehensively meet multiple requirements. Vegetated facilities allow the applicant to meet pollution reduction, flow control, and infiltration requirements.

1.3.1 Infiltration and Discharge

Prior to development, most native soils have a sufficient duff layer and permeability to absorb and infiltrate rainwater. This is because of a combination of factors, including the structure of the soil, the connected pores and channels created by plant roots, and the presence of leaf litter and other organic matter. Because most rain storms are not large enough to exceed the soil permeability and completely saturate the native and undisturbed soil, only a small percentage of water collects on the surface. Under these conditions, water that accumulates at the surface typically collects in rivulets that combine to form creeks, streams, and rivers.

Urbanization results in the loss of native soil conditions as a result of soil compaction and the creation of impervious surfaces, which disrupts the hydrologic cycle. Impacts include increased stormwater flow rates and volumes as well as decreased groundwater recharge and, consequently, low base flows into streams.
Portland's infiltration and discharge requirements are designed to:

- Protect watershed health by requiring onsite infiltration wherever feasible in order to mimic pre-development hydrologic conditions...
- Protect the capacity of downstream infrastructure and minimize combined sewer overflows and basement sewer backups within the combined sewer system.
- Protect groundwater resources by preventing and removing pollutants from stormwater before discharging it into a UIC.

Feasibility

Stormwater must be infiltrated onsite to the maximum extent feasible, before discharging any flows offsite. The appropriate use of infiltration depends on a number of factors, including soil type, soil conditions, slopes, and depth to groundwater. The point of discharge is also site specific and dependent on the availability and condition of public and private infrastructure. The feasibility of infiltration and the discharge point have a direct impact on the pollution reduction and flow control requirements for a site. Therefore, it is critical to determine the feasibility of infiltration and the point of discharge before designing a stormwater facility.

While many of the stormwater management facilities presented in **Chapter 2** aim to maximize infiltration, not every site can infiltrate all of the stormwater from large, intense rainfall events. Unless complete infiltration of the 10-year storm (3.4 inches of rainfall over 24 hours) can be accomplished, an offsite discharge point must be identified.

BDS (Bureau of Development Services) approves infiltration on private property.

BES (Bureau of Environmental Services) approves infiltration on public property, including the public right-of-way, and approves all offsite discharge for both public and private property.

Infiltration Facility Prerequisites

To use an infiltration facility, the following prerequisites must be met:

1. Seasonally high groundwater must be more than 5 feet below the lowest elevation of a UIC 5 feet or less in depth. Seasonally high groundwater must be more than 10 feet below the lowest elevation of a UIC more than 5 feet in depth.

2. All setbacks must be met pursuant to **Chapter 2**. Setbacks are measured from the center of the stormwater facility to the adjacent boundary, structure, or facility. All setback requirements are minimums and can be increased, based on the discretion of City of Portland staff.

Exhibit 1-2: Stormwater Hierarchy

Stormwater Infiltration and Discharge Hierarchy

Onsite Infiltration

Catagory 1: Requires total onsite infiltration with vegetated infiltration facilities. Examples include infiltration swales, planters and basins.

Catagory 2: Requires total onsite infiltration with vegetated facilities that overflow to subsurface infiltration facilities. Examples of subsurface infiltration facilities include drywells, soakage trenches and sumps. These facility types are underground injection control structures (UICs) and must be registered with DEQ. Roof runoff is exempt from pollution reduction requirements and may drain directly to a UIC.

Offsite Discharge

Catagory 3: Requires onsite detention with vegetated facilities that overflow to a draingeway, river, or storm-only pipe. Vegetated facilities (lined or unlined) must meet pollution reduction and flow control requirements to the maximum extent feasible prior to offsite discharge.

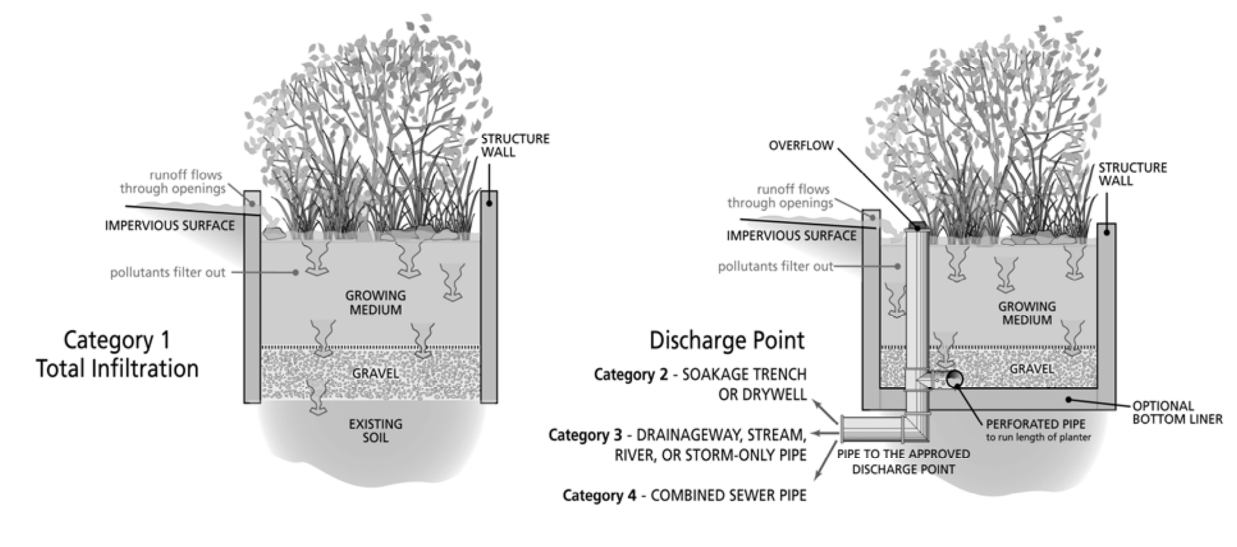
Catagory 4: Requires onsite detention with vegetated facilities that overflow to the combined sewer system. Vegetated facilities (lined or unlined) must meet pollution reduction and flow control requirements to the maximum extent feasible prior to offsite discharge.

Stormwater Hierarchy

Decisions regarding the degree of onsite infiltration and the discharge point (when complete onsite infiltration is not feasible) are based on the stormwater hierarchy, as shown in **Exhibit 1-2**[2] and **Exhibit 1-3.** The highest technically feasible category must be used (1 = highest, 4 = lowest). Applicants must provide the appropriate technical analysis and evaluation to demonstrate the need to move from Category 1 through each consecutive category. Infiltration testing is required to determine the feasibility of onsite infiltration and the existing infiltration rate.

Roof runoff is exempt from pollution reduction requirements and may drain directly to a UIC. Residential roofs (up to three units) are excluded from UIC authorization. See **Section 1.4** for further clarification of UIC requirements.

Exhibit 1-3: Stormwater Hierarchy Illustration



2 The stormwater hierarchy is based on the City's WPCF permit with DEQ regarding onsite infiltration and offsite discharge. The hierarchy is how the City satisfies the requirements of Oregon Administrative Rules (OAR) 340-040 for the protection of groundwater.

Stormwater Hierarchy Exemptions

The following circumstances may qualify a site to move to the next category of the stormwater hierarchy. These circumstances are evaluated on a site-by-site basis. It is the responsibility of the applicant to justify moving from one category to the next, based on technical issues or competing code requirements. All circumstances are subject to BES review and approval and may require an appeal.

- The site is located within a wellhead protection area and must meet the Water Bureau's requirements for protection of groundwater resources (see **Section 1.3.4**).

- The site has high groundwater, poor infiltration rates (less than 2.0 inch per hour tested rate), or steep slope conditions. The City may require a certified geotechnical engineer or engineering geologist to demonstrate and recommend that this exception applies to a site.

- Contamination is present at the site, as determined by DEQ. Sites that have contaminated soils conditions must be evaluated by DEQ to determine if areas on the property are suitable for infiltration without the risk of mobilizing contaminants in the soil or groundwater. Documentation showing DEQ's contamination assessment and determination must be submitted to BES at the time of permit application.

- There is a conflict with required source controls for high-risk sites (as identified in **Chapter 4**).

- Space constraints may prohibit the construction of onsite infiltration facilities. Code requirements such as minimum density, minimum lot coverage, and required zero lot line setback for urban districts may exempt the use of onsite retention facilities. (**Note:** Maximum density allowed by the zoning code does not exempt the applicant from stormwater requirements. In this case, technical requirements for infrastructure must be met before the development is approved.)

Infiltration Standards

Where complete onsite infiltration is feasible, the following standards apply:

- **Surface Infiltration Facilities (Public or Private).** Surface infiltration facilities must demonstrate the ability to infiltrate the 10-year, 24-hour storm. **Chapter 2** provides detailed facility sizing and design procedures.

- **Public Infiltration Sump Systems.** The peak flow rate from a 10-year storm must be calculated using the Rational Method (Q=C*I*A), with a safety factor of 2 applied. The intensity must correspond to the calculated time of concentration (5-minute minimum). (See the *Bureau of Environmental Services Sewer and Drainage Facilities Design Manual* for rainfall intensity charts; for 5-minute time of concentration, intensity = 2.86 in/hr.)

- **Private Drywells and Soakage Trenches**. Drywell sizing charts or soakage trench sizing guidelines found in **Section 2.3.3** must be used. Drywells must be able to pass the testing procedure outlined in **Section 2.3.3** when post-construction testing is required by BDS.

Discharge Standards[3]

<u>Offsite Discharge to Surface Flow</u>
Where stormwater is discharged to an offsite surface flow conveyance facility, such as a ditch, drainageway, stream, or river, the following standard applies:

- Beginning at the point of discharge from the site, the surface conveyance facility must have the capacity to convey flows from the 25-year storm from all contributing upstream drainage areas. The 25-year storm flow rate must be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance.

<u>Offsite Discharge to Piped Flow</u>
Where stormwater is discharged to an offsite piped conveyance facility, such as a storm sewer or combined sewer, the following standards apply:

- **For new development or redevelopment with an increase in net impervious area:** Beginning at the point of discharge from the site, the piped conveyance facility must have the capacity to convey flows from the 10-year storm from all contributing upstream drainage areas without surcharge. The piped conveyance facility may surcharge during the 25-year storm, but the hydraulic grade line must remain below ground surface level. Combined sewers, or sewers in the Cascade Station/Portland International Center and Columbia South Shore Plan Districts (see **Exhibit 1-8**), must have the capacity to convey flows from the 25-year storm without surcharge. The 10-year and 25-year storm flow rates must be calculated using the Rational Method (Q=C*I*A), with intensity corresponding to

[3] The discharge and conveyance information contained in this section is provided for general reference. Please refer to the *Sewer and Drainage Facilities Design Manual* (Environmental Services, August 2006) for the complete list of approved hydrologic modeling methods, rainfall intensity charts and allowable surcharge criteria.

the calculated time of concentration (5-minute minimum), or other approved hydrologic modeling method for conveyance.

- **For redevelopment with no net increase in impervious area**: Existing downstream pipe conveyance facilities may be allowed to surcharge under certain circumstances.

Discharge to Existing Stormwater Management Facilities

A development may discharge to an existing **publicly** operated stormwater facility if **all** of the following criteria are met:

- The applicant illustrates that private onsite infiltration facilities have been thoroughly considered and applied where feasible.

- The existing stormwater management facility was adequately designed to include the proposed development area. For infiltration facilities, the discharging property must have been included in the assumed drainage basin when the existing facility was sized.

- The conveyance system and facility to which the development will discharge will have capacity for existing and proposed flows, as approved by BES.

- Stormwater runoff from development on private property must not discharge into any public infiltration sump systems.
- Drainage from City rights-of-way with more than 1,000 vehicle trips per day (TPD) cannot be discharged to public UICs that receive drainage primarily from public rights-of-way with less than 1,000 TPD.

In addition to publicly owned and operated stormwater management facilities, many private facilities exist. A development may discharge to an existing **private** stormwater management facility if **all** of the following criteria are met:

- The stormwater management facility was adequately designed to include the proposed development area.

- The conveyance system and facility to which the development will discharge will have adequate capacity.

- The development's owner enters into a written legal agreement with the owner of the private stormwater management facility. BES and BDS must review and approve this agreement, and the owners must record it as an easement on both properties.

- There is no history of maintenance violations at the facility to which the development will discharge, as determined by BES and BDS. BES may choose to conduct a site investigation to determine if the existing facility is being maintained adequately.

Escape Route

All projects must demonstrate that in the event the stormwater facility fails or rainfall exceeds the facility design capacity, that flows will be routed to maintain public safety and avoid property damage. Depending on site conditions, this may include an overflow structure or storage in parking lot, street, or landscaping areas. Applicants must describe where the flow will be routed on a basin site plan to illustrate where flood conditions or ponding is expected to occur.

1.3.2 Flow Control

As discussed in the previous section, urbanization decreases the infiltration capacity and permeability of native soils and increases the amount of impervious area. Combined, these circumstances create increased stormwater flow rates and volumes.

The basic concept for flow control (detention and retention) is that water from developed areas is managed with a variety of techniques and released to downstream conveyance systems at a slower rate and lower volume. Managing flows in this way attempts to mimic the natural rainfall runoff response of the site prior to development, protecting downstream properties, infrastructure, and natural resources from the increases in stormwater runoff peak flow rates and volumes that result from development.

- **Detention facilities** store stormwater and release the water slowly, typically over a number of hours.

- **Retention facilities** also store stormwater. Rather than storing and releasing the entire runoff volume, however, the facility permanently retains a portion of the water onsite. The water infiltrates and recharges the groundwater aquifer and, in the case of surface retention facilities, evaporates or is absorbed and used by vegetation. In this way, retention facilities reduce the total volume of water released downstream.

In the past, flow control efforts often relied solely on detention facilities such as ponds, tanks, or vaults that control peak flow rates. These facilities, however, allow the duration of high flows in creek systems to increase, causing the potential for increased erosion downstream. For example, after development with detention, the magnitude of the 2-year peak flow rate may not increase, but the amount of time (duration) that the flow rate occurs will increase, and the frequency with which the 2-year peak flow rate occurs will also increase.

In contrast, systems such as pervious pavement, ecoroofs, planters, swales, and other surface vegetated facilities are particularly effective in lowering the overall runoff volume and reducing the amount of time (duration) and frequency of the peak flow rate. Therefore, stream systems that require erosion protection, including salmonid habitat streams, warrant the use of retention systems. In addition, by infiltrating and evaporating stormwater, vegetated retention systems recharge groundwater that serves as the base flow for streams during the dry season. Where retention systems cannot be used, detention systems that control the duration of the geomorphically significant flow (i.e., flow capable of moving sediment) must be used. Such detention systems lower release rates and must be designed to protect the stream channel.

Time of concentration (the time it takes rainfall to accumulate and run off a site) is another important factor in determining downstream hydrologic impacts created by development. Flow rates from individual sites may be controlled, but when they are combined quickly in fast-flowing conveyance pipes, the downstream effect will still be increased instream flow rates and volumes. Breaking flow patterns up into surface retention systems helps increase a site's time of concentration and lessens downstream impacts.

The City's flow control requirements aim to ensure that post-development peak flows leaving the site:

- Do not exceed the capacity of the receiving conveyance facility or water body.
- Do not increase the potential for stream bank and stream channel erosion.
- Do not add significant volume to an existing closed depression, such as Holgate Lake or other similar geologic features found throughout the City.
- Do not create or increase any upstream or downstream flooding problems.
- Do not create or increase the occurrence of combined sewer overflows or basement sewer backups.

Flow Control Requirements

To meet flow control requirements, planters, swales, and other vegetated surface facilities are required to the maximum extent feasible. Impervious area reduction techniques, such as pervious pavement and ecoroofs, may also be necessary in order to meet flow control requirements.

Flow control standards vary, depending on the point of discharge. The base standard must be sufficient to maintain peak flow rates at their pre-development levels for the 2-year, 5-year, and 10-year, 24-hour runoff events. Note that for redevelopment projects, pre-development condition is defined as undeveloped land (see **Definitions**).

Applicants proposing to discharge stormwater offsite must evaluate the capacity of the offsite receiving system (storm sewer, combined sewer, ditch, drainageway, etc.) with regard to the discharge requirements presented in **Section 1.3.1**. BES staff may determine that additional onsite flow control is required if the offsite receiving system does not have sufficient capacity to accept the proposed flows.

Flow Control Requirements When Discharging to a Stream

Most tributary streams in Portland show evidence of excessive stream bank and channel erosion. Any development that discharges stormwater offsite that eventually flows to a tributary stream must be designed to a more restrictive requirement to reduce the potential for further aggravation of instream erosion problems. This applies to all tributaries and storm sewers that drain to streams or overland storm drainage systems within the Portland area except the Columbia Slough, which is regulated by Multnomah County Drainage District.

Flow control in these areas should aim to avoid discharging flows that will cause channel erosion. Channel-eroding flow varies from stream to stream. Unless more specific data are available, the City assumes that channel-eroding flow is one-half of the 2-year, 24-hour pre-developed (Lewis & Clark era) peak flow, and the requirements of this manual are based on that assumption. Specifically, the more restrictive flow control requirement is to limit the 2-year, 24-hour post-development peak flow rate to the pre-development erosion-initiating rate (one-half of the 2-year, 24-hour flow rate). The facilities must also control the post-development flows from the 5-, 10-, and 25-year, 24-hour peak flows to the pre-development 5-, 10-, and 25-year, 24-hour levels.

Flow Control Requirements in Combined Sewer Areas

Substantial stormwater volumes in the combined sewer system result in overflows to surface water and basement flooding in many areas served by combined sewers. Stormwater that enters the combined sewer system during low-flow periods is treated at the City's wastewater treatment plants, using costly energy and other resources. For these reasons, it is important to limit the quantity of stormwater entering the combined sewer system. Development projects in combined sewer areas are required to **infiltrate stormwater onsite to the maximum extent feasible**. (See **References and Resources** for a link to a map of the combined sewer basins.)

For developments that are served by combined sewers but are unable to achieve total onsite infiltration, the following requirements apply:

1. BES will review development and redevelopment plans to ensure that discharge to a combined sewer system will not increase the risk of an overflow event or localized basement flooding. Additional requirements may apply depending on the scope and location of the project.

2. Development projects that are allowed to discharge to a combined sewer system do not need to provide detention for the 2-year and 5-year storm events. Detention facilities must be designed to control post-development flows from the 25-year peak flow to the pre-developed 10-year peak flow rate.

Exhibit 1-4 summarizes the City's flow control requirements.

Flow Control Exemptions

New development and redevelopment projects may be exempt from flow control requirements if they discharge stormwater runoff directly into the Willamette River, Columbia River, or Columbia Slough through a private storm sewer, separated public storm sewer, or Multnomah Country Drainage District system with available capacity. See **References and Resources** for a link to a map that delineates areas where flow control may not be required. This map is not definitive and BES must confirm all sites exempt from flow control requirements.

- This exemption is for flow control only; the pollution reduction requirements presented in **Section 1.3.3** still apply.

- Development must still properly dispose of stormwater using approved methods in accordance with **Section 1.3.1**.

When flow control is not required, facilities may be downsized to meet pollution reduction requirements only. (This exemption does not apply to facilities sized with the Simplified Approach.) When facilities are downsized to meet pollution reduction requirements only, flows above the pollution reduction design flow must be routed around the facility with an approved diversion structure, unless otherwise approved by BES.

Temporary Structures
Temporary structures (see **Definitions**) are exempt from **flow control** requirements, subject to BES review. Exemptions will not be allowed in circumstances where permits or other municipal regulations may be violated if the requirement(s) are lifted.

Exhibit 1-4: Summary of the City's Flow Control Requirements

Onsite infiltration is required to the maximum extent feasible. Where complete onsite infiltration is not feasible, vegetated onsite retention facilities are required to the maximum extent feasible.

After the stormwater infiltration and discharge requirements from **Section 1.3.1** have been applied and the point of stormwater discharge is determined, the flow control requirements below apply.

Piping systems that provide conveyance from a site to an approved discharge point must have adequate capacity, per the *Sewer and Drainage Facilities Design Manual*; if not, additional onsite flow control may be required.

1. Discharge Point	2. Retention Requirement	3. Detention Requirement
Direct discharge to Willamette River, Columbia River, or Columbia Slough, or discharge to a storm-only piping system or Multnomah Country Drainage District system (with capacity) that directly discharges to one of the above water bodies.	Use onsite retention (flow volume control) facilities and infiltrate onsite to the maximum extent feasible.	None.
Discharge to any other overland storm drainage system, including streams, drainageways, and ditches, or to any storm pipe system that eventually discharges to an overland drainage system.	Use onsite retention (flow volume control) facilities and infiltrate onsite to the maximum extent feasible.	Limit post-development peak runoff rates as follows: • 2-year post-development peak rate to one-half of the2-year pre-development peak rate • 5-year post to 5-year pre • 10-year post to 10-year pre • 25-year post to 25-year pre
Discharge to a combined sewer.	Use onsite retention (flow volume control) facilities and infiltrate onsite to the maximum extent feasible.	Limit 25-year post-development peak runoff rate to 10-year pre-development peak rate.
Base requirement for all other discharge points.	Use onsite retention (flow volume control) facilities and infiltrate onsite to the maximum extent feasible.	Maintain peak flow rates at their pre-development levels for the 2-year, 5-year, and 10-year, 24-hour runoff events.

1.3.3 Pollution Reduction

Urbanization has serious impacts on the quality of surface water and groundwater. As land is developed, impervious areas interfere with the natural biological processes of soil that remove impurities from the water, and also increase stormwater runoff. The increased flows pick up pollutants from impervious areas and transport them downstream to receiving waters and the City sewer system.

Pollutants of concern include:

- Suspended solids (sediment)
- Heavy metals (dissolved and particulate, such as lead, copper, zinc, and cadmium)
- Nutrients (such as nitrogen and phosphorus)
- Bacteria and viruses
- Organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers)
- Floatable trash and debris

Vegetated Facilities and Pollution Reduction

Vegetated facilities included in **Chapter 2** under the Simplified Approach or Presumptive Approach are assumed to meet Portland's pollution reduction requirements. Vegetated facilities filter stormwater, removing pollutants as the water flows through the vegetation and soil.

Vegetation may be one of the most cost effective and ecologically efficient means available to improve water quality. Vegetation shades water courses, which lowers water temperature; captures and absorbs water in leaves and roots, which reduces peak flows; and stabilizes soil by providing cover for disturbed soils. Vegetation also provides wildlife habitat and scenic and aesthetic benefits.

As stormwater enters a vegetated facility, the vegetation slows the water down, allowing sediments to be trapped on the surface of the facility. Typically, the surface area of the facility is designed to allow stormwater to pond and evaporate while sediments settle into a layer of mulch and then soil. The mulch prevents soil erosion and retains moisture for plant roots. It also provides a medium for biological growth and the decomposition or decay of organic matter. The soil stores water and nutrients to support plant life. Bacteria, nematodes, and other soil organisms degrade organic pollutants such as petroleum-based compounds. They also help mix organic material, increase aeration, and improve water infiltration and water-holding capacity. Bacteria and other beneficial soil microbes process the majority of pollutants.

Vegetated facilities are required to the maximum extent feasible. If a project proposes to use facilities other than those presented in **Chapter 2** for pollution reduction, the applicant must demonstrate through the Performance Approach that the proposal meets or exceeds the pollution reduction requirements.

Pollution Reduction Requirements

The City of Portland has the following citywide pollution reduction requirements for all projects that develop or redevelop over 500 square feet of impervious area and all existing development that proposes to create new offsite stormwater discharges:

- 70 percent removal of total suspended solids (TSS) is required from 90 percent of the average annual runoff. (See **Appendix E** for more detailed information about the formulation of Portland's pollution reduction standards.)

- In watersheds that have established total maximum daily loads (TMDLs) or that are on DEQ's 303(d) list of impaired waters (**Exhibit 1-5**), stormwater management facilities must be capable of reducing the pollutant(s) of concern, as approved by BES.

Total Suspended Solids Requirements

Total suspended solids are particles that are too small or light to settle out from stormwater under high flow conditions. In many ways, TSS is a surrogate measure for water quality; therefore, the percentage of TSS removal from stormwater is an accepted standard to measure pollution reduction.

- Projects may use vegetated facilities from the Simplified Approach or Presumptive Approach (as specified in **Chapter 2**) to meet the 70 percent removal of TSS from 90 percent of the average annual runoff, without submitting additional data on TSS removal.

- If a project uses non-vegetated facilities for pollution reduction, the applicant must demonstrate through the Performance Approach (as specified in **Chapter 2**) that the development proposal meets the specific TSS removal requirements.

Total Maximum Daily Load (TMDL) and 303(d) List Requirements

- Development projects in watersheds with established TMDLs or on DEQ's 303(d) list may use vegetated facilities from the Simplified Approach or Presumptive Approach (as specified in **Chapter 2**) without submitting additional data on pollutant removal.

- If a project in a watershed with established TMDLs or on the 303(d) list uses non-vegetated facilities for pollution reduction, the applicant must demonstrate through the Performance Approach (as specified in **Chapter 2**) that the development proposal is consistent with specific TMDL or 303(d) requirements. The base requirement is to select and use a stormwater management facility that is capable of reducing the pollutants of concern, as approved by BES.

Exhibit 1-5: TMDL and 303(d)-Listed Parameters by Watershed as of August 1, 2008

TMDL Parameters						
Columbia River	**Willamette River**	**Columbia Slough**	**Johnson Creek**	**Fanno and Ash Creek**	**Tryon Creek**	**Westside Streams**
Total dissolved gas Dioxin	Bacteria Dioxin Temperature	Bacteria Phosphorus Lead PCB DDT/DDE Dieldrin Dioxin Temperature	Bacteria DDT Dieldrin Temperature	Bacteria Phosphorus TSS Temperature	Bacteria Temperature	Bacteria

303(d)-Listed Parameters				
Columbia River	**Willamette River**	**Columbia Slough**	**Johnson Creek**	**Fanno and Ash Creek**
Bacteria Dissolved oxygen pH DDT/DDE PCB Arsenic PAH Temperature	Mercury Manganese Iron DDT/DDE PCB Aldrin PAH	Manganese Iron	PCB PAH	Dieldrin

Pollution Reduction Exemptions

Rooftops

Projects that infiltrate stormwater runoff from rooftops using UICs (i.e. private soakage trenches or drywells) are not required to provide pollution reduction prior to infiltration. This exemption does not apply to projects that discharge stormwater offsite. All UICs must be registered with DEQ except for residential roofs (up to three units) and footing drains which are excluded from UIC regulations. Refer to **Section 1.4** for specific pollution reduction requirements for UICs.

Temporary Structures

Temporary structures (see **Definitions**) are exempt from **pollution reduction** requirements, subject to BES review. Exemptions will not be allowed in circumstances where permits or other municipal regulations may be violated if the requirement(s) are lifted.

Pollution Reduction Standards

In Portland, flow rate-based pollution reduction facilities are designed to treat runoff generated by a rainfall intensity of 0.19 inches per hour (depending on time of concentration; see **Exhibit 1-6**).

Exhibit 1-6: Rainfall Intensity Needed to Treat 90 Percent of the Average Annual Runoff in Portland for Flow Rate-Based Facilities

Site's Time of Concentration (Minutes)	Rainfall Intensity (inches per hour)
5	0.19
10	0.16
20	0.13

The above rainfall intensities must be used in the Rational Method (Q=CIA) equation to calculate pollution reduction runoff rates for rate-based pollution reduction facilities.

Facilities sized by routing a hydrograph through the facility (rate-based facilities with a storage volume component) may use a continuous simulation program (with a minimum of 20 years of Portland rainfall data) or a single-storm hydrograph-based analysis method, such as the Santa Barbara Urban Hydrograph (with 0.83 inch of rainfall over 24 hours and NRCS Type 1A rainfall distribution), to demonstrate treatment of 90 percent of the average annual runoff volume. (See **Appendix E** for more detailed information about the formulation of Portland's pollution reductions standards.)

Volume-based facilities are designed to treat runoff generated by 0.83 inch of rainfall over 24 hours (with NRCS Type 1A rainfall distribution) with a Vb/Vr (volume of basin/volume of runoff) ratio of 2, and will treat roughly 90 percent of the average annual runoff.

Manufactured Treatment Technologies

There will be sites where BES staff members and permit applicants agree that it is not technically feasible for vegetated facilities, including swales and planters, to meet all stormwater management requirements for the proposed impervious area. Manufactured treatment devices may be considered for sites in separated storm sewer areas when slope and infiltration limitations prevent the use of any reasonably located vegetated facilities (lined or unlined) or for sites unable to size the water quality storm (.83" in 24 hours). In those instances, specific approved manufactured treatment technologies may be proposed for pollution reduction.

If BES staff members agree that a manufactured treatment technology is appropriate, the applicant may select a treatment device from the approved vendor list under the Presumptive Approach in **Chapter 2**. Other facility types that are not on the list may be used in some specific applications that include additional treatment in a "treatment train," but must be submitted to BES as a Performance Approach.

As of this writing, the proprietary technologies that have been demonstrated to meet Portland's pollution reduction requirements are limited, particularly those approved as "stand-alone pollution prevention facilities." The approved vendor list is posted on the BES website at: http://www.portlandonline.com/shared/cfm/image.cfm?id=205377

Additional Pollution Reduction Requirements for Vehicle and Equipment Traffic Areas

Vehicle and equipment traffic areas with the following characteristics must also incorporate a coalescing plate oil/water separator into the stormwater management design:

- Commercial or industrial parking lots that store wrecked or impounded vehicles.
- Areas with a high likelihood of total oil and grease loadings—e.g., vehicle repair, vehicle sales, and vehicle fueling services.

Requirements:

1. The coalescing plate oil/water separator must be installed upstream of the stormwater management facilities, and the sizing must meet **Section 4.3.2** requirements. Examples of oil/water separators are located in **Appendix G.5** (Typical Detail **SW-501)**.

2. An operations and maintenance (O&M) Plan, per **Chapter 3 and Appendix D.5** requirements, must be submitted for the oil/water separator.

3. Vehicle and equipment traffic areas that trigger these requirements must be paved with an impervious material; pervious/porous pavements are not allowed. Gasoline can react with asphalt pavement and compromise its integrity. Areas that have a high risk of gasoline spills or exposures must therefore be paved with concrete.

4. If discharging to a public or private UIC, the federal Safe Drinking Water Act requires a state-issued UIC authorization by rule or a water pollution control facility (WPCF) permit for facilities that have subsurface discharges of stormwater or wastewater. These permits must be obtained from DEQ before any subsurface injection system is constructed. DEQ may classify the vehicle and equipment traffic areas described in this section as high risk and may not allow the use of UICs for stormwater disposal. Discharge of any stormwater mixed with runoff from motor vehicle waste from repair or maintenance activities or fluids from industrial or commercial areas where hazardous substances, toxic materials or petroleum

products are stored, used or handled is prohibited. Contact DEQ and review **Section 1.4** for information about infiltration prohibitions in certain areas of the City and additional UIC requirements. Private discharges to a City UIC are prohibited.

5. Alternatives to these requirements can be requested by filling out the Source Control Special Circumstances form located in **Appendix D8**.

Pollution Reduction in Combined Sewer Areas

Pollution reduction is required in combined sewer areas for both public rights-of-way and private property, unless all of the following conditions are met:

1. The project has used vegetated stormwater management facility types to the maximum extent feasible, as approved by BES.

2. BES has assessed the impacted downstream area and confirmed that flow from the combined system will at no juncture be diverted to a surface water body, except as intended by the municipal system's design.

3. Future adopted plans for the combined sewer overflow (CSO) program do not include a separation of that conveyance system.

4. No activities are planned for the site that will require stormwater pollution prevention measures, as described in **Chapter 4** of this manual.

5. There is no significant risk of pollutant loading of a degree or nature that cannot be treated by the proposed stormwater facilities.

6. An offsite management fee is paid to BES. (See **Appendix D.7** for the appeal process to request an offsite management fee.)

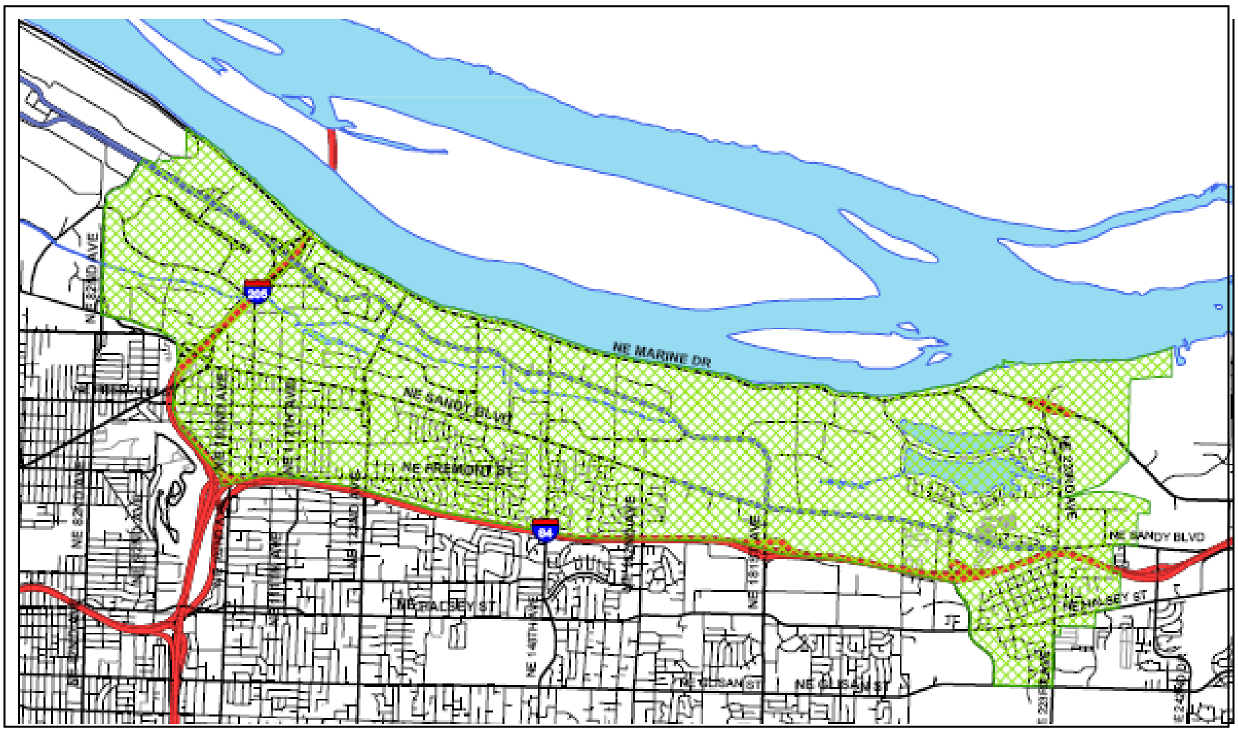
1.3.4 Columbia South Shore

Columbia South Shore Well Field Wellhead Protection Area

The Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003) regulates the storage, handling, use, and transportation of hazardous materials in the Columbia South Shore Well Field Wellhead Protection Area (see **Exhibit 1-7**). Requirements apply to indoor and outdoor storage areas; loading and unloading areas; fuel dispensing facilities; storage, maintenance, and repair of vehicles and equipment; and transportation routes on private property and in public rights-of-way.

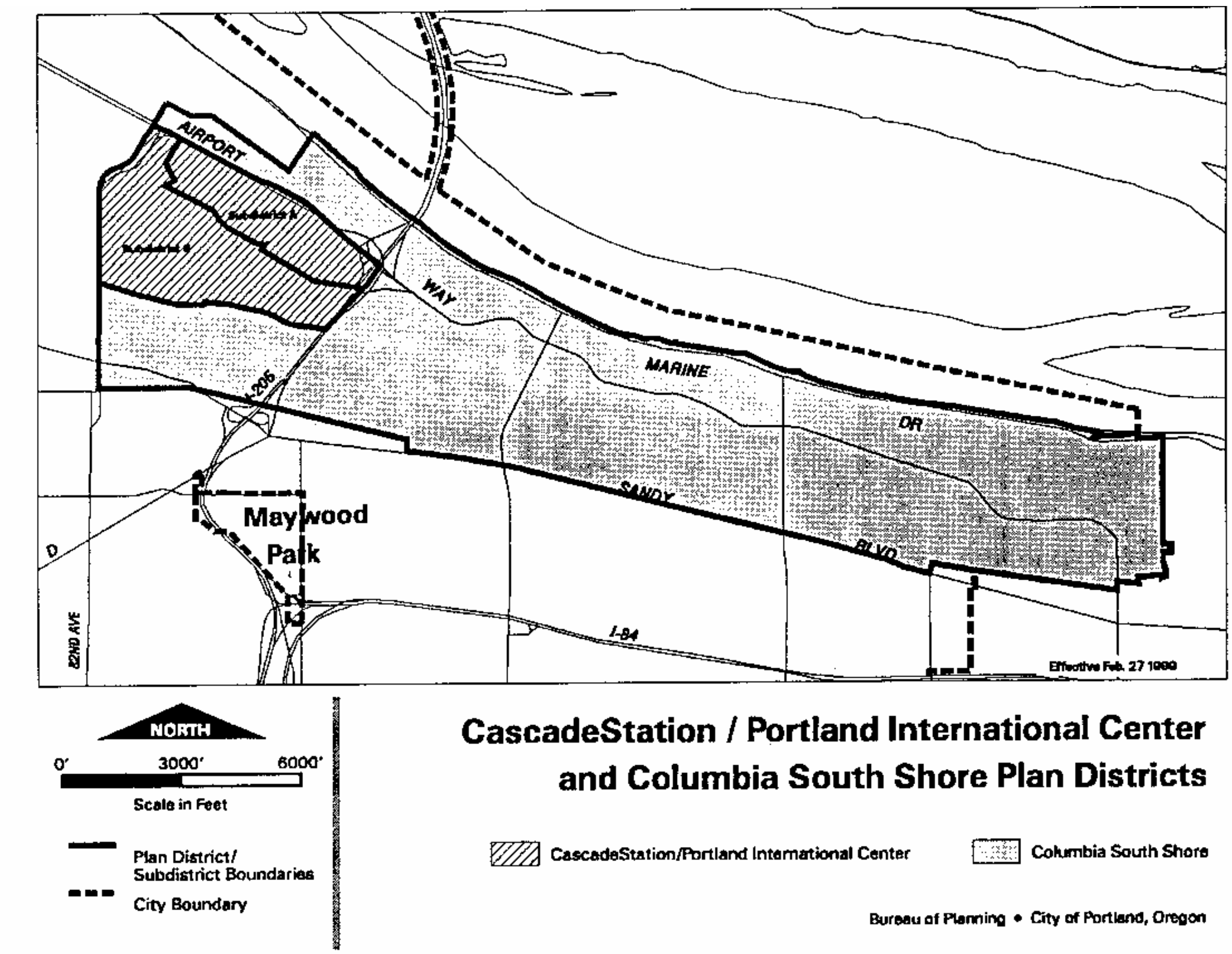
To protect groundwater from spills of hazardous materials, the requirements focus on spill control measures and prevention of infiltration into the ground. In portions of the wellhead protection area, drainage facilities in the public right-of-way must be lined with a polyethylene geomembrane liner and have appropriate spill control measures. Material and installation requirements for the polyethylene geomembrane liners are stated in Sections 00350 and 02320 of the *2007 City of Portland Standard Construction Specifications*. Planting trees or deep rooted shrubs over the top of required polyethylene geomembrane liners is prohibited in the wellhead protection area to protect the liners from root damage. Water Bureau review is required to determine which requirements apply. In some instances, infiltration may be allowed.

Exhibit 1-7: Columbia South Shore Well Field Wellhead Protection Area



The Columbia South Shore Plan District (Zoning Code Chapter 33.515.255) and Cascade Station/Portland International Center Plan District (Zoning Code Chapter 33.508.270) (see **Exhibit 1-8)** prohibit all new sumps, septic tanks, and other onsite disposal systems for sanitary disposal or disposal of industrial process water. All onsite stormwater and wastewater treatment and disposal systems must be discharged into a system approved by BES and BDS.

Exhibit 1-8: Cascade Station/Portland International Center and Columbia South Shore Plan Districts



1.3.5 Summary of Stormwater Management Requirements

Properties that propose new offsite discharges or new connections to the public system must comply with stormwater **infiltration and discharge** requirements for the impervious area draining to the discharge point, as specified in the stormwater hierarchy described in **Section 1.3.1.** **Exhibit 1-9** summarizes these requirements.

Exhibit 1-9: Summary of Infiltration and Discharge Requirements

Infiltration and Discharge	Stormwater Hierarchy
Applies citywide. See **Section 1.3.1**. The Bureau of Development Services (BDS) approves infiltration on **private** property; the Bureau of Environmental Services (BES) approves infiltration on **public** property, including the public right-of-way and approves offsite discharge locations. ***Exemptions****: Sites with soils that do not infiltrate (less than 2.0 in/hr tested infiltration rate), unstable soils, contamination or high risk of contamination, and wellhead protection areas are exempt from the total infiltration requirement. Flow control and pollution reduction requirements still apply.*	• **Category 1**: Vegetated infiltration facility with no overflow. • **Category 2:** Vegetated facility with overflow to sump, drywell, or soakage trench. • **Category 3:** Vegetated detention facility with overflow to drainageway, stream, river, or storm-only pipe. • **Category 4:** Vegetated detention facility with overflow to a combined sewer.

Projects that develop or redevelop over 500 square feet of impervious surface are required to comply with the **flow control** and **pollution reduction** requirements described in **Section 1.3.2** and **Section 1.3.3**, respectively. Properties with existing development that propose new offsite discharges or new connections to the public system must also meet the pollution reduction and flow control requirements. **Exhibit 1-10** summarizes these requirements.

All projects must comply with **Chapter 3** operations and maintenance requirements and **Chapter 4** source control requirements.

Exhibit 1-10: Summary of Flow Control and Pollution Reduction Requirements

<table>
<tr><th colspan="2">Flow Control (Detention and Retention)</th></tr>
<tr><td>Applies citywide to all projects that develop or redevelop over 500 square feet of impervious area.

Flow control facilities are approved by BDS and BES.

Detention exemptions: Sites that drain directly to the Columbia or Willamette Rivers or Columbia Slough (see site evaluation maps listed in References and Resources) and via storm-only systems with adequate capacity.

Retention exemptions: Sites with unstable soils, contamination, or high risk of contamination.</td><td>• Must use vegetated retention facilities to infiltrate onsite to the maximum extent feasible.

• For discharge to a surface water body or storm-only system that discharges to surface water (other than those exempt), must detain:
– 2-year post-development peak runoff rate to one-half of the 2-year pre-development peak rate
– 5-year post-development peak runoff rate to 5-year pre-development peak rate
– 10-year post-development peak runoff rate to 10-year pre-development peak rate
– 25-year post-development peak runoff rate to 25-year pre-development peak rate

• For discharge to a combined sewer, must detain the 25-year post-development peak runoff rate to the 10-year pre-development peak rate.

• For all other discharge points the base requirement is maintain peak flow rates at their pre-development levels for the 2-year, 5-year, and 10-year, 24-hour runoff events.</td></tr>
<tr><th colspan="2">Pollution Reduction (Water Quality)</th></tr>
<tr><td>Applies citywide to all projects that develop or redevelop over 500 square feet of impervious area.

Pollution reduction facilities are approved by BDS and BES.

Exemptions: Runoff from residential roofs (three units or less) that goes to infiltration facilities.</td><td>• Must achieve 70 percent TSS removal from 90 percent of the average annual runoff.

• In watersheds with a TMDL or on DEQ's 303(d) list of impaired waters, must use a pollution reduction facility that will reduce pollutants of concern.

• Must use vegetated facilities to the maximum extent feasible.</td></tr>
</table>

1.4 UNDERGROUND INJECTION CONTROL (UIC) STRUCTURE REQUIREMENTS

This section provides general UIC information only. Complete UIC regulations and requirements are available on the DEQ website:
http://www.deq.state.or.us/wq/uic/uic.htm

DEQ defines a UIC as any system, structure, or activity that is intended to discharge fluids below the ground surface. UICs can pollute soil and groundwater if not properly designed, sited, and operated. Stormwater systems such as, but not limited to, sumps, drywells, and soakage trenches are examples of UICs subject to DEQ regulation.

DEQ can also classify other systems as UICs, depending on the design. Additional information about UIC determination is available on the DEQ website noted above. Examples of systems that DEQ can classify as UICs are provided below, along with criteria to help determine when the system is or is not a UIC.

UICs are regulated under the federal Safe Drinking Water Act (administered by DEQ) and the State Plumbing Code. Applicants must obtain authorization from the DEQ Water Quality Division, UIC Program before constructing, operating, modifying, or decommissioning any UIC.

Surface Infiltration Facilities
DEQ generally does not classify surface infiltration facilities such as pervious pavements, swales, planters, and basins as UICs.

Perforated Pipe Systems
An assemblage of perforated pipes, drain tiles, or other similar mechanisms, including French drains, designed and intended to collect and convey infiltrated stormwater to another disposal or discharge point is not classified as a UIC. However, the final discharge point receiving stormwater from the collection or conveyance system may be classified as a UIC. If the final discharge point is below the ground surface, the system is generally classified as a UIC.

Pervious Pavements
When pervious pavement is designed with perforated pipe(s) to convey the stormwater to another point of discharge, DEQ does not classify the system itself as a UIC; however, the point of discharge may be classified as a UIC. When pervious pavement is designed with a trench that is deeper than it is wide or with perforated pipe(s) under the pervious pavement, DEQ may classify the pervious pavement as a UIC. Utility trenches such as water, sewer, and gas lines are exempt from this classification.

If it is difficult to determine whether the proposed stormwater system design is or is not a UIC, it is best to consult with DEQ prior to submitting a City permit application.

UIC Registration, Rule Authorization, and Permitting

Owners or operators of new and existing public or private UICs, with the exception of single-family residential roof and footing drains, are required to register and provide site inventory data to DEQ.

Rule authorization allows the owner to operate a UIC without a water pollution control facility (WPCF) permit from DEQ. For rule authorization approval, UICs must meet the requirements of OAR Chapter 340, Division 44. These requirements are summarized below under *Criteria for UIC Rule Authorization*.

In some instances, DEQ may issue a permit for UICs instead of rule authorization; this is determined on a site-specific basis.

This section of the manual focuses on proposed public or private UICs for new construction and redevelopment, including UIC closures. Therefore, registration and rule authorization for proposed public and private UICs only (not existing UICs) will be discussed further.

The difference between a public and private UICs is:

Public UIC: A public UIC collects stormwater from publicly owned facilities, parking lots, and public rights-of-way and is managed by the City of Portland.

Private UIC: A private UIC collects stormwater from private property, including roofs, parking lots, and other impervious surfaces, and discharges it to an onsite UIC. The onsite UIC is managed by the private property owner.

Development that proposes the use of either public or private UICs must follow the infiltration and discharge requirements in **Section 1.3.1** and meet all other requirements within this manual for managing stormwater.

DEQ has set minimum criteria for rule authorization, listed below and also found on the DEQ website at http://www.deq.state.or.us/wq/uic/authorization.htm.

- Only stormwater will be entering a UIC.
- Site development, design, construction, and management practices have minimized stormwater runoff entering the UIC.
- No other stormwater disposal destination is appropriate. Note: Discharge to the combined sewer system is not considered an appropriate discharge point if onsite infiltration is approved.
- UICs must not be located within 500 feet of water supply wells (domestic, irrigation, or industrial).
- UICs must not be located within 500 feet or a two-year time of travel of public drinking water supply wells (whichever is more protective).
- No soil or groundwater contamination is present.
- The UIC is not deeper than 100 feet and does not discharge within required separation distances of the highest seasonal groundwater level:
    - ✓ For UICS ≤ 5 feet deep, the separation distance is a minimum of 5 feet.
    - ✓ For UICs > 5 feet deep, the separation distance is 10 feet.
- A confinement barrier or filtration medium is present, or best management practices (BMPs) are used to prevent or treat stormwater contamination prior to entering a UIC.
- Design and operation of the UIC prevents accidental or illicit spills and allows for temporary blocking.

Compliance with these criteria must be demonstrated during the registration process to obtain rule authorization. If the criteria cannot be met, the applicant will have to apply for a permit or use another method of stormwater disposal. The provision of all required information in the application form will ensure a more timely review and approval process.

UIC Rule Authorization Process

DEQ has issued a WPCF permit to the City to construct and operate public UICs as specified within the permit. The permit requires the City to develop and implement a comprehensive management plan that details how the City will construct, operate, and evaluate UICs to ensure compliance with permit requirements. Because of the City's permit, the rule authorization process for proposed public UICs is different than for private UICs. The public and private rule authorization processes are outlined below.

Constructing New UICs

Public UICs

The City of Portland manages the registration and rule authorization submittal process for public UICs proposed for construction, redevelopment, or decommissioning. To ensure a timely rule authorization process, it is critical for applicants to notify the City immediately once they have determined that UICs may be used for stormwater discharge from the public right-of-way. The City will complete the rule authorization process in accordance with the requirements of the City's WPCF permit. Notice to proceed will be given when the City determines that the proposed UIC meets permit requirements.

Private UICs

For private development or redevelopment using UICs for stormwater discharge, applicants must apply directly to DEQ for rule authorization before constructing the UIC. To ensure a timely review by DEQ, all required information should be provided in the application. For general requirements, see *Criteria for UIC Rule Authorization*, above. A City building permit does not authorize the construction of a UIC on private property; only DEQ can authorize a UIC.

DEQ recommends that registration and rule authorization applications for UICs serving private property should be submitted to DEQ according to the following timelines:

> *Summer: At least 90 days prior to construction*
> *Winter: At least 60 days prior to construction*

These timelines could be exceeded if all the required information is not provided by the applicant at the time of submittal. The applicant should allow for an appropriate amount of time to obtain all required information prior to submittal. For time-sensitive projects, DEQ recommends that applicants contact DEQ directly for an estimated application turn-around time.

DEQ requires a copy of the rule authorization approval letter to be kept onsite for local, state, and federal inspections.

Depth to Groundwater Investigation Requirements

Part of the rule authorization and permitting process requires both public and private UICs to have a minimum separation distance between the bottom of the UIC and the seasonal high groundwater level (see **Exhibit 1-11**). Several areas within the City have known shallow groundwater. Within areas of known or suspected shallow groundwater, additional information about depth to groundwater (DTW) must be collected to ensure the bottom of the proposed UIC meets separation distance requirements.

Exhibit 1-11: Depth to Groundwater Requirements

Depth of UIC	Minimum Separation Distance between the Bottom of UIC and Seasonal High Groundwater
≤ 5 feet deep	5 feet
> 5 feet deep	10 feet

To determine if a DTW investigation is required for a proposed public or private UIC, refer to **Appendix F.1** *Depth to Groundwater Investigation,* and the *Estimated Depth to Seasonal High Groundwater* map located in **References and Resources** section. The City derived this map based on the *Estimation of Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area,* prepared by the United States Geological Survey (USGS).

For public or private UICs proposed within the **50-foot** groundwater contour of the above-referenced map, the applicant must provide the site-specific DTW investigation. One of the following methods must be used to obtain the DTW measurement:

- Install a temporary piezometer.
- Use existing onsite or nearby high-quality shallow groundwater level data.

For DTW investigation installation, DTW measurement, and reporting requirements and criteria for using existing data, see **Appendix F.1** under *Depth to Groundwater Investigation*.

UIC Decommissioning Process

The decommissioning, or closure, of a UIC system requires submittal of a completed pre-closure notification application to DEQ prior to closure. The pre-closure application requires information about the UIC, development of a sampling plan, and collection and laboratory analyses of any sediment and standing water from within the UIC in accordance with the sampling plan to ensure that site remediation or cleanup is not necessary prior to closure. Include sufficient time in construction schedule to accommodate the time necessary to collect, analyze, and summarize any sediment and water samples collected for decommissioning. DEQ recommends that applications be submitted 60 days prior to closure.

If flow is redirected from a private UIC to a City stormwater or drainage system, all new discharge connections must meet the requirements of this manual.

Public UICs

The City of Portland manages the pre-closure application submittal process for public UICs proposed to be decommissioned. The City will complete the decommissioning process in accordance with the City's *UIC Management Plan, Appendix D: Decommissioning Procedure for UIC Systems*.

Private UICs

Pre-closure applications for private UICs must be submitted directly to DEQ. A City building permit does not authorize the decommissioning of a UIC on private property. Only DEQ can authorize the decommissioning of a UIC.

For questions regarding rule authorization, permitting, and decommissioning of UICs, call (503) 229-5886.

For copies of UIC registration applications, call 503-229-5189.

Rule authorization, permit, and pre-closure applications, along with general information, can be found on the DEQ website at: http://www.deq.state.or.us/wq/uic/uic.htm.

Rule authorization and pre-closure applications for private UICs should be sent, along with the associated application fee, to:

Oregon Department of Environmental Quality
Business Office
811 SW 6th Avenue
Portland, OR 97204

For technical questions, call the DEQ UIC Program at 503-229-5945.

Registration and Rule Authorization Resources

Resources are available to help the applicant provide the required criteria for rule authorization. Below is a partial list of resources. Resources are also provided on the DEQ UIC registration forms.

- Well logs and drinking water well locations: Oregon Water Resources Department, http://www.wrd.state.or.us
- Site cleanup and releases: DEQ Profiler: http://deq12.deq.state.or.us./fp20
- Depth to groundwater: US Geological Survey, (503) 251-3200

1.5 NON-CONFORMING PARKING LOT AND LANDSCAPE REQUIREMENTS

In addition to the requirements of this manual, development and redevelopment projects must also meet the following requirements of City Code (Title 33: Planning and Zoning).

Chapters 33.266 (Parking and Loading) and 33.248 (Landscaping and Screening) identify parking requirements and development standards.

Chapter 33.258 (Nonconforming Situations) requires nonconforming parking and maneuvering areas to be brought toward compliance with current landscaping requirements under certain conditions (Section 33.258.070). Many of these parking lots lack stormwater facilities and must also upgrade their stormwater facilities if it is feasible to use the new landscaped areas for stormwater treatment and discharge. Feasibility is determined by a number of factors, including but not limited to the following:

Grade: Existing grades must allow for stormwater to sheet flow directly to the new facilities. This requirement does not apply when it is impractical for runoff to flow into landscaped areas.

Soil conditions: Soil conditions must be evaluated to determine if infiltration is feasible at the proposed location. Sites that have contaminated soils conditions must be evaluated by DEQ to determine if areas on the property are suitable for infiltration without the risk of mobilizing contaminants in the soil or groundwater.

Surrounding development: Because infiltration facilities must be setback 5 feet from any property line, sites where perimeter landscaping abuts the property line will be evaluated for stormwater infiltration. Review will consider, among other things, the location of existing development on abutting or downhill parcels.

If a stormwater facility is determined feasible, the appropriate sizing requirements, as specified in **Chapter 2** of this manual, must be used to calculate the size of the facility.

1.6 LEED CREDITS

In 2001, the City adopted a Green Building Policy that requires new construction and major renovations of all City facilities to meet the "Certified" level of LEED (Leadership in Energy and Environmental Design). The policy was updated in 2005 to require that new City facilities earn at least LEED Gold and go 30 percent beyond the City of Portland's *Stormwater Management Manual* baseline code requirements. In addition, the policy requires 70 percent ecoroof coverage on all new or replacement roofs.

In 2005, the Portland Development Commission (PDC) adopted a similar policy that requires LEED Silver certification for all publicly financed private-sector projects (that have PDC financing equal to or greater than 10 percent of total project costs and over $300,000) larger than 10,000 square feet. To help offset the cost of LEED certification, the Oregon Department of Energy expanded the state Business Energy Tax Credit (BETC) to include buildings rated LEED Silver and higher, which has become a powerful incentive for developers and building owners to design and build to the LEED standard. These policies, in addition to a number of other green building initiatives throughout the City, are helping move environmental building practices and LEED certification forward in Portland.

The stormwater management requirements included in this manual support the achievement of LEED v2.2 for New Construction Sustainable Sites Credits 6.1 and 6.2.[4] The requirements can also assist with integrated credit strategies relating to water-efficient landscaping, water use reduction (using stormwater for non-potable uses such as landscape irrigation, toilet and urinal flushing, and custodial uses), and heat island effects from roofs.

Sustainable Sites Credit 6.1 Stormwater Management: Rate and Quantity

With Portland's requirement to maximize onsite infiltration, the rate and quantity of stormwater that leaves a site depends on the amount of stormwater that can be infiltrated. Vegetated facilities that achieve total onsite infiltration designed with Portland's **Simplified Approach** or **Presumptive Approach** (presented in **Chapter 2**) meet the LEED stormwater management standard for rate and quantity and therefore qualify for Sustainable Sites Credit 6.1 (see **Exhibit 1-12)**.

[4] The LEED Rating System is an evolving menu of products and standards. Similarly, the requirements in Portland's Stormwater Management Manual are subject to change. It is the responsibility of the LEED team member assigned to the stormwater management credits to verify that the project will fulfill the credit requirements. The City of Portland assumes no responsibility for verifying or interpreting credit achievement.

Exhibit 1-12: LEED Sustainable Sites Credit 6.1 Stormwater Management: Rate and Quantity

Option 1 - Existing imperviousness is less than or equal to 50 percent
Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development 1- and 2-year, 24-hour design storms.

OR

Implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream protection strategy and quantity control strategies.

Option 2 - Existing imperviousness is greater than 50 percent
Implement a stormwater management plan that results in a 25 percent decrease in the volume from the 2-year, 24-hour design storm.

In Portland, if a site is unable to achieve total infiltration, the flow control standards that apply depend on the point of discharge. In any case, Portland's flow control standards are different from those specified in Credit 6.1. It is therefore necessary for the applicant to conduct additional analysis beyond the Simplified and Presumptive sizing methodology to demonstrate that the LEED Credit 6.1 requirements are met.

If some other calculation method is used under the **Performance Approach** (presented in **Chapter 2**), the applicant is responsible for demonstrating that the LEED stormwater management standard for rate and quantity is met.

Sustainable Sites Credit 6.2 Stormwater Management: Treatment

The City of Portland's pollution prevention (or treatment) standard is a performance standard that requires 70 percent average annual TSS removal from 90 percent of the average annual rainfall. (See **Appendix E** for more detailed information.) Vegetated facilities designed using Portland's **Simplified Approach** or **Presumptive Approach** are presumed to generally exceed the LEED stormwater management standard for treatment (80 percent average annual TSS removal from 90 percent of the average annual rainfall) and therefore qualify for Sustainable Sites Credit 6.2 (see **Exhibit 1-13**). If the facilities are designed using some other calculation method under the **Performance Approach**, the applicant must demonstrate that the LEED stormwater management standard for water quality treatment is met.

Exhibit 1-13: LEED Sustainable Sites Credit 6.2 Stormwater Management: Treatment

Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater from 90 percent of the average annual rainfall, using acceptable BMPs. BMPs used to treat runoff must be capable of removing 80% of the average annual post development TSS load based on existing monitoring reports.

For more information about LEED requirements, see the U.S. Green Building Council's website at http://www.usgbc.org/.

1.7 SPECIAL CIRCUMSTANCES AND APPEALS

Special Circumstances

Special circumstances on a proposed site may make it impractical to implement onsite pollution reduction or flow control to the standards specified in this chapter. In that case, applicants may fulfill all or a portion of their stormwater management obligations by compensating the City for the future development of offsite facilities.

Onsite stormwater management must be achieved to the maximum extent feasible, as approved by the City, in all cases before any offsite facilities or fees will be allowed. **Appendix D.7** provides additional information and contains a **Special Circumstances Form** that must be submitted.

Special circumstances may make it impractical to meet the source control requirements of Chapter 4. In that case, applicants may propose alternatives or exceptions. Appendix D.9 provides additional information and contains a Source Control Special Circumstances Form that must be submitted.

> **Impervious Area Reduction Techniques**
>
> Applicants should thoroughly consider impervious area reduction techniques before designing a stormwater management plan (see **Section 2.3.1**). If site conditions are appropriate, the use of these techniques can reduce the required size of a stormwater management facility. This can be especially important if a site is unable to fully meet the stormwater management requirements. Depending on the scope and impact of a project, BES may require consideration of an onsite ecoroof or pervious pavement before any special circumstance is allowed.

Appeals

The City has an appeals process that allows applicants to appeal staff interpretation of the City Code and of adopted policies and procedures that guide the review of development proposals. Applicants may appeal any issue related to interpretation of the stormwater management policy (e.g., staff assessment of a site's stormwater management level or a permit denial).

Appendix D7 describes the appeals process for the requirements of Chapters 1 through 3 (except Section 1.3.3). **Appendix D.9** describes a separate appeals process for Section 1.3.3 and for the source control requirements in Chapter 4.

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Chapter 2 FACILITY DESIGN

This chapter provides the information needed to select and design stormwater management facilities that meet the City of Portland's pollution reduction, flow control, and infiltration and discharge requirements. It is divided into three main sections: site planning, sizing methodologies, and facility design.

2.1 SITE PLANNING

As presented in Chapter 1, the City of Portland requires stormwater to be managed onsite to the maximum extent feasible before it is discharged to a pipe system with limited capacity or to a surface drainage channel. This is achieved by limiting effective impervious area and by directing stormwater to vegetated areas designed to manage stormwater.

This section introduces several overarching goals for integrating stormwater requirements into a comprehensive site plan and outlines the overall process for creating and permitting a stormwater management plan.

2.1.1 Design Goals

The following goals provide guidance for incorporating stormwater management facilities into an integrated site design.

Goal 1: Create an Informed Project Team

Early in the design process, it is critical to establish a clear understanding of the City of Portland's stormwater requirements with all members of the project team. With Portland's emphasis on vegetated facilities, stormwater management decisions have expanded beyond traditional civil engineering expertise. Members of the design team may include the developer, the developer's representatives, civil engineers, geotechnical engineers, landscape architects, architects, geologists and planners. It is recommended that licensed design professionals develop the stormwater management plan or oversee its development. On teams where there is more than one design professional making stormwater management decisions, clear roles and responsibilities should be established to ensure efficient communication and design development.

Stormwater management can greatly impact project permitting, as well as the project schedule and budget; therefore, it is important to anticipate potential issues and encourage early collaboration across all disciplines. Project team members should be prepared to strategize and integrate solutions that reduce impervious area, limit stormwater discharge, and protect and improve water quality.

Goal 2: Maximize Permeability, Minimize Offsite Discharge

Creating a site design with less pavement and roof area reduces the stormwater volumes and flow rates, which can ultimately result in smaller stormwater management facilities and lessen downstream impacts. Options include clustering the development to limit the building footprint, as well as **impervious area reduction techniques** (see **Section 2.3.1** for guidelines and specifications). Maximizing permeability at every opportunity requires the integration of many decisions at all levels of the project, from site planning to materials selection; these decisions should be made with stormwater management in mind.

Goal 3: Use Stormwater as a Design Element

Unlike conveyance systems that hide water beneath the surface and work independently of site topography, infiltration systems can work with natural land forms and land uses to become a major site design element. When stormwater management is considered during the conceptual design phase, the infiltration and drainage system can suggest building footprints and circulation routes. In this way, the drainage pattern helps generate the urban form, creating a more aesthetically pleasing relationship to the natural features of the site.

In addition to serving as the organizing element for the site, the drainage system can be integrated into development plans to:

- ✓ Improve site aesthetics.
- ✓ Provide recreational opportunities.
- ✓ Maximize land values.
- ✓ Improve project marketability.
- ✓ Help meet landscape and screening requirements.
- ✓ Provide wildlife habitat.
- ✓ Provide environmental education for employees, visitors, and the public.

Fencing or hiding stormwater facilities out of view not only loses the opportunity to create an aesthetically pleasing site design, but also sends the message that stormwater is an attractive nuisance. While there are legitimate concerns for safety and liability, these concerns can usually be resolved with careful design consideration, such as specifying shallow facility depths with gentle side slopes.

Plans that integrate stormwater facilities with the other development objectives can yield a series of small landscaped areas that meet other project objectives, rather than creating one large, fenced pond at the end of the conveyance system. Furthermore, facilities such as ecoroofs, swales, planters, and basins can all be landscaped with plants that are attractive and easy to maintain.

2.1.2 Steps in the Design and Permit Process

Once the project goals and objectives are established and the concept development is complete, the following steps are recommended for designing and permitting a stormwater management plan. See **Appendix D** for all submittal requirements and forms. A detailed explanation of each step is provided on the following pages.

1. **Evaluate the Site**
2. **Confirm Current Requirements**
3. **Characterize Site Drainage Area and Runoff**
4. **Determine Source Control Requirements**
5. **Develop Conceptual Design**
6. **Develop Landscape Plan**
7. **Complete Stormwater Management Plan**
8. **Prepare Operation and Maintenance Plan**
9. **Submit Final Plans and Obtain Permits**
10. **Construct and Inspect**

Steps 1 through 6 must be complete to ensure that Bureau of Environmental Services (BES) approval criteria and land use review requirements can be met. If an underground injection control (UIC) facility is proposed, steps 1 through 5 also allow the applicant to prepare for Oregon Department of Environmental Quality (DEQ) rule authorization or water pollution control facility (WPCF) permit application. Once a land use or DEQ decision is rendered, the applicant can proceed with steps 6 through 10. Steps 1 through 5 can also be referenced for early assistance and other preliminary reviews.

If land use review or DEQ authorization is not required for the development proposal, the applicant will generally complete steps 1 through 10 in the course of acquiring the required zoning, site development, building, and public works permits.

Note: Every project is different, and it is not within the scope of this manual to specify what permits or reviews are required. Every applicant is encouraged to visit the Development Services Center to identify comprehensive project review and permit requirements. (See **References and Resources** for contact information.)

Step 1: Evaluate the Site

The first step in designing a stormwater management plan is to document and evaluate existing site conditions. (See **References and Resources** for a list of available site evaluation maps.)

- Identify existing site features that could be protected or incorporated into the site. Identify existing natural or man-made drainage features, including open channels, drainageways, ditches, ponds, depressions, wetlands, streams, lakes, and rivers. Include riparian areas and other significant vegetation, including mature trees. Identify limits of development and access, as related to disturbance of soils, vegetation, and water quality sensitive areas.

- Delineate tree canopy on and around the site. If feasible, conserve or plan to supplement existing tree canopy, especially conifers.

- Identify surface and groundwater features that will affect the facility design, including size of drainage area/basin, topography and slopes, geologic formations, and seasonal groundwater levels. Document distance to drinking water wells, wellhead protection areas, and other groundwater areas of concern.

- Identify existing utilities, including all public and private storm, sanitary, and combined sewers, as well as water lines. (Refer to site evaluation maps in the **References and Resources** section.) Identify drainage flows across the property from upland areas to downstream receiving waters.

- Private systems may need to be decommissioned and public service provided. Locate existing sumps, drywells, cesspools, and septic systems. Contact Records & Resources at (503) 823-7660 for plumbing as-builts and access to building plans on private property. Contact BES System Development Assistance at (503) 823-7761 for as-builts on public property.

- Consider land use, traffic area and circulation, and other water quality concerns with respect to contributing drainage basins. Plan to keep stormwater management facilities a safe distance from operations that involve hazardous materials or solid waste.

- Research existing soil conditions, particularly infiltration potential and whether contamination exists onsite. Determine hydrologic soil group, soil drainage class, and potential for erosion. (Refer to site evaluation maps in the **References and Resources** section.) Examine boring and/or infiltration test results from nearby drywells or sumps to support the feasibility of infiltration.

Step 2: Confirm Current Requirements

The next step is to confirm current requirements for the site.

- This is the appropriate time to confirm all required City of Portland reviews and permits, as well as all other permit requirements—e.g., NPDES construction site and discharge permits, UIC authorization, and other applicable requirements.

- In addition to confirming stormwater management requirements, identify setbacks (see **Exhibit 2-1**), easements, protected areas, and other site restrictions by consulting all applicable standards and requirements. These include, but are not limited to, environmental zones, wellhead protections areas, greenway overlays, plan districts, tree root protection areas, landscape and/or screening requirements, and all other zoning or density requirements.

- Collect and confirm existing reports, tests, or studies required for site development—e.g., phase I and phase II environmental site assessments and geotechnical reports.

- If the site conditions and/or the development proposal is complex, contact the Bureau of Development Services (BDS) to initiate an Early Assistance meeting with City staff to discuss conceptual site plan ideas. If the project is subject to a land use review, the pre-application process may also be initiated. Contact the Stormwater Early Assistance Team at (503) 823-7761 for more information.

Exhibit 2-1: General Summary of City of Portland Setbacks

Setbacks are measured from the center of the stormwater facility to the adjacent boundary, structure, or facility. All setback distances provided are minimums that can be increased at the discretion of City of Portland staff. Setbacks assume that the stormwater facility is either level to or at a lower elevation than the finished floor elevation of any nearby structures. If an applicant proposes to encroach in a setback, an approved plumbing code appeal is required, and an impermeable liner or modifications to the plans may be required.

Distance in Feet	Setback from	Stormwater Facility
5	**Property line**	All infiltration facilities
10	**Any foundation**	All infiltration facilities
100	**Upslope from any drainfield**	All infiltration facilities
100	**Slopes 10% or greater**	Swales and basins
100	**Slopes 20% or greater**	Trenches and drywells
200	**Slope greater than 10' high & steeper than 2h:1v**	UIC
500 (or 2 yr time of travel)	**Drinking water well**	UIC

Notes:

- Waterproof, lined flow-through facilities may be located up to the property line as long as the facility is less than 30 inches above the lowest adjacent grade.
- No setbacks are required for permeable pavers, pervious asphalt, or pervious concrete. A liner may be required where if located within 5′ of infrastructure.
- Ponds – see pond guidelines in Section 2.3.
- Splash blocks - 2′ from foundation; 6′ from basement, 5′ from property lines, and 10' from adjacent property foundations.
- Plastic 2′x 2′ drywell – 8′ from foundation; 5′ from property line.
- Where grade is 20% or greater and the slope setbacks cannot be met, geotechnical reports or engineering will be required. This applies to all infiltration facilities.

Step 3: Characterize Site Drainage Area and Runoff

The third step involves evaluating the characteristics of the stormwater created by the proposed development or redevelopment.

- Determine if the project will use the Simplified, Presumptive, or Performance Approach (see **Section 2.2** for a complete description of each) to size the stormwater management facilities. This is important because it establishes the type and number of infiltration tests that will be required. Begin to gather the information needed for the stormwater management submittals. (See **Appendix D** for submittal requirements.)

- Conduct soil infiltration testing, as specified in **Appendix F.2**. Infiltration testing is also discussed in **Sections 2.2.1** and **2.2.2**.

- Begin to formulate how the stormwater management plan will meet the pollution reduction, flow control, and infiltration and discharge requirements of this manual.

- Work with BES staff to determine what upstream and downstream cumulative activities will impact the proposed project.

- Work with BES staff to determine if the capacity of the downstream receiving system (natural or manmade) must be characterized.

- If necessary, plan to safely route upstream flows across the site both during and post construction. Determine if drainageway protection is necessary. Refer to Appendix A.3: Drainage Reserve Administrative Rules if necessary.

- Develop preliminary calculations that estimate how much stormwater will be created, how much can be infiltrated onsite, and how much, if any, will be discharged offsite.

Step 4: Determine Source Control Requirements

Source control measures prevent contaminants from entering stormwater. This step evaluates whether source control issues apply to the project and identifies the appropriate measures to limit exposure of contaminants to stormwater.

- It is important to evaluate commercial and industrial sites. Depending on the activity, materials handled, and potential for spills at a site, the potential for high pollutant loads is typically greater than for other land uses. Cover of outdoor storage and work areas and other measures may be required. (See **Chapter 4** for more detail.)

- Some vehicle and equipment traffic areas (e.g., areas used for storage, repair, fueling, and washing of vehicles) are subject to specific requirements. (See **Section 1.3.3** and **Chapter 4** for more detail.)

- Stormwater management options may be limited in some cases because of contamination onsite or on an adjacent site, as determined by BES. If the site has groundwater or soil contamination, the facility must be lined with an impervious liner unless the contaminants of concern do not mobilize with stormwater or additional leachability testing and hydrology modeling have been completed to show that infiltration will not mobilize contaminants offsite or to surface waters.

Step 5: Develop a Conceptual Design

This step includes stormwater facility selection and preliminary sizing.

- Select the appropriate facility type, location, and size for each proposed facility (see **Section 2.2**). Consider detail specifications, especially minimum and maximum dimension and setback requirements.

- Develop a preliminary site grading plan. It is essential for impervious surfaces to be graded to drain toward the stormwater facilities. The facilities must also be depressed to allow sheet flow into the area. Since this design approach is still new to many construction contractors, it is advisable to clearly supplement the grading plan with appropriate cross sections and detailed drawings.

- Some situations, such as steep sites and high sediment loads, may limit facility options. Steep slopes will typically require more complex engineering. Plan to implement onsite erosion and sediment controls to reduce the amount of sediment getting into the stormwater. Excessive sedimentation can damage a facility and require costly repairs. Pretreatment may be necessary to protect vegetated facilities. If a facility will be used for erosion control during construction, it should be constructed before general grading occurs and rehabilitated after construction.

- Determine if hydrologic and hydraulic models specified in the City's *Sewer and Drainage Facilities Design Manual* are necessary to size the conveyance facility. Correlate calculations between the conveyance infrastructure and the stormwater facility sizing.

- Complete a conceptual site plan and necessary submittals required for land use review. Submit them to the City for review. Include preliminary design calculations that demonstrate how the proposed plan will meet the pollution reduction, flow control, and infiltration and discharge requirements, including which category of the stormwater hierarchy (**Section 1.3.1**) the project will achieve.

Step 6: Develop a Landscape Plan

Once the preliminary sizing is complete, attention to the proposed soils and vegetation is necessary. See **Section 2.3.2** for more detailed information about landscape requirements, **Appendix D.1** for submittal guidelines, and **Appendix F** for soil and plant specifications.

- At this step, it is appropriate to consult with a qualified landscape professional. Proper soil and plant selection is critical to the success of a facility and must not be left unspecified.

- Stormwater management facilities should be integrated with the other project landscape areas. Select plant species and develop a planting plan. Consider the use of native plants where appropriate. Harsh urban conditions may require hardier species.

- Schedule plantings so they are well established before concentrated flows are routed to a facility. If possible, plan to wait 3 to 6 months before routing water into a facility. If this is not possible, establish approved erosion control measures before routing stormwater to a facility.

Step 7: Complete a Stormwater Management Plan

Once the conceptual plan is complete (or approved through the land use review process), complete final plans and permit items. See **Section 2.2** for a more complete description of requirements and **Appendix D** for submittal guidance.

- Plans and specifications must be prepared or closely supervised by a certified design professional licensed in the State of Oregon.

- Confirm that all design criteria are met. Confirm that volume storage within a facility is adequate. Complete grading plans, including inlet and outlet locations, elevations, and sizes. Ensure that landscape construction and erosion control techniques are well described. Ensure adequate maintenance access to all stormwater facilities.

- Finalize the project schedule.

- Complete the facility design, with applicable construction documents.

- Finalize required stormwater submittals (forms, plans, reports).

Step 8: Prepare an Operation and Maintenance Plan

See **Chapter 3** for O&M submittal guidelines and a sample O&M plan.

- Outline the scope of activities, schedule, and responsible parties for inspecting and maintaining the facility, both during the warranty period (if applicable) and over the long term. Vegetation, compaction, sediment management, access, and safety are the primary issues to be addressed. Commercial and industrial sites generally require more frequent maintenance than residential sites.

- Vegetation may need temporary irrigation during times of drought, as well as mulch to retain topsoil, heat, and moisture and to suppress weed growth.

- Avoid the use of fertilizers, herbicides, or pesticides, especially in the main flow path of water (they are prohibited in public facilities). If they must be used, use sparingly and in a manner that minimizes the discharge of these pollutants into the stormwater.

- Temporary fencing may be needed to protect plants from foot traffic and construction activities that can compact soil and damage vegetation.

- Excessive sediment accumulation can block stormwater infiltration into a facility and damage vegetation and should therefore be monitored and removed promptly. Store and dispose of sediment in accordance with local regulations. (Refer to Metro at www.OregonMetro.gov or (503) 797-1700 for proper disposal options.) This is particularly important on sites with high pollutant levels and on contaminated sites.

- Facilities that will come into the City's ownership and operation are subject to more specific policies and guidance. See **Section 3.2.3.**

- If UICs are proposed, DEQ also requires an operations and maintenance plan.

Step 9: Submit Final Plans and Obtain Permits

- Submit all final plans and drawings to the City of Portland for review, final approval, and permitting of the project.

- Provide additional information to City staff reviewing the application, as requested, to expedite the review process.

- Once permits are approved and issued, call for locates and begin construction.

Step 10: Construct and Inspect

- Once design plans for **public facilities** are approved and permitted, the applicant must schedule a preconstruction meeting with all relevant bureau construction inspection teams to coordinate and evaluate all stormwater components of the project before construction. Meetings with design engineers, contractors, and construction review teams are integral to ensuring that all stormwater facilities are constructed according to the development goals, project plans, and current design specifications.

- City staff performs construction inspections on **public facilities** as needed. Initial inspection coordination is established at the preconstruction meeting. Inspections throughout the project are coordinated by the City inspector and the contractor or general manager.

- BDS performs construction inspections on **private property.** The inspections listed below are not all-inclusive and should be referred to for general guidance only. Please refer to BDS and the conditions of the permit for all inspection requirements. For additional information, refer to www.portlandonline.com\bds.

  - **Residential inspections** are required for one- and two-family dwellings, including duplexes and townhouses, under the scope of the Oregon Residential Specialty Code. Types of inspections include structural, mechanical, electrical, and plumbing permit inspections. The one- and two-family inspection section is also referred to as "combination inspections" because residential BDS inspectors inspect all aspects of the project.

  - **Commercial inspections** are required for industrial, commercial and multifamily construction projects. Types of inspections include structural, mechanical, electrical, and plumbing. Each type of inspection is requested separately and performed by a separate inspector.

  - **Additional inspections** may be required, including special inspections and site development inspections. When additional inspections are required, the applicant will be notified at the time of permit review.

- BES inspects private facilities to ensure long-term compliance and provide technical assistance on facility operation and maintenance.

- BDS uses an automated request system known as interactive voice response (IVR) to schedule inspections. Applicants receive the IVR numbers and information on how to request an inspection when they pick up their permit. The IVR phone system allows the applicant to schedule, cancel, and reschedule inspections and to get inspection results. To schedule, reschedule, or cancel a same-day inspection call (503) 823-7000. Request must be placed no later than 6:00 a.m.

2.2 SIZING METHODOLOGIES

This section presents three methodologies for sizing stormwater management facilities: the **Simplified Approach**, the **Presumptive Approach,** and the **Performance Approach**. Facilities sized with the Simplified and Presumptive approaches comply with the City's infiltration and discharge, flow control, and pollution reduction requirements (see **Section 1.3.5**). When the Performance Approach is used, it is up to the applicant to demonstrate that those requirements are met.

Applicability

Applicants must select **one** of the following approaches. Each approach has a unique plan review and approval process that establishes a permit track for the project. The final selection of a project design approach is subject to City approval.

For every application, the impervious area should include the **total** proposed impervious area, including all streets, tentative driveways plans, redeveloped areas, and tentative building footprints, based on the allowed building coverages and setbacks per the zoning code.

The **Simplified Approach** is available for projects with less than 10,000 square feet (.23 acre) total new or redeveloped impervious area, including but not limited to roofs, patios, parking areas, and driveways. (See **Section 2.2.1** for more information.) This approach is most appropriate for private, small-scale residential development, typically with limited professional design services available. It is not allowed for use on large, complex projects or on projects that have multiple catchments that, when combined, exceed 10,000 square feet of new or redeveloped impervious area. It is not allowed on projects that require a public works permit or include private street improvements.

The **Presumptive Approach** is available for medium- to large-scale residential and commercial projects of any size on either private or public property. Slightly modified requirements apply to streets. (See **Section 2.2.2** for more information.) This approach is required for projects with new or redeveloped impervious area of 10,000 square feet (.23 acre) or greater or projects with proposed street improvements. It can also be applied to size facilities on smaller projects where the more detailed hydrologic calculations will allow the applicant to size a facility more accurately by taking measured infiltration rates and other more specific design factors into account. This approach requires the assistance of a licensed engineer or qualified design professional.

The **Performance Approach** is available for projects with unique circumstances that require analysis that goes beyond the capabilities or specifications of the Simplified and Presumptive approaches. It may be used to address a range of circumstances, including but not limited to:

- Size a performance-based facility (wetlands, ponds, grassy swales, etc.).
- Propose an alternate design methodology or facility specification.
- Address unique site conditions.
- Apply a new or emerging design technology.

The Performance Approach requires the assistance of a licensed engineer or qualified professional. Detailed engineering calculations must be provided as evidence of the proposed design's performance with respect to the stormwater requirements provided in **Section 2.2.3**.

Escape Route

All projects designed with either the Simplified, Presumptive or Performance Approach must identify an **escape route** in the event the stormwater facility temporarily fails or rainfall exceeds the facility design capacity. The escape route must demonstrate that flows will be routed to maintain public safety and avoid property damage. Depending on site conditions, this may include an overflow structure or storage in parking lot, street, or landscaping areas. Applicants must describe where the flow will be routed on a basin site plan to illustrate where flood conditions or ponding is expected to occur.

2.2.1 Simplified Approach

Projects that use the Simplified Approach use a simple surface area ratio calculation to size stormwater facilities. The applicant quantifies the amount of new or redeveloped impervious area that is proposed and multiplies that area by a sizing factor that varies by facility type. The sizing factors were developed with analysis based on the Santa Barbara Urban Hydrograph (SBUH) method. **Appendix C.1** provides information about the SBUH method, and **Appendix C.2** provides information about the Simplified Approach basis of sizing.

Vegetated surface facilities available with the Simplified Approach include swales, planters, basins, and filter strips, all of which are designed to receive and manage stormwater runoff from adjacent impervious surfaces. All vegetated surface facilities designed with the Simplified Approach require an overflow to an approved discharge point. Onsite infiltration is achieved when overflows are directed to a s**ubsurface infiltration facility,** including but limited to drywells and soakage trenches.

Simplified Approach Infiltration Testing

The Simplified Approach requires, at minimum, one open pit infiltration test to be conducted before selecting and sizing facilities. (See the **Simplified Approach Form 1** in **Appendix D.3** for open pit test instructions.)

The Simplified Approach does not require correction factors be applied to the tested infiltration rate. A tested infiltration rate of 2 inches per hour or greater requires onsite infiltration. A tested infiltration rate of less than 2 inches per hour requires the use of a partial infiltration or flow-through facility with overflow to an approved discharge point. Exceptions apply depending on site conditions and the approved discharge point. See **Section 2.3** for a description of facility configurations and **Appendix F.2** for infiltration testing information. If the tested infiltration rate is greater than 2 inches per hour, the designer should consider the use of the Presumptive Approach where well draining soils can be factored in to more accurately design the stormwater facility.

Simplified Approach Submittal Requirements

Applicants using the Simplified Approach must submit a completed **Simplified Approach Form** as part of their permit application, along with a complete site plan, construction drawings, and facility details. An **Operations and Maintenance Form** and a copy of the appropriate **Operations and Maintenance Specifications** must also be included. The O&M Form is not required for drywells or soakage trenches that accept only residential roof runoff. On sites with steep slopes or shallow groundwater, BES or BDS may require a geotechnical report in order to evaluate the suitability of the proposed facility and its location.

See **Appendix D.3** for complete information about the submittal requirements and necessary forms for the Simplified Approach.

2.2.2 Presumptive Approach

The Presumptive Approach allows the designer to factor in site-specific data to determine the size and configuration of the stormwater facility. Like the Simplified Approach, the Presumptive Approach includes impervious area reduction techniques, vegetated surface facilities, subsurface facilities, and hybrid facilities. See **Section 2.3.1** for a complete overview of facility types.

The Presumptive Approach Calculator (PAC) is discussed below. The PAC allows the designer to size stormwater facilities with consideration of native infiltration rates and other unique site conditions of the project. See **Appendix C.3** for the PAC and the PAC User's Manual. The PAC is based on the SBUH methodology.

Vegetated surface facilities available with the Presumptive Approach include swales, planters, and basins, all of which are designed to receive and manage stormwater runoff from adjacent impervious surfaces. Under the Presumptive Approach, swales, planters, and basins can be designed as infiltration, partial infiltration, or flow-through facilities.

Subsurface facilities that can be used with the Presumptive Approach include drywells and sumps. Sizing assumptions and facility dimensions are required with every permit application.

Hybrid facilities can only be designed under the Presumptive Approach. They combine the benefits of vegetated surface facilities with those of subsurface infiltration facilities to provide pollution reduction, flow control, and full or partial infiltration. (See **Section 2.3.1** for a complete description of hybrid facilities.)

Presumptive Approach Infiltration Testing

The Presumptive Approach requires infiltration tests to be conducted before performing any design calculations. Three infiltration testing methods are available to determine the design infiltration rate:

- Open pit falling head
- Encased falling head
- Double-ring infiltrometer.

A qualified professional must exercise judgment in the selection of the infiltration test method. Refer to **Appendix F.2** for the number and location of tests required. Depending on site conditions and the proposed facility location, the City may adjust the required number of tests. If the location and/or orientation of the proposed facility are revised during the design process, retesting will be required, unless otherwise approved by the City.

The Presumptive Approach requires in all cases that **correction factors** be applied to the **tested infiltration rate** to determine the **design infiltration rate**. See **Exhibit F.2-1** for the corrections factors that apply.

For the Presumptive Approach a design infiltration rate of 2 inches per hour or greater requires onsite infiltration. A design infiltration rate less than 2 inches per hour allows the use of a partial infiltration or flow-through facility depending on site conditions. Exceptions apply depending on site conditions and the approved discharge point. See **Section 2.3** for a description of facility configurations and **Appendix F.2** for infiltration testing information.

Presumptive Approach Calculator (PAC)

The PAC is provided to perform sizing calculations for vegetated surface facilities with catchment areas up to 1 acre in size. **Appendix C.3** provides information about the **PAC,** including the **PAC User's Manual**. If the facility catchment size exceeds 1 acre, the designer must use appropriate alternative software that follows the same principles discussed under the calculations section below and must submit the project under the Performance Approach.

The designer must complete the Presumptive Approach Calculation Worksheets (located in the PAC) and enter the impervious catchment area, tested infiltration rate, and geometric design criteria of the stormwater facility. The worksheets serve to clearly summarize the catchment criteria for each project.

If the project designer proposes to deviate from the allowable ranges specified in the PAC, the proposal must be submitted under the Performance Approach.

Presumptive Approach Calculations

If the PAC is not used, the following principles must apply. The inflow hydrograph generated by the catchment area is routed through the surface infiltration facility modeled as a reservoir, with an infiltration rate of 2 inches per hour assumed for the growing medium. The model should **not** adjust the infiltration rate as the hydraulic head is increased.

When designing swales and basins where some infiltration can be accounted for through the side slopes, the entire area of the facility cannot be assumed to infiltrate. Infiltration through the side slopes is limited to the horizontal area at 75 percent of the maximum depth. To find the design infiltration area of the facility, follow the equations below or use the swale worksheet within the PAC.

When designing a stormwater facility (onsite surface and subsurface infiltration), calculations should confirm that the inflow hydrograph of the 10-year, 24-hour storm can be stored and infiltrated without exceeding the maximum depth or storage capacity of the facility. Where sites have a native soil design infiltration rate greater than the design infiltration rate of the growing medium, the analysis should assume a free outlet condition at the base of the growing medium. If the native soils have a lower design infiltration rate than the growing medium, it is necessary to route a second hydrograph through the drain rock below the growing medium, also modeled as a reservoir with infiltration. The inflow to the second hydrograph (gravel reservoir) is the outflow hydrograph generated through infiltration of the growing medium. Again, the analysis should confirm that this second hydrograph can be stored and infiltrated without exceeding the maximum depth or storage capacity of the gravel reservoir. If necessary, the size of the facility should be revised until capacity is not exceeded. There is the added complexity in cases where the gravel reservoir is filled while the surface facility is still draining. This full condition can influence the infiltration capacity of the growing medium and affect the results of the initial routing model

Presumptive Approach Required for Green Streets

The Presumptive Approach is required for sizing vegetated stormwater facilities in the public right-of-way and private streets. In addition to the other requirements and specifications provided in **Section 2.2.2,** the following apply:

- The open pit falling head infiltration test may be used for sizing street facilities, but depending on the development proposal and the existing site conditions, the City may require the double-ring infiltrometer test. Both the open pit falling head test and the double-ring infiltrometer test specifications are located in **Appendix F.2.** Refer to **Exhibit F.2-1** for the location and minimum number of tests required.

- **Street trees**, planted in accordance with the City of Portland Urban Forestry requirements, may be used as an impervious area reduction technique in the public right-of-way and on private streets. Refer to **Section 2.3.3** for more information.

- **Stormwater Management Typical Details** are available specifically for streets (see **Appendix G.3**). Commonly referred to as "Green Street Details," they are tailored to circumstances commonly found in the right–of-way. Vegetated stormwater facilities for streets are often affected by street design criteria and are subject to certain dimensional limitations.

Presumptive Approach Submittal Requirements

Applicants using the Presumptive Approach must submit a **Stormwater Management Report** as part of their permit application, along with a complete site plan, construction drawings, and details. An **Operations and Maintenance Form** and a copy of the site-specific **Operations and Maintenance Plan** must also be included.

See **Appendix D.4** for complete information about the submittal requirements for the Presumptive Approach.

2.2.3 Performance Approach

Applicants who have developed stormwater management facilities or plans that do not meet the requirements of the Simplified Approach or Presumptive Approach as described above must submit plans under the Performance Approach. Performance Approach submittals may include impervious area reduction techniques, vegetated surface facilities and subsurface facilities that vary from the specified design requirements. Performance Approach submittals will be reviewed by technical staff under the direction of the Chief Engineer or designee.

The Performance Approach may be used to:

- Size a performance-based facility (ponds, grassy swales, etc).
- Propose an alternate design methodology or facility specification.
- Address unique site conditions.
- Apply a new or emerging design technology.

Facilities must be designed using the hydrologic analysis methods described below. If these hydrologic analysis methods are not used, BES must pre-approve the alternative method before the plans and calculations are submitted. Regardless of how the hydrologic calculations are performed, all hydrologic submittals must include data necessary to facilitate BES's review.

The Presumptive Approach Calculator (PAC) can be used under the Performance Approach, with justification included for sizing variables outside the allowable ranges of the Presumptive Approach.

Infiltration and Discharge

If surface infiltration facilities such as swales, planters, or basins are proposed to meet infiltration requirements, the sizing methodology must rely on retaining the 10-year storm through a facility that can be calculated using SBUH, NRCS TR-55, HEC-1, or SWMM. The Rational Method must be used to design the infiltration flow rate for public infiltration sumps.

Flow Control

With the exception of facilities sized using the Simplified Approach, BES will use the SBUH to check design calculations for flow control facilities. The design professional may also use NRCS TR-55, HEC-1, or SWMM to demonstrate compliance with flow control standards.

The City will accept a proposed design for meeting pollution reduction requirements if the applicant demonstrates that:

- Facilities will perform at the required efficiency: 70 percent total suspended solids (TSS) removal from 90 percent of the average annual runoff (see **Section 1.3.3**) and is capable of reducing total maximum daily load (TMDL) pollutants of concern (if applicable). See **Appendix B**: Approved Vendor Technologies Submittal Guidelines, for definition of 70 percent TSS removal, which is actually a function of influent concentration. Also see **Appendix B** for required testing protocol, related definitions, and additional requirements. Documented performance is required and must include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.

- Facilities can be efficiently maintained to perform at the required level. Public facilities should not require more costly maintenance than facilities designed using the Simplified or Presumptive approach.

Flow Rate-Based Facilities
With the exception of facilities sized using the Simplified and Presumptive approaches, BES will use the Rational Method, with rainfall intensities presented in **Section 1.3.3**, to verify flow rates used to size rate-based pollution reduction facilities. Through a continuous simulation model using Portland rainfall data, BES has verified that these intensities treat 90 percent of the average annual runoff volume. The design professional may also use SBUH, NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of 90 percent of the average annual runoff volume.

Flow Volume-Based Facilities
Volume-based pollution reduction facilities included in this manual (wet ponds and extended wet detention ponds) must use the predetermined volume of 0.83 inch over 24 hours with a Vb/Vr (volume of basin/volume of runoff) ratio of 2 to be in compliance. Through a continuous simulation model using Portland rainfall data, BES has determined that this volume provides adequate detention time to treat 90 percent of the average annual runoff volume.

Combination Rate/Volume-Based Facilities
With the exception of facilities sized using the Simplified Approach, BES will use a software program based on the SBUH method, or a continuous simulation model with Portland rainfall data, to verify the sizing of flow rate-based pollution reduction facilities that also rely on a storage volume component. The design professional may also use NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of 90 percent of the average annual runoff volume.

Conveyance

Refer to BES's *Sewer and Drainage Facilities Design Manual* for acceptable hydrologic analysis methods for stormwater conveyance. The Rational Method will be used to verify design calculations for pipe or surface conveyance facility sizing. HEC-HMS or SWMM must be used for projects greater than 50 acres in size. (See Section 6-7 of the *Sewer and Drainage Facilities Design Manua*l.)

Hydrologic Analysis Method Resources

The **SBUH method** may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the Simplified Approach.

The **SCS TR-55 method** may be applied to small, medium, and large projects. This is also one of the recommended methods for completing hydrologic analysis necessary for designing flow control facilities when not using the Simplified Approach. (Refer to SCS Publication 210-VI-TR-55, Second Edition, June 1986.)

The **HEC-HMS method** may be used on medium and large projects. (Refer to the HEC-HMS User's Manual.)

The **SWMM method** may be used on medium and large projects. (Refer to the SWMM User's Manual.)

Performance Approach Submittal Requirements

Under the Performance Approach, the applicant must demonstrate that the proposed management plan meets or exceeds all of the City of Portland's stormwater requirements. Applicants using the Performance Approach must submit a **Stormwater Management Report** as part of their permit application, along with a complete site plan, construction drawings, and details. An **Operations and Maintenance Form** and a copy of the **Operations and Maintenance Plan** must also be included.

See **Appendix D.5** for complete information about the submittal requirements for the Performance Approach.

2.3 FACILITY DESIGN

This section provides the detailed guidelines and specifications for designing the stormwater facilities included in this manual. The three sizing methodologies described in **Section 2.2** (the Simplified, Presumptive, and Performance approaches) are available to appropriately design and size the stormwater facilities. (See **Exhibit 2-4** on page 2-36 for a list of stormwater facilities and their applicable design methodologies.)

2.3.1 Facility Overview

Impervious Area Reduction Techniques

Ecoroofs, pervious pavement, and street trees are impervious area reduction techniques that can affect which design approach is required and reduce the overall square footage of impervious area that requires stormwater management. (See **Section 2.3.3** for facility restrictions and specifications). For example, if an applicant has a project with 11,000 square feet of impervious area and site conditions allow for 3,000 square feet of pervious pavement, the applicant can reduce the impervious area to 8,000 square feet and use the Simplified Approach, as long as all other requirements for the Simplified Approach are met. Ecoroofs, pervious pavement, and street trees intercept rainfall directly and are not allowed to receive stormwater runoff from other areas.

Stormwater Management Facility Configuration

Stormwater management facilities can be configured to achieve:

- surface infiltration,
- subsurface infiltration, or
- both surface and subsurface infiltration.

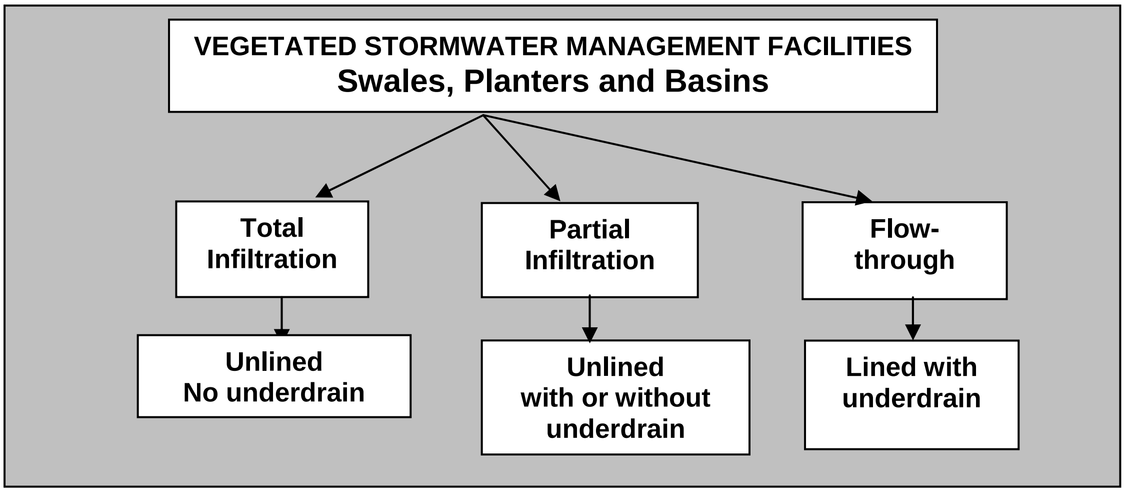
Surface infiltration facilities achieve infiltration in the upper layer of the ground surface and can include facilities such as swales, planters and basins.

Subsurface infiltration facilities achieve infiltration below the ground surface and include facilities such as sumps, drywells, and soakage trenches. Subsurface infiltration facilities are subject to DEQ's UIC regulations (see **Section 1.4**).

Hybrid facilities achieve both surface infiltration and subsurface infiltration by bypassing flows greater than the water quality storm directly to a gravel layer below the facility growing medium. By providing a direct connection to the gravel layer, the designer can take advantage of higher native infiltration rates, if they exist, or utilize the below grade storage to reduce the size of the facility. Hybrid facilities are also subject to DEQ's UIC regulations.

Swales, planters and basins can be configured to achieve total infiltration, partial infiltration, or flow-through. See **Appendix G.1** **SW-150** for typical configuration details.

Exhibit 2-2: Vegetated Stormwater Management Facilities Configurations



Total infiltration facilities need soils that drain well and infiltrate 2 inches per hour or greater allowing the stormwater to infiltrate into the surface or subsurface. Facilities that achieve total onsite infiltration do not require an offsite discharge point and therefore meet Category 1 or Category 2 requirements of the Stormwater Hierarchy (see **Section 1.3.1**).

Partial infiltration facilities are appropriate for sites with soils that drain fairly well and infiltrate greater than 0.5″ per hour but less than 2″ per hour. They achieve partial infiltration because they do not have a bottom or a liner but may include a surface overflow and an underdrain where flows in excess of the facility capacity are routed to an approved discharge point as specified in Category 3 or 4 of Stormwater Hierarchy (see **Section 1.3.1**). Depending on site conditions, partial infiltration facilities may be used where complete infiltration is not achievable or allowed.

For the Simplified Approach refer to the tested infiltration rate.

For the Presumptive Approach refer to the design infiltration rate.

Flow-through facilities are appropriate for sites with soils that do not drain well and infiltrate less than 0.5 inches per hour or that have other restrictive site conditions. Flow-through facilities typically include an impervious or lined bottom (liner may be waived under the Presumptive Approach where site conditions allow). They also include a surface overflow and an underdrain in the gravel layer where treated flow is routed to an approved discharge point as specified in Category 3 or 4 of Stormwater

Hierarchy (see **Section 1.3.1**). Lined flow-through facilities are required on sites with steep slopes, high groundwater, or contamination. They are also appropriate next to structures or property lines to protect foundations, basements, and adjacent properties.

Hybrid Facilities

The hybrid facility is a new configuration type that combines a vegetated surface facility with a subsurface infiltration facility. It is appropriate for sites with well draining soil but with space limitations. See the Presumptive Approach Calculator and User's Manual in **Appendix C** for more information. Also refer to the typical details for configuration E and F in **Appendix G.1** **SW-151** and **SW 152** respectively. Hybrid facilities are UICs and subject to all DEQ UIC regulations (see **Section 1.4** for UIC requirements). They are not allowed on projects using the Simplified Approach sizing.

Facility Overflows

It is important to note the distinction between an **underdrain**, a facility **overflow,** and an **escape route**.

While both the underdrain and the overflow typically require a connection to an approved discharge point, the **underdrain** is typically set at an elevation below the growing medium to drain flows that pass through the growing medium and are trapped in a lined facility or can not infiltrate. An **overflow** is typically set at an elevation above the growing medium and is included as a backup in case the vegetated facility becomes clogged or the flow exceeds the design capacity of the facility. Where **underdrains** are utilized, an approved discharge point is required. **Overflows** are required when infiltration requirements cannot be met. See **Appendix G.1,** **SW-150** for typical overflow configuration details.

An **escape route** is a submittal requirement for all projects that delineates where flows will be routed to maintain public safety and prevent property damage in the event the facility fails or flows exceed the facility design capacity. It does not typically require a hard connection to an approved discharge point.

Performance Approach Facilities

Filter strips, grassy swales, and ponds are vegetated facilities that meet limited stormwater management requirements. Filter strips are allowed under the Simplified Approach for impervious area under 500 square feet. If filter strips are proposed for use with over 500 square feet of impervious area, the Performance approach is required. Ponds and grassy swales are allowed only under the Performance Approach.

Non-vegetated and structural stormwater management facilities such as sand filters, rainwater harvesting, and detention tanks require review and approval under the Performance Approach (see **Section 2.2.3**).

Manufactured Treatment Devices

Manufactured treatment devices must be selected from the approved vendor list and may be used with the Simplified or Presumptive approaches. Other facility types that are not on the list may be used in some specific applications that include additional treatment in a "treatment train," but must be submitted to BES as a Performance Approach.

Source Control Devices

Source control devices include spill control manholes and oil/water separators. They are used to meet the source control requirements specified in **Chapter 4.**

2.3.2 Landscape Requirements

As presented in **Section 1.3**, the City of Portland's stormwater management approach relies on the use of vegetated infiltration facilities to comprehensively meet multiple requirements. Vegetated facilities must be used to the maximum extent feasible. Thriving vegetation is required in order to achieve compliance with the pollution reduction and flow control standards. This section outlines the landscape requirements for both private and public vegetated stormwater management facilities. These requirements are based on the City's experience and on standard design and construction methods in the landscape industry.

Relationship to Other Landscape Requirements

When vegetated facilities are integrated into project landscape areas, they can meet many, if not all, of Title 33 landscape requirements, applicable plan district requirements, and Title 17 requirements. The benefits of integrated designs include construction cost savings, combined maintenance, aesthetic benefits, and the greater likelihood of maintaining long-term functionality. A well-designed and established landscape will also prevent post-construction soil erosion. These approaches can also help reduce urban heat island effects and contribute to other sustainable principles.

Where the plant material requirements of this manual and Title 33 differ, the designer must use the larger quantity and sizes. (In calculating quantities, fractions should be rounded to the higher whole number.) Landscaping required by Title 33 may be counted toward meeting the facility-specific landscape requirements in this chapter if the plantings are located within the facility area. Similarly, plantings that meet the requirements in this chapter may also meet Title 33 landscape requirements.

An integrated design may require changing the size of some site elements. For example, Title 33.266 parking code allows parking layout and dimensions to be designed to allow more space for stormwater facilities.

Standard Landscape Requirements

This section addresses the landscape requirements that apply to the design and construction of all vegetated stormwater facilities, both private and public. (See the individual facility descriptions in **Section 2.3.3** for facility-specific requirements.) It includes the following steps:

1. Site Preparation and Grading
2. Piping
3. Gravel Drain Rock
4. Geotextiles
5. Growing Medium
6. Vegetation
7. Mulch
8. Irrigation
9. Pollution Prevention

1. Site Preparation and Grading

- ✓ Existing vegetation to be saved must be clearly marked and securely protected. If native plants are present, they should be salvaged and stored for replanting once construction is complete. Unwanted vegetation in the facility area should be removed during site preparation with equipment appropriate for the type of material and site conditions.

- ✓ The location of all areas of future stormwater facilities should be clearly marked before site work begins. All stormwater facilities areas should be fenced or covered to protect them from damage or misuse during construction. Fencing is required around all infiltration facilities to prevent soil compaction during construction. The subgrade in proposed infiltration areas must not be compacted. At least 6 inches of native material must be maintained above the proposed bottom of the facility until construction is scheduled for the facility. **No vehicular traffic, material storage, or heavy equipment is allowed within 10 feet of the infiltration facility area after site clearing and grading have been completed, except that needed to excavate, grade, and construct the facility.** Flow-through facilities must be covered with plywood or other sheeting to prevent misuse. No stormwater facility area should be used for dumping concrete or other construction waste, mixing grout, cleaning tools, washing paint brushes, etc.

- ✓ The erosion and sediment control plan set should show the fencing layout for vegetation to be protected and the location of stormwater facilities.

- ✓ Location of all stockpiles must be indicated, including erosion protection measures per the City's 2008 *Erosion and Sediment Control Manual*.

- ✓ Once the facility area is graded, all native subsoil must be tilled before installing the specified stormwater facility growing medium. No tilling should occur within the drip line of existing trees. After tilling is completed, no other construction traffic should be allowed in the area, except for planting and related work. **All construction and other debris must be removed before the growing medium is placed.** Furthermore, the soil must not be exposed during wet weather conditions and must be covered with the growing medium within 1 day of being exposed.

- ✓ Surface drainage must be prevented from entering the facility during construction until the facility is fully installed and the contributing catchment area is constructed. Proposed facility areas must be protected from sedimentation during construction. The contractor is responsible for protecting the facility from erosion before water is allowed to enter the facility. Appropriate erosion control measures, as required by the City's 2008 *Erosion and Sediment Control Manual*, must be used.

2. Piping

- ✓ For private property, piping must be cast iron, ABS SCH40, or PVC SCH40. Three-inch pipe is required for facilities draining up to 1,500 square feet of impervious area; otherwise 4-inch pipe minimum is required. Piping installation and sizing must follow current Uniform Plumbing Code.

- ✓ For public facilities, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required. Refer to the City's *Sewer and Drainage Facilities Design Manual* for more information.

3. Gravel Drain Rock

- ✓ Drain rock may be required below the growing medium of a vegetated facility. For infiltration facilities, where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½ – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock must be used.

- ✓ For private soakage trenches, the specification is 2½ - ¾-inch washed drain rock.

- ✓ The required depth of the drain rock for facilities designed with the Simplified Approach is 12 inches. The depth of the drain rock varies with the Presumptive Approach. Depending on native infiltration rates and the amount of stormwater being routed to the facility, zero to a maximum of 48 inches of drain rock may be specified.

- ✓ If geotextiles are not used, a separation lens is needed between the growing medium and drain rock to keep the layers distinct and allow for good conveyance. The gravel lens should be ¾ - ¼-inch washed, crushed rock 2 to 3 inches in depth, depending on the facility design.

4. Geotextiles
   - ✓ Geotextiles are often used in the design and construction of stormwater facilities. Non-woven fabrics make the best filters, but are also good at separation. Woven fabrics have greater strength and are less likely to clog. Anywhere a geotextile is used in a critical application, a geotechnical professional should specify for that application. Specifications provided in **Exhibit 2-3** are taken directly from the *2007 City of Portland Standard Construction Specifications*, Table 02320-1.

5. Growing Medium
   - ✓ The City of Portland specifies the stormwater facility growing medium. The depth of the growing medium must be a minimum of 18 inches.

   - ✓ For facilities designed with the Simplified Approach or facilities on private property, the imported soil must be a sandy loam mixed with compost or a sand/soil/compost blend. It must be roughly one-third compost by volume, free-draining, and support plant growth. The compost must be derived from plant material; animal waste is not allowed.

   - ✓ For streets, growing medium is required as specified in **Appendix F.3**.

   - ✓ Soil analysis for all growing medium is required for all public facilities and may be required for private facilities. Soil analysis is not required for single-family residential sites. The source of stormwater facility growing medium must be provided.

   - ✓ Soil placement and planting should occur in conditions that do not result in over-compaction or erosion. Temperature, moisture levels, and handling can have a huge influence on the infiltration rate of a facility and on plant survivability.

Exhibit 2-3: Standard Geotextile Specifications

Drainage Geotextile for Filtration

Permittivity ASTM D4491	Grab Strength ASTM D4632	Puncture Strength ASTM D4833	Mullen Burst ASTM D3786	Apparent Opening Size ASTM D4751
0.5 s^{-1} Minimum	80 (180) Lb Minimum	35 lb Minimum	130 (290) Psi Minimum	70 US Sieve Maximum

Non-woven fabrics*: LINQ 125EX; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL. (ODOT Type II variation).*

Subgrade Geotextile for Separation

Permittivity ASTM D4491	Grab Strength ASTM D4632	Puncture Strength ASTM D4833	Mullen Burst ASTM D3786	Apparent Opening Size ASTM D4751
0.01 s^{-1} Minimum	180 Lb Minimum	80 Lb Minimum	290 psi Minimum	30 US Sieve Maximum

Woven fabrics*: Geotex 111F; AMOCO 1198 (GEOTEX 106F). Also refer to the Federal Highway Administration Manual "Geosynthetic Design and Construction Guidelines," Publication No. FHWA HI-95-038, May 1995 for design guidance on geotextiles in drainage applications.*

6. Vegetation

✓ Plants are critical to the performance of vegetated stormwater facilities and therefore must be selected for the appropriate soil, hydrologic, and site-specific conditions. The planting design must minimize the need for herbicides, fertilizers, pesticides, or soil amendments at any time before, during, and after construction and on a long-term basis. Plantings should also be designed to minimize the need for mowing, pruning, and irrigation.

✓ For facilities located in environmental zones or for BES-maintained facilities located outside of the public right-of-way, all plants within the facility area must be appropriate native species from the BES recommended plant lists in **Appendix F.4** or the latest edition of the *Portland Plant List*. No nuisance or prohibited plants are allowed. The designer may also refer to the Planning Bureau's *Environmental Handbook* for more information.

✓ Structural components such as chain link fence, concrete bulkheads, outfalls, rip-rap, gabions, large steel grates, pipe, blank retaining walls, vault lids, and access roads should be screened from view by vegetation. The quantities and spacing of plant material required for each facility should provide sufficient screening. Attention should be paid to site conditions that may require adjustments to the planting plan, including the need for additional trees and shrubs. The intent of this requirement is not to dictate a specific solution such as a linear hedge. Designers are encouraged to integrate the facility landscaping with the screening objective. As a guide, landscape standards for screens are provided in L2, L3, or L4 standards as specified in City Code Chapter 33.248.

- ✓ The planting plan must indicate the location of all landscape elements, including size, spacing, and species of all proposed plantings and existing plants and trees to be preserved. The plant list must include the botanical and common name, size at time of planting, quantity, type of container, evergreen or deciduous, and other information in accordance with the facility-specific planting section and landscape industry standards. See facility specifications in **Section 2.3.3** for density and size requirements. Refer to **Appendix G.4** for planting templates appropriate for public and private streets, which require the use of containerized plants.

- ✓ Because portions of vegetated facilities areas are designed to accommodate inundation through the wet periods of the year, it is imperative for the designer to delineate the wet zone and develop a planting plan in accordance with the level of inundation/saturation. Many stormwater facilities are expected to have a wet zone (Zone A) that is saturated through most of the year in the center and lowest areas of the facility. The moderate to dry Zone B surrounds Zone A and is likely to be inundated much less frequently than the lower portions of the facility. For the purposes of this manual in determining landscaping requirements, **the delineation between Zone A and Zone B must be the elevation of either the outlet elevation or the top of the check dam, whichever is lower.** Planting plans must be specific to the designated zones.

- ✓ Depending on when stormwater will be routed to the facility, planting should preferably occur in the dormant season. For best results, planting should occur in the spring (March) or early fall (September through October).

- ✓ Plants must be healthy and vigorous. Within 2 years, a survival rate of 75 percent (no replacements) must be achieved. If the survival rate falls below this threshold, additional plants sufficient to meet the 75 percent survival rate must be installed. The number of additional plants required should be based on the mortality rate of the initial planting.

7. Mulch

- ✓ Fine to medium hemlock bark or well-aged organic yard debris compost is recommended for most stormwater facilities. Washed pea gravel or river rock may be used in stormwater planters. Mulch should be weed-free and applied 2 to 3 inches thick to cover all soil between plants. It should not be over-applied.

- ✓ **Mulch should be placed in the facility only in Zone B areas. Care should be given to keeping mulch material out of a stormwater flow path to avoid any material from clogging inlets or outlets or otherwise escaping the facility. Manure mulching and high-fertilizer hydroseeding are prohibited in a facility area during and after construction.** At the time of final inspection, all surface area soils should be covered with plants and/or mulch sufficient to prevent erosion.

8. Irrigation

- ✓ Permanent irrigation systems are not allowed for stormwater facilities in public or private streets, unless approved by BES. Temporary irrigation systems or alternative methods of irrigation for landscape establishment should be specified. Permanent irrigation systems are allowed for private facilities, but designers are encouraged to minimize the need for permanent irrigation. Innovative methods for watering vegetation are encouraged, such as the use of cisterns.

9. Pollution Prevention

- ✓ Projects must be designed to minimize the need for toxic or potentially polluting materials such as herbicides, pesticides, fertilizers, or petroleum-based fuels within the facility area before, during, and after construction. Use of these materials creates the risk of spills, misuse, and future draining or leaching of pollutants into facilities or the surrounding area. (For information about alternatives, contact Metro's Alternatives to Pesticides Program at 503-797-1811.)

- ✓ Materials that could leach pollutants or pose a hazard to people and wildlife must not be used as components of a stormwater facility. Some examples of these materials are chemically treated railroad ties and lumber and galvanized metals. Many alternatives to these materials are available.

Standard Landscape Requirements for Streets

Vegetation in stormwater facilities located in the public right-of-way must be covered by a 2-year warranty period, beginning from the time of signing the certificate of completion of the public works project. This is necessary to ensure proper establishment before the City assumes ownership. During the warranty period, regular maintenance tasks must be performed. These may include hand removal of undesirable or "weedy" vegetation, mowing, pruning, mulching, and regular summer irrigation. These tasks are essential to plant establishment and should not be deferred. City inspectors will monitor the establishment of the vegetation during the warranty period.

See http://www.portlandonline.com/shared/cfm/image.cfm?id=69048 for the landscape requirements for private streets.

See **Appendix G.4** for Greenstreet planting templates and **Appendix F.4** for plant lists. Typically, plants are specified in 1-gallon pots and planted 12 inches on center. No medium to large shrubs are allowed in a stormwater facility next to a street.

Watershed Revegetation Program

Public works permit applicants may choose to enter into an agreement for vegetation services with BES's Watershed Revegetation Program (WRP). This agreement is optional and is offered so permit applicants can benefit from BES's professional expertise in establishing and maintaining stormwater management facility landscapes that treat public stormwater. This ensures plant establishment and proper performance of facilities that will eventually be maintained by the City following the warranty period.

Projects that use the WRP agreement for vegetation services will be exempt from the 10-month and 20-month inspections of vegetation establishment (as described in **Section 3.2.3**). The City becomes the responsible party for establishing vegetation to treat stormwater within the facility. No other permitted elements (structural, inlets, etc.) are exempt from the warranty.

The WRP can deliver the following services:

- Prepare planting plan and plant establishment treatment schedule to meet the requirements of the *Stormwater Management Manual*.
- Inspect topsoil prior to placement to meet the requirements on the permitted plans.
- Provide post-construction erosion control within the facility to stabilize soil, as shown on the plans.
- Source and acquire all plant material, and plant according to the plans. The City will interchange bare-root, containerized, and balled and burlapped plant material to meet the design intent.
- Irrigate the site as needed to establish plant material to meet performance criteria.
- Mulch the site as needed.
- Remove excessive sediment buildup.
- Interplant (replace dead vegetation) as needed to adapt to site conditions and performance.
- Clean garbage and other undesirable debris.
- Monitor for vegetation establishment through the end of the warranty period, at which time the City assumes responsibility for the project.

- Work with the permit holder to ensure that project implementation follows the permit, construction documents, design intent, and field conditions.
- Ensure prompt delivery of services with adequate coordination with other contractors.
- Provide all necessary labor and other miscellaneous work incidental to completion of the project, unless otherwise specified in the agreement.
- Install project signage, if appropriate.
- Perform treatments specific to the agreement for maintenance and monitoring of the project site(s).

Applicants can obtain more information directly from the WRP by calling (503) 823-2365. The WRP is also available to provide some consultation regarding plant selection and proper placement within a facility that will eventually become City property.

2.3.3 Facility Design Criteria

This section provides a description and the specific design requirements for each stormwater facility listed below in **Exhibit 2-4**. It also includes facility-specific information regarding submittal requirements, construction considerations, inspections, and maintenance, as well as additional resources as available. Variations that exist between the Simplified Approach and Presumptive Approach and variations between streets and private property are identified.

Exhibit 2-4: Stormwater Facilities

Page	Impervious Area Reduction Technique	Simplified	Presumptive for Private	Presumptive for Streets	Performance For Streets
2-37	Ecoroof	•	•		
2-40	Pervious Pavement	•	•		•
2-45	Street Tree			•	

Page	Vegetated Facility	Simplified	Presumptive for Private	Presumptive for Streets	Performance
2-48	Swale	•	•	•	
2-53	Planter	•	•	•	
2-57	Basin	•	•	•	
2-61	Filter Strip	•			•
2-63	Grassy Swale				•
2-68	Pond				•

Page	Facility	Simplified	Presumptive for Private	Presumptive for Streets	Performance
2-78	Sand Filter				•
2-82	Soakage Trench	•	•		
2-87	Drywell	•	•		
2-91	Sump		•	•	
2-96	Manufactured Treatment Technology		•	•	
2-98	Rainwater Harvesting				•
2-101	Structural Detention				•

Page	Facility	As Required	Source Control
2-106	Oil/Water Separator	•	•
2-109	Spill Control Manhole	•	•

Exhibit 2-5: Hamilton Building Ecoroof. See **Appendix G.1** **SW-100** for typical ecoroof details.

Facility Description

An ecoroof, also called a green roof, is a lightweight vegetated roof system consisting of waterproofing material, growing medium, and specially selected plants. An ecoroof can be used in place of a traditional roof as a way to limit impervious site area and manage stormwater runoff. Ecoroofs reduce post-developed peak runoff rates to near pre-developed rates and reduce annual runoff volume by at least 50percent. Ecoroofs also help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in dry seasons. Although ecoroofs consist of lightweight growing medium and low-growing succulent vegetation, other more heavily planted systems are possible; in either case, the design must be self-sustaining.

The structural roof support must be sufficient to hold the additional weight of the ecoroof. Greater flexibility and options are available for new buildings than for re-roofing existing buildings, but retrofits are possible. For retrofit projects, an architect, structural engineer, or roof consultant can determine the condition of the existing building structure and what might be needed to support an ecoroof. Alterations might include additional decking, roof trusses, joists, columns, and/or foundations. Generally, the building structure must be adequate to hold an additional 15 to 30 pounds per square-foot (psf) saturated weight, including the vegetation and growing medium that will be used (in addition to snow load requirements). An existing rock ballast roof may be structurally sufficient to hold a 10-20 psf ecoroof (if the ballast is removed).

Design Requirements

- **Sizing:** Ecoroofs replace impervious area at a 1:1 ratio. They are not allowed to receive water from other impervious areas.
- **Slope**: Maximum roof slope shall be 25 percent, unless the applicant provides documentation of runoff control on steeper slopes.
- **Waterproofing:** A good-quality waterproofing material, such as modified asphalt, synthetic rubber, or reinforced thermal plastics, shall be used on the roof surface. Some waterproofing materials also act as a root barrier.
- **Protection boards or materials** (optional): These materials protect the waterproof membrane from damage during construction and over the life of the system and are usually made of soft fibrous materials. They often are not needed, depending on the membrane selected.
- **Ballast** (optional): Gravel ballast is sometimes placed along the perimeter of the roof and at air vents or other vertical elements. The need for ballast depends on operational and structural design issues. It is sometimes used to provide maintenance access, especially to vertical elements that require regular, periodic maintenance. In many cases, very little, if any, ballast is needed.
- **Header/separation board** (optional): In some situations, a header or separation board may be placed between gravel ballast and adjacent elements (such as soil or drains), but pressure-treated lumber is prohibited. In many cases, a header is not needed, and designers are encouraged to use one only when necessary.
- **Root barrier:** A root barrier is sometimes required in addition to waterproofing material, depending on the type used and the types of vegetation proposed. Root barriers impregnated with pesticides, metals, or other chemicals that may leach into stormwater are not allowed, unless the applicant can provide documentation that leaching does not occur. If a root barrier is used, it must extend under any gravel ballast and the growing medium and up the side of any vertical elements.
- **Drainage:** A method of drainage must be provided, although a manufactured product is not required. The drainage layer may include filter fabric, gravel, or be the growing medium itself. An approved discharge location must be identified for every ecoroof and a drain(s) provided.
- **Growing medium**: A minimum of 4 inches of growing medium is required, composed of roughly 70 percent porous material/20 percent organic material (i.e. aged compost)/10 percent digested fiber or other mix approved by BES. Ecoroofs with more than 6 inches of growing medium are acceptable, but must meet all other requirements.

- **Vegetation and coverage:** Drought-tolerant plants (per *Green Roof Plants* by Snodgrass & Snodgrass, the 2008 BES *Ecoroof Plant Report*, and/or equivalent) must achieve 90 percent coverage within 2 years. At least 50 percent of the ecoroof must be composed of evergreen species. A maximum of 10 percent of the ecoroof may be composed of non-vegetated components such as gravel ballast, pavers for maintenance access, etc. Mechanical units may protrude through the ecoroof, but are not considered elements of the ecoroof. Ecoroof vegetation should be:
  - Drought-tolerant, requiring little or no irrigation after establishment.
  - Self-sustaining, without the need for fertilizers, pesticides, or herbicides.
  - Able to withstand heat, cold, and high winds.
  - Very low-maintenance, needing little or no mowing or trimming.
  - Perennial or self-sowing.
  - Fire-resistant.

  A mix of sedum/succulent plant communities is recommended because they possess many of these attributes. Herbs, forbs, grasses, and other low groundcovers can also be used to provide additional benefits and aesthetics; however, these plants may need more watering and maintenance to survive and keep their appearance.

- **Mulch:** A method to protect exposed soil from erosion must be provided, such as gravel mulch.

- **Permits:** Residential (RS) or commercial (CO) permits are required.

Maintenance Requirements

- **Fertilizers:** Only non-chemical fertilizers may be used.
- **Pesticides/herbicides**: Pesticides and herbicides of any kind are prohibited on ecoroofs.
- **Irrigation:** During the establishment period (up to 3 years), irrigation shall not exceed ½ inch of water every 10 days, regardless of water source. Post-establishment irrigation shall not exceed ¼ inch of water every 14 days (May through October), regardless of water source. Ecoroofs greater than 5,000 square feet should consider installing an irrigation flow meter.

Resources

For information about the floor area ratio (FAR) bonus for ecoroofs in the Central City, refer to City Code Chapter 33.510.210, option #10.

City of Portland ecoroof website:
http://www.portlandonline.com/bes/index.cfm?c=44422&

Exhibit 2-6: Multnomah Art Center Permeable Pavers. See **Appendix G.1** **SW-110** for typical details.

Facility Description

There are two main categories of pervious pavements: **pervious concrete and pervious asphalt** are poured in place, while **permeable pavers** are discrete units set in place. These methods of infiltrating stormwater provide a stable load-bearing surface without increasing the project impervious area. These impervious area reduction techniques decrease the obligation of stormwater management on the project site.

Pervious asphalt, pervious concrete, and permeable pavers can be used in practically all pedestrian areas, as well as residential driveways and commercial parking lots. Pervious asphalt and concrete will be approved on private streets and public roadways on a case-by-case basis. See **Exhibit 2-7** for a summary of the design requirements.

Pervious Asphalt and Concrete

Pervious asphalt and pervious concrete are similar to conventional asphalt and concrete in structure and form, except that the fines (sand and finer material) have been removed. The top lifts are thicker than traditional pavements to provide the required stability.

Pervious asphalt consists of an open-graded coarse aggregate cemented together by asphalt cement. The Oregon Department of Transportation (ODOT) has approved a pervious asphalt mix for its uses on numerous public highways and freeways, referred to as its open-graded ½-inch or ¾-inch asphalt mix design. Another common asphalt mix is the 3/8-inch mix. This mix cannot be used on roadways because the long-term perviousness is not clear. Refer to the ODOT 2008 Standard Specifications 00745 for more about open-graded mixes.

Pervious concrete is a structural, open-textured pervious concrete paving surface consisting of standard Portland cement, fly ash, locally available open-graded coarse aggregate, admixtures, fibers, and potable water. When properly handled and installed, porous concrete has a high percentage of void space (approximately 17 - 22 percent).

Permeable Pavers
There are many types of permeable pavers on the market today. Many manufacturers make specific pavers for pervious applications, while others make pavers that are not designed to accommodate infiltration. Brand names and specifications shall be supplied with permit applications.

Edge restraints for pavers are required to be permanent (cast-in-place or pre-cast concrete curbs) and a minimum of 6 inches wide and 12 inches deep for private streets, public roadways, and commercial pavements. Residential restraints may be plastic, set with spikes.

Design Requirements

Additional stormwater from other impervious areas, such as roof tops, may not be directed to a pervious pavement system. Pervious pavements shall not be located over cisterns, utility vaults, underground parking, or other impervious surfaces.

- **Infiltration:** Where the tested infiltration rate is less than 2 inches/hour, the pavement section must sheet-flow to an adequately sized filter strip (500 square foot limit for pavement). If an underdrain is proposed for collection, the conveyance must lead to a vegetated facility sized to treat the entire pervious paved area.
- **Setbacks:** There are no required setbacks, but impermeable liners between base rock and adjacent foundations are highly recommended.
- **Sizing:** Pervious pavement and permeable pavers replace impervious area at a 1:1 ratio. The pavement section must be designed to directly infiltrate all stormwater from the pavement surface into a crushed rock storage layer, which must contain enough void space to store the 10-year, 24-hour storm less the designed infiltration and infiltrate it into the subgrade in less than 30 hours.
- **Slope:** Where slopes are greater than 5percent, the design must be engineered to specifically address under-pavement water retention. If the slope of the area is 10 percent or greater, pervious pavement is not allowed.

- **Subgrade:** Pervious pavement shall not be constructed over fill soils. The area to be paved should be leveled and lightly compacted with a plate compactor to include a slight grade away from foundations. Compaction of the subgrade soil is required for public roadways, private streets, parking lots, and fire lanes to ensure adequate structural stability and minimize rutting. Compaction should be to 95 percent for public roadways. Compaction will reduce the permeability of the soils and should therefore be done with caution and scarified prior to setting the aggregate base. Subgrade shall not be subject to truck traffic.
- For private streets a **California Bearing Ratio** or **resilient modulus** of the saturated subgrade must be determined. For all streets, the pavement design must be prepared by a registered professional engineer.
- **Geotextile fabric:** Subgrade geotextile for separation is required between subgrade (native soil) and aggregate base (gravel layer). See **Exhibit 2-3** for geotextile specifications.
- **Aggregate base:** 6-inch minimum of washed crushed 2-inch – ¾-inch or No. 57 rock.
- **Sand:** 1 inch of clean washed coarse filter grade sand (ASTM No. 8 or 9). "Landscapers" or "playground" sand should not be used because it includes too many fines.
- **Top lift:** See **Exhibit 2-8** for the top lift depth requirements, which depend on the application. Asphalt and concrete must have at least 15 percent air voids in the completed top lift. Concrete must be 2400-2500 psi in 28 days.

Exhibit 2-7: Pervious Pavement Requirements for Top Lift Depth, Engineering, and Compaction

	Concrete (inches)	**Asphalt** (inches)	**Pavers** (inches)	**Engineering Required?**	**Compaction Required?**
Residential Driveway or Pedestrian Only	4	2.5	2 ⅜	No	No
Private Street, Parking Lot, or Fire Lane	4	3	3 ⅛	Yes	Yes
Public Street	7	6	3 ⅛	Yes	95%

Submittal Requirements

Depending on the scope and scale of the proposed project, the following design approaches apply to pervious pavement:

- Simplified Approach for pedestrian walkways and residential driveways.

- Presumptive Approach for parking lots, shared courts, and fire lanes.

- When considering permeable pavement for the public right-of-way, the applicant must submit the project under the Performance Approach. Permeable pavement in the public right-of-way is approved on a case-by-case basis at the discretion of the City of Portland's chief engineers.

- When considering pervious pavement for private streets, the applicant must meet the specifications of the Bureau of Development Services' private street administrative rule, and the street section must be designed by (or under the direction of) a registered professional engineer. A site development permit is required for private street construction.

Since achieving structural integrity and infiltration ability can be difficult, the pervious concrete supplier may be required to submit a testimonial with the permit application that the pervious mix will accomplish both tasks. Test panels may be required.

Construction Considerations

It is imperative during design to establish protection for the pervious pavement subgrade from over-compaction. The design professional must show how the construction manager will avoid traffic on the proposed paved area.

Maintenance

It is imperative during design to establish protection for the pervious pavement subgrade from over-compaction. The design professional must show how the pervious pavement requires specialized vacuuming at least once a year to remove fine particulates from the infiltration spaces. This maintenance must be performed with high-power vacuums (vac trucks). Without this maintenance, the facility will become impervious over time. Additionally, some settling may occur over time, requiring additional aggregate base, washed sand, and/or paver replacement and repair.

Resources

Pervious Asphalt

ODOT 2008 Standard Specifications 00745.00
PDOT 2007 Standard Specifications 00744.00
National Asphalt Pavement Association Design, Construction, and Maintenance Guide

Pervious Concrete

AASHTO Guide for Design of Pavement Structures

Pervious Pavers

PDOT 2007 Standard Specifications 00760.00
Interlocking Concrete Pavement Institute (ICPI) Specifications
AASHTO Guide for Design of Pavement Structures

Refer to the Bureau of Development Services' administrative rules that include the private street permanent rule:
http://www.portlandonline.com/bds/index.cfm?c=36837.

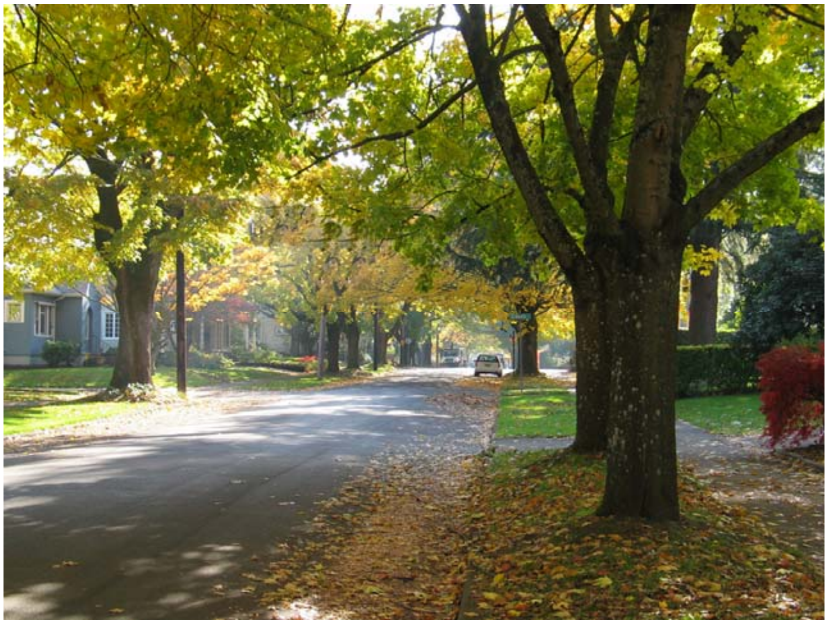


Exhibit 2-8: Portland Street Trees. See **Appendix G.4** **SW-400** for typical street tree details.

Facility Description

Trees intercept precipitation and provide several stormwater management benefits: they hold water on the leaves and branches and allow it to evaporate, retaining flow and dissipating the energy of runoff. These functions are most measurable for storms of less than 0.5 inch over 24 hours, typical of Portland storm events. Although deciduous trees are not as effective during winter months, evergreen trees are effective year round for these smaller storms and portions of larger storms. Generally, large trees with small leaves are the most efficient rainfall interceptors. Trees also facilitate stormwater infiltration and groundwater recharge.

Trees can also shade impervious area. This provides two direct benefits. First, the hard surface is protected from direct solar exposure, which reduces heat gain. The less heat gain there is in pavement, the less heat is absorbed by stormwater as it flows over the surface. Second, by shading pavement, the trees help reduce or minimize air temperature increases caused by the hot pavement.

- Street trees are available as an impervious area reduction technique with the development or improvement of streets for public streets only. They are not available as an impervious area reduction technique for private streets.

- New street trees shall be planted within 25 feet of ground-level impervious surfaces. One hundred square feet of credit is given for new deciduous trees, and 200 square feet of credit is given for new evergreen trees. (See minimum tree sizes below.)

- The street trees selected shall be suitable species for the site conditions and the design intent. Trees should be relatively self-sustaining.

- New deciduous trees must be at least 2 caliper inches, and new evergreen trees must be at least 6 feet tall to receive credit.

- Trees planted to meet stormwater facility planting requirements cannot also receive impervious area reduction credit.

- By City ordinance, the City Forester is authorized to set standards for tree sizes planted on publicly owned lands and public rights-of-way. A permit is required from Urban Forestry to plant, prune, or remove trees in the public right-of-way. Trees planted in the public right-of-way trees shall be at least 2 caliper inches for residential zones and 3.5 caliper inches for other zones, including commercial areas. For parks and other public areas, the tree standard is 3.5 caliper inches.

Approved Trees
See **Exhibit 2-9** for the list of approved street tree species. Other species may be allowed, as approved by BES or the Urban Forester.

Exhibit 2-9: Approved Street Tree List

Acer macrophyllum	Libocendrus decurrens	Quercus garryana
Alnus rubra	Pinus contorta	Rhamnus purshiana
Arbutus menziesii	Pinus monticola	Thuja plicata
Chamacyparis lawsoniana	Pinus ponderosa	Tsuga heterophylla
Cornus nuttallii	Pseudotsuga menziesii	Umbellularia californica
Fraxinus latifolia		

See **Appendix F.4** for more plant species information.

Submittal Requirements

Trees to be given credit as an impervious area reduction technique shall be clearly labeled as such, with the size and species included. Approximate setbacks from property lines and structures shall be shown. Street trees planted less than 10 feet from a water line (or facility) require the installation of a tree root guard, per **Standard Plan 5-109**. Temporary irrigation measures shall be shown, if applicable. A note shall be included on the permit drawings that call for City inspection after the tree has been planted.

Maintenance

- Street trees shall be maintained and protected on the site after construction and for the life of the development (50-100 years or until any approved redevelopment occurs in the future). During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City. Trees that are removed or die shall be replaced within 6 months with like species.

- Trees may be pruned for safety purposes only; however, if a tree is planted near a building, pruning to protect the structure is recommended.

- Long-term irrigation is not required.

Resources

Urban Forestry website: http://www.portlandonline.com/parks/index.cfm?c=38294

City of Portland Standard Plans and Specifications:
http://www.portlandonline.com/transportation/index.cfm?c=40032 .

Exhibit 2-10: Henry V Swale. See **Appendix G.1** **SW-120** for typical private property swale detail and **Appendix G.3** **SW-300-302** for typical Green Street swale details.

Facility Description

Swales are typically long, narrow, gently sloping landscaped depressions that collect and convey stormwater runoff. They are planted with dense vegetation that treats stormwater from rooftops, parking lots, and streets. As the stormwater flows along the length of the swale, the vegetation and check dams slow the stormwater down, filter it, and allow it to infiltrate into the ground. Where soils do not drain well, swales can overflow to an approved discharge point such as a drywell or sump. Swales should be integrated into the overall site design and can be used to help fulfill landscape requirements.

Design Requirements

- **Soil suitability:** Existing infiltration rates will determine if the facility can be designed to achieve infiltration, partial infiltration, or allow the stormwater to flow through the facility. See **Appendix F.2** for infiltration testing procedures. For the Simplified Approach (**Section 2.2.1**), if the tested infiltration rate is greater than or equal to 2 inches per hour, the swale must overflow to a subsurface infiltration facility. If the tested infiltration rate is less than 2 inches per hour, the swale should be designed as a partial infiltration or flow-through facility, with an overflow to an approved discharge point. For the Presumptive Approach (**Section 2.2.2**), the existing infiltration rate also determines the type of swale, but additional variables are factored in to determine the configuration of the facility.

- **Setbacks:** Infiltration swales must be set back 5 feet from property lines and 10 feet from building foundations. There are no setback requirements for lined flow-through swales.

- **Sizing:** For the Simplified Approach, a sizing factor of 0.09 is required. For the Performance Approach, surface area and depth of facility vary. The Presumptive Approach Calculator (PAC) allows the designer to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project. See **Appendix C.3** for the PAC and the PAC User's Manual.

- **Dimensions and slopes:** The minimum swale width is 5 feet on private property and 8 feet on streets. A 2-foot-wide flat bottom width is required where feasible. Swales designed with the Simplified Approach are 9 inches deep measured from the top of the growing medium to the overflow inlet elevation. Swales designed with the Presumptive Approach vary in depth from 6 to 12 inches. In all cases, maximum side slopes are 3 horizontal to 1 vertical and 4 horizontal to 1 vertical is required immediately adjacent to pedestrian areas. Maximum longitudinal slope is 6 percent. Freeboard for swales must be noted on the plans. Freeboard can be defined as the vertical distance between the design water surface elevation and overtopping elevation or the vertical distance between the top of the check dam and the outside berm or curb elevation (whichever is lower).

- **Check dams:** Check dams are required in swales to allow water to pool and infiltrate into the ground. They shall be constructed of durable, non-toxic materials such as rock, brick, concrete, or soil by integrating these materials into the grading of the swale. Check dams are as long as the width of the swale, perpendicular to flow line. They generally form a 12 inch wide bench on top and measure 4 to 10 inches high, depending on the depth of the facility. See **Appendix G.3** **SW-340** for typical check dam details.

- **Gravel drain rock:** Drain rock may be required below the growing medium of a swale. For infiltration facilities, where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½-inch – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock shall be used. Drain rock and growing medium must be separated by filter fabric (see **Exhibit 2-3** for geotextile specifications), or a 2- to 3-inch layer of ¾ - ¼-inch washed, crushed rock must be used.

- **Piping:** For private property, piping shall be cast iron, ABS SCH40, or PVC SCH40. Three-inch pipe is required for facilities that drain up to 1,500 square feet of impervious area; otherwise, a 4-inch pipe minimum is required. Piping installation must follow current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required. Refer to the City's *Sewer and Drainage Facilities Design Manual* for more information.

- **Growing medium:** For swales designed with the Simplified Approach or swales on private property, the imported soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. The compost shall be derived from plant material; animal waste is not allowed. For streets, the growing medium is specified in **Appendix F.3**. In all cases, the growing medium shall be 18 inches deep.

- **Vegetation:** The entire facility area must be planted with vegetation. The facility area is equivalent to the total area of the swale, including bottom and side slopes, as developed in the sizing calculations.

  Swales should be designed so they do not require mowing.

  See **Appendix F.4** for suggested plant material appropriate for private property and the public right-of-way. See **Appendix G.4** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibits 2-11 through 2-14**.

  <u>**Private Property**</u>

Exhibit 2-11: Private Swale Vegetation - ZONE A

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
115	**Herbaceous plants**	100	1 gallon	1'
		OR		
100	**Herbaceous plants**	100	1 gallon	1'
4	**Small shrubs**	100	1 gallon	3'

Exhibit 2-12: Private Swale Vegetation - ZONE B

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
1	**Evergreen tree**	200	Min height 6’	-
		OR		
1	**Deciduous tree**	200	Min caliper 1½” at 6” above base	-
		AND		
3	**Large shrubs**	100	3 gallon or equivalent	4’
4	**Medium to small shrubs**	100	1 gallon or equivalent	2’
70	**Groundcover**	100	1 gallon or equivalent	1’

Streets

Plantings adjacent to streets require special attention to line-of-sight and maintenance issues.

Exhibit 2-13: Street Swales - ZONE A

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
115	**Herbaceous plants**	100	1 gallon	1’
		OR		
100	**Herbaceous plants**	100	1 gallon	1’
4	**Small shrubs**	100	1 gallon	2’

Exhibit 2-14: Street Swales - ZONE B

Number of plants	Vegetation type	Per square feet	Spacing density (on center)	Size
12	**Small shrubs**	100	2’	1 gallon or equivalent
70	**Groundcover**	100	1’	1 gallon or equivalent

Mulch: Fine to medium hemlock bark or well-aged organic yard debris compost is recommended for swales. It should be placed in the facility only in areas above the high-water line. Care should be given to keeping mulch material out of a stormwater flow path to avoid any material from clogging inlets or outlets or otherwise escaping the facility. It must be weed free and applied 2 to 3 inches thick to cover all soil between plants. It should not be over-applied.

Construction Considerations

Infiltration swales areas should be clearly marked before site work begins to avoid soil disturbance or sedimentation during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration swale areas.

Curb Extensions

Curb extensions are very similar to swales and are often used to retrofit existing developed roadway. They protrude into the roadway by removing a portion of the existing pavement and roadbed. A curb is constructed closer to the centerline of the roadway in order to install the facility. A stormwater curb extension may also be constructed with new roadway development. Existing sidewalks, plantings strips, and curbs may or may not be modified. Plantings are surrounded on all sides by curbing between the existing curb and a new curb. If total infiltration cannot be achieved, an approved conveyance and discharge method per **Section 1.3.1** is required.

Exhibit 2-15: North East Siskiyou Street Curb Extension. See **Appendix G.3** **SW-320** through **SW-324** for typical curb extension details.

Exhibit 2-16: Epler Hall Planter. See **Appendix G.1** **SW-130** for typical private property planter detail and **Appendix G.3** **SW-310** through **SW-313** for typical Green Street planter details.

Facility Description

Planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater, allowing pollutants to settle and filter out as the water percolates through the vegetation, growing medium, and gravel. Depending on site conditions, planters can be designed to completely or partially infiltrate the stormwater they receive. They can also be designed as lined, flow-through facilities where stormwater is temporarily stored. Excess stormwater collects in a perforated pipe at the bottom of the flow-through planter and drains to an approved discharge point. Planters can be used to help fulfill a site's required landscaping area requirement and should be integrated into the overall site design. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. Because flow-through planters can be constructed immediately next to buildings, they are ideal for sites with setback requirements, poorly draining soils, steep slopes, or other constraints.

Design Requirements

- **Soil suitability**: Existing infiltration rates will determine if the facility can be designed to achieve infiltration, partial infiltration, or allow the stormwater to flow through the facility. See **Appendix F.2** for infiltration testing procedures. For the Simplified Approach (**Section 2.2.1**), if the tested infiltration rate is greater than or equal to 2 inches per hour, the planter must overflow to a subsurface infiltration facility. If the tested infiltration rate is less than 2 inches per hour, the planter should be designed as a partial infiltration or flow-through facility, with an overflow to an approved discharge point. For the Presumptive Approach (**Section 2.2.2**), the existing infiltration rate also determines the type of planter, but additional variables are factored in to determine the configuration of the facility.

- **Setbacks:** Infiltration planters require 5-foot setbacks from property lines and 10-foot setbacks from building foundations. No setbacks are required for lined flow-through planters where the height above finished grade is 30 inches or less. Lined flow-through planters can be used next to foundation walls, adjacent to property lines, or on slopes when they include a waterproof lining.

- **Sizing:** For the Simplified Approach, a sizing factor of 0.06 is required. For the Performance Approach, surface area and depth of facility vary. The Presumptive Approach Calculator (PAC) allows the designer to size the planter with respect to native infiltration rates and other unique site conditions of the project. See **Appendix C.3** for the PAC and the PAC User's Manual.

- **Dimensions and slopes:** The minimum infiltration planter width is 30 inches, and the minimum flow-through planter width is 18 inches (measured from inside the planter walls). Facility storage depth must be at least 12 inches (from inlet elevation of overflow to top of growing medium), unless a larger-than-required planter area is specified. Planters are flat facilities that shall not slope more than 0.5 percent in any direction. A minimum of 2 inches of freeboard (vertical distance between the design water surface elevation and overtopping elevation) shall be provided.

- **Planter walls:** Planter walls shall be made of stone, concrete, brick, or other durable material. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

- **Waterproof liners:** Flow-through facilities require a waterproof liner. There are many liner options, and installation varies. Liner shall be 30 mil PVC or equivalent.

- **Gravel drain rock:** Drain rock may be required below the growing medium of a planter. For infiltration facilities, where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½ – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock shall be used. Drain rock and growing medium must be separated by filter fabric (see **Exhibit 2-3** for geotextile specifications) or use a 2- to 3-inch layer of ¾ - ¼-inch washed, crushed rock.

- **Piping:** For private property, piping shall be cast iron, ABS SCH40, or PVC SCH40. Three-inch pipe is required for facilities draining up to 1,500 square feet of impervious area; otherwise, a 4-inch pipe minimum is required. Piping installation must follow current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required. Refer to the City's *Sewer and Drainage Facilities Design Manual* for more information.

- **Growing medium:** For planters designed with the Simplified Approach or planters on private property, the imported soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. The compost shall be derived from plant material; animal waste is not allowed. For streets, the growing medium is specified in **Appendix F.3**. In all cases, the growing medium shall be 18 inches deep.

- **Vegetation:** The entire facility area must be planted with vegetation. The facility area is equivalent to the total area of the planter, as developed in the sizing calculations. The entire surface area of a planter is inundated with water and therefore requires only Zone A plants. See **Appendix F.4** for suggested plant material appropriate for private property and the public right-of-way. See **Appendix G.4** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibit 2-17**.

  <u>**Private and Public Property**</u>

  Exhibit 2-17: Planter Vegetation - ZONE A

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
115	**Herbaceous plants**	100	1 gallon	1'
	OR			
100	**Herbaceous plants**	100	1 gallon	1'
4	**Small shrubs**	100	1 gallon	2'

  Note: Tree planting is not required in planters, but is encouraged where practical. Tree planting is also encouraged near planters.

- **Mulch:** Washed pea gravel or river rock is recommended for planters. It should be applied 2 to 3 inches thick to cover all soil between plants. It should not be over-applied.

Construction Considerations

Special attention should be paid to the structural waterproofing if the planter is constructed adjacent to building structures. Infiltration planter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration planter areas.

Exhibit 2-18: Glencoe School Infiltration Basin. See **Appendix G.1** **SW-140** for typical basin details.

Facility Description

Vegetated infiltration basins are flat-bottomed, shallow landscaped depressions used to collect and hold stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground. They are either excavated or created with bermed side slopes. An inlet pipe or sheet flow over impervious area conveys the stormwater into the basin, where it is temporarily stored until it infiltrates into the ground. Basins often provide complete onsite infiltration for small storm events. They can be sized to infiltrate large storms in areas where soils drain well or overflow to an approved discharge point. Basins can have a formal or informal design that can be used to help fulfill a site's landscape requirements.

Design Requirements

- **Site suitability:** Existing infiltration rates will determine if the facility can be designed to achieve infiltration, partial infiltration, or allow the stormwater to flow through the facility. See **Appendix F.2** for infiltration testing procedures. For the Simplified Approach (**Section 2.2.1**), if the tested infiltration rate is greater than or equal to 2 inches per hour, the basin must overflow to a subsurface infiltration facility. If the tested infiltration rate is less than 2 inches per hour, the basin should be designed as a partial infiltration or flow-through facility, with an overflow to an approved discharge point. For the Presumptive Approach (**Section 2.2.2**), the existing infiltration rate also determines the type of basin, but additional variables are factored in to determine the configuration of the facility.

- **Setbacks:** The required setback is 5 feet from property lines and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10 percent; add 5 feet of setback for each additional percent of slope up to 30 percent; infiltration basins shall not be used where slopes exceed 30 percent. There are no setback requirements for lined, flow-through basins.

- **Sizing:** For the Simplified Approach, a sizing factor of 0.09 is required. The maximum designed ponding time shall be a function of the facility storage depth. For the Presumptive Approach, surface area and depth of facility vary. The Presumptive Approach Calculator (PAC) allows the designer to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project. See **Appendix C.3** for the PAC and the PAC User's Manual.

- **Dimensions and slopes:** For basins designed with the Simplified Approach, the facility storage depth is 12 inches from the top of the growing medium to the overflow inlet elevation. For basins designed with the Presumptive Approach, the facility storage depth may vary from 9 to 18 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum bottom width is 2 feet. A minimum of 2 inches of freeboard (vertical distance between the design water surface elevation and overtopping elevation) shall be provided.

- **Gravel drain rock**: Drain rock may be required below the growing medium of a basin. For infiltration facilities, where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½-inch – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. For all flow-through facilities, ¾-inch wash drain rock shall be used. Drain rock and growing medium must be separated by filter fabric (see **Exhibit 2-3** for geotextile specifications) or use a 2-to 3-inch layer of ¾ - ¼-inch washed, crushed rock.

- **Piping:** For private property, piping shall be cast iron, ABS SCH40, or PVC SCH40. Three-inch pipe is required for facilities draining up to 1,500 square feet of impervious area; otherwise, a 4-inch pipe minimum is required. Piping installation must follow current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required. Refer to the City's *Sewer and Drainage Facilities Design Manual* for more information.

- **Growing medium:** For basins designed with the Simplified Approach or planters on private property, the imported soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. The compost shall be derived from plant material; animal waste is not allowed. For streets, the growing medium is specified in **Appendix F.3**. In all cases, the growing medium shall be 18 inches deep.

- **Vegetation:** The entire facility area must be planted with vegetation. The facility area is equivalent to the total area of the basin, including bottom and side slopes, as developed in the sizing calculations, plus a 10-foot buffer around the basin. See **Appendix F.4** for suggested plant material appropriate for private property and the public right-of-way. See **Appendix G.4** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibits 2-19 and 2-20**.

Exhibit 2-19: Basin Vegetation - ZONE A

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
115	**Herbaceous plants**	100	1 gallon	1'
		OR		
100	**Herbaceous plants**	100	1 gallon	1'
4	**Small shrubs**	100	1 gallon	3'
		OR		
100%	**Seed coverage**			

Exhibit 2-20: Basin Vegetation - ZONE B

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
1	**Evergreen tree**	300	Min height 6'	-
		OR		
1	**Deciduous tree**	300	Min caliper 1 ½" at 6" above base	-
		AND		
4	**Large shrubs**	100	3 gallon or equivalent	4'
6	**Medium to small shrubs**	100	1 gallon or equivalent	2'
70	**Groundcover**	100	1 gallon or equivalent	1'

Wildflowers, native grasses, and ground covers shall be selected and designed to not require mowing. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

- **Mulch:** Fine to medium hemlock bark or well-aged organic yard debris compost is recommended for basins. It should be placed in the facility only in areas above the high-water line. Care should be given to keeping mulch material out of a stormwater flow path to avoid any material from clogging inlets or outlets or otherwise escaping the facility. It must be weed free and applied 2 to 3 inches thick to cover all soil between plants. It should not be over-applied.

Construction Considerations

Infiltration basin areas should be clearly marked before site work begins to avoid soil disturbance or sedimentation during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration basin areas.

See **Appendix G.1** **SW-160** for typical filter strip details.

Facility Description

Vegetated filter strips are gently sloped areas that are designed to receive sheet flows. They are typically linear facilities that run parallel to the impervious surface and are commonly used to receive the runoff from walkways and driveways. Filter strips are covered with vegetation, including grasses and groundcovers, that filter and reduce the velocity of the stormwater. As the stormwater travels downhill, it infiltrates into the soils below.

Driveway center filter strips are used between the drive aisles of residential driveways. They are typically 3 feet wide and placed between two 3-foot-wide paved sections. (The minimum width of a residential driveway is 9 feet, of which the inner 3-foot section could be pervious and used for infiltration as long as all other code requirements are met.) The strip is used exclusively to treat and infiltrate the stormwater from the impervious area of the drive aisles. The drive aisles must be sloped toward the driveway center filter strip. The driveway center filter strip must be maintained to the required design requirements (including 100 percent landscaping coverage) stated below.

Design Requirements

- **Soil Suitability:** Filter strips are appropriate for all soil types. Unless existing vegetated areas are approved as a filter, stormwater facility growing medium shall be used for the top 12 inches of the facility.

- **Setbacks**: The facility must begin 5 feet from the property line; 10 feet from buildings; and 50 feet from wetlands, rivers, streams, and creeks, unless an appeal is approved by the Bureau of Development Services.

- **Sizing**: Where the Simplified Approach is applicable, the filter strip is sized at 20 percent of impervious area treated up to 500 square feet of impervious area. If the Simplified Approach cannot be used, the Performance Approach will be required for sizing the filter strip, with demonstration of infiltration feasibility.

- **Dimensions and slopes:** Filter strips shall slope between 0.5 and 6 percent. Slope of pavement area draining to the strip shall be less than 6 percent. Filter strips shall have a minimum width of 5 feet, measured in the direction of the flow.

- **Level spreaders:** A grade board or sand/gravel trench may be required to disperse the runoff evenly across the filter strip. The top of the level spreader must be horizontal and at an appropriate height to provide sheet flow directly to the soil without scour. Level spreaders shall not hold a permanent volume of runoff. Grade boards can be made of any material that will withstand weather and solar degradation. Trenches used as level spreaders can be filled with washed crushed rock, pea gravel, or sand. (See **Appendix G.5** **SW-524**).

- **Growing medium:** For filters designed with the Simplified Approach or filters on private property, the imported soil shall be a sandy loam mixed with compost or a sand/soil/compost blend. It shall be roughly one-third compost by volume, free-draining, and support plant growth. The compost shall be derived from plant material; animal waste is not allowed. The growing medium shall be 12 inches deep for filter strips.

- **Vegetation:** The entire filter strip must have 100 percent coverage by native grasses, native wildflower blends, native ground covers, or any combination thereof. See **Appendix F.4** for more information.

- **Check dams:** If necessary, check dams shall be constructed of durable, non-toxic materials such as rock or brick or graded into the native soils. Check dams shall be 12 inches wide, 3 to 5 inches high, and run the length of the filter. .

Facility Description

Grassy swales are long, narrow grassy depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows through the facility. In addition to providing pollution reduction, they can also manage flow rates and volumes. Grassy swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement.

Grassy swales must be designed and submitted under the Performance Approach. (See **Section 2.2.3** for submittal requirements.) The facility must be able to provide 70 percent total suspended solids removal from 90 percent of the average annual runoff (as described in **Section 1.3.3**) and provide detention of the post-development peak runoff rates to less than pre-development peak runoff rates (as described **Section 1.3.2)**.

Design Requirements

- **Soil suitability:** Grassy swales are appropriate for all soil types.

- **Setbacks:** The required setback from the centerline of the swale to property lines is 5 feet; the required setback from building foundations is 10 feet, unless the swale is lined with impermeable fabric.

- **Sizing**: The Simplified Approach and Presumptive Approach are not available to size grassy swales. The Performance Approach must be used, and the following criteria apply:

  The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity at:

  - Maximum design velocity of 0.9 feet per second.
  - Minimum hydraulic residence time (time for Q_{design} to pass through the swale) of 9 minutes.
  - Designed using a Manning "n" value of 0.25.

  A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute intensity = 3.32 inches per hour).

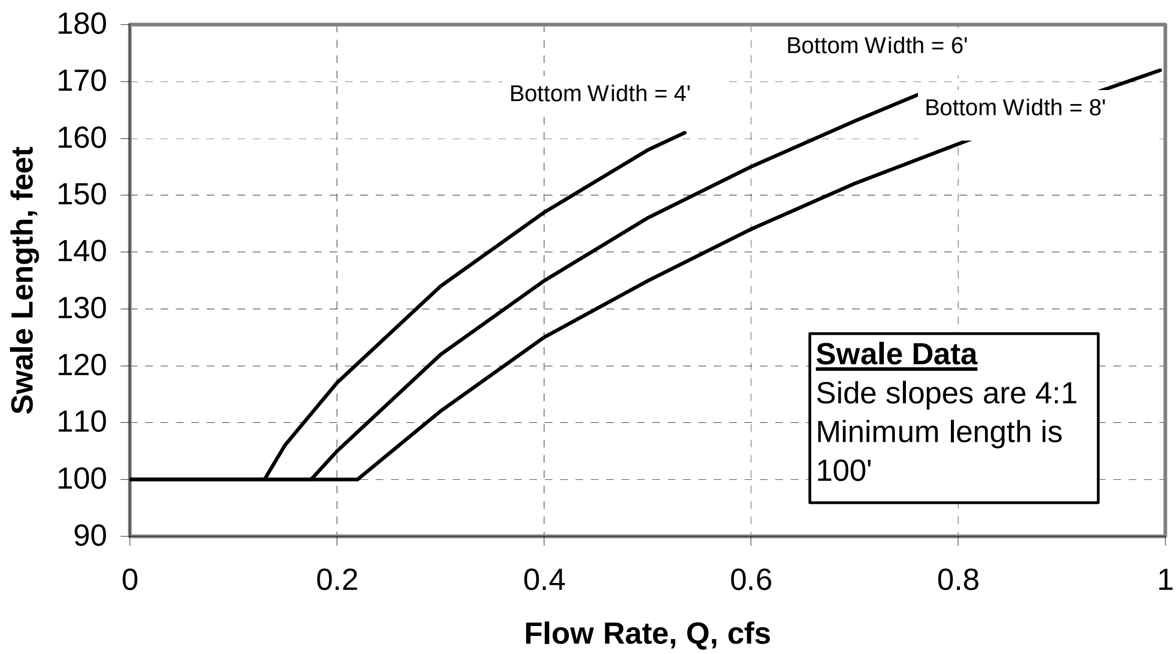
Velocity through the facility shall not exceed 3 feet per second (fps) during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

- **Flow spreader**: The grassy swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than 6 feet, a flow spreader shall be installed at least every 50 feet.

- **Check dams:** For slopes greater than 5 percent, check dams shall be used (a minimum of one 6-inch-high dam every 10 feet).

Exhibits 2-21, 2-22, and 2-23 are based on the City standards and may be used to easily determine swale length, given the peak flow rate and the desired swale bottom width.

Exhibit 2-21 (Sheet 1)
Swale Length at 1.5% Longitudinal Slope



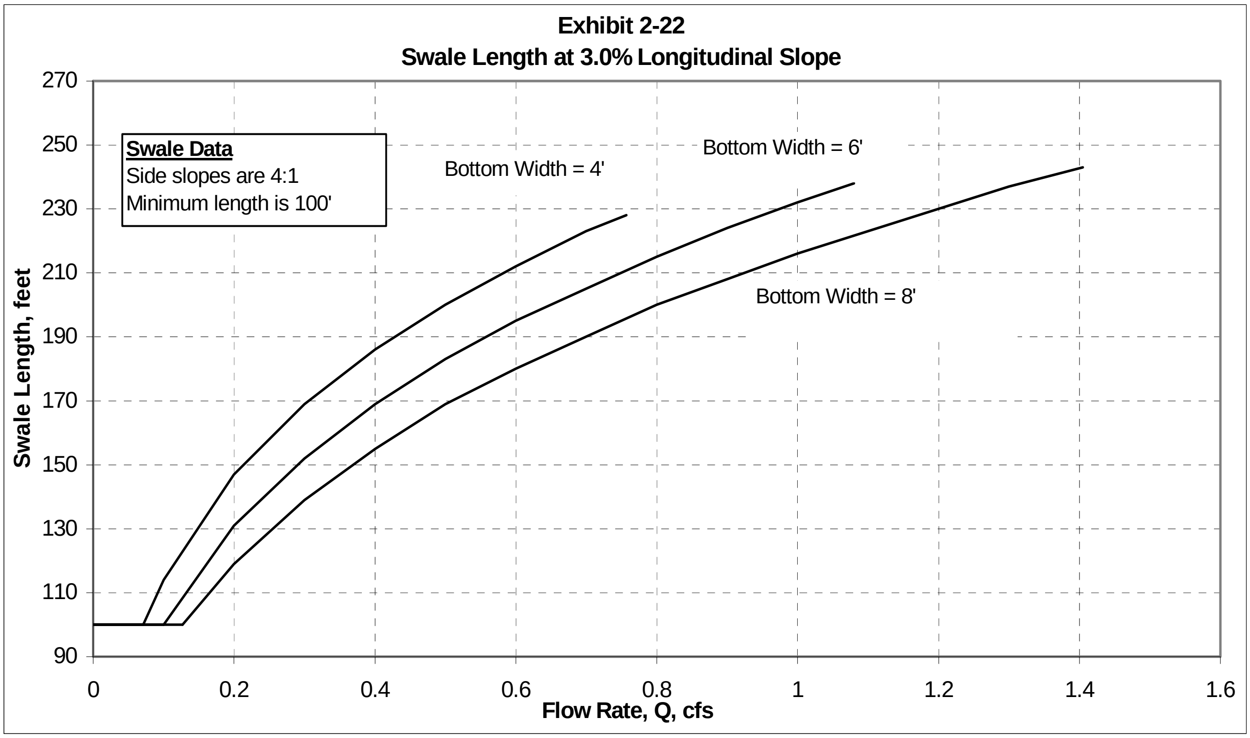


Exhibit 2-22
Swale Length at 3.0% Longitudinal Slope
Swale Data
Side slopes are 4:1
Minimum length is 100'
Bottom Width = 4'
Bottom Width = 6'
Bottom Width = 8'
Swale Length, feet
Flow Rate, Q, cfs
270
250
230
210
190
170
150
130
110
90
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6

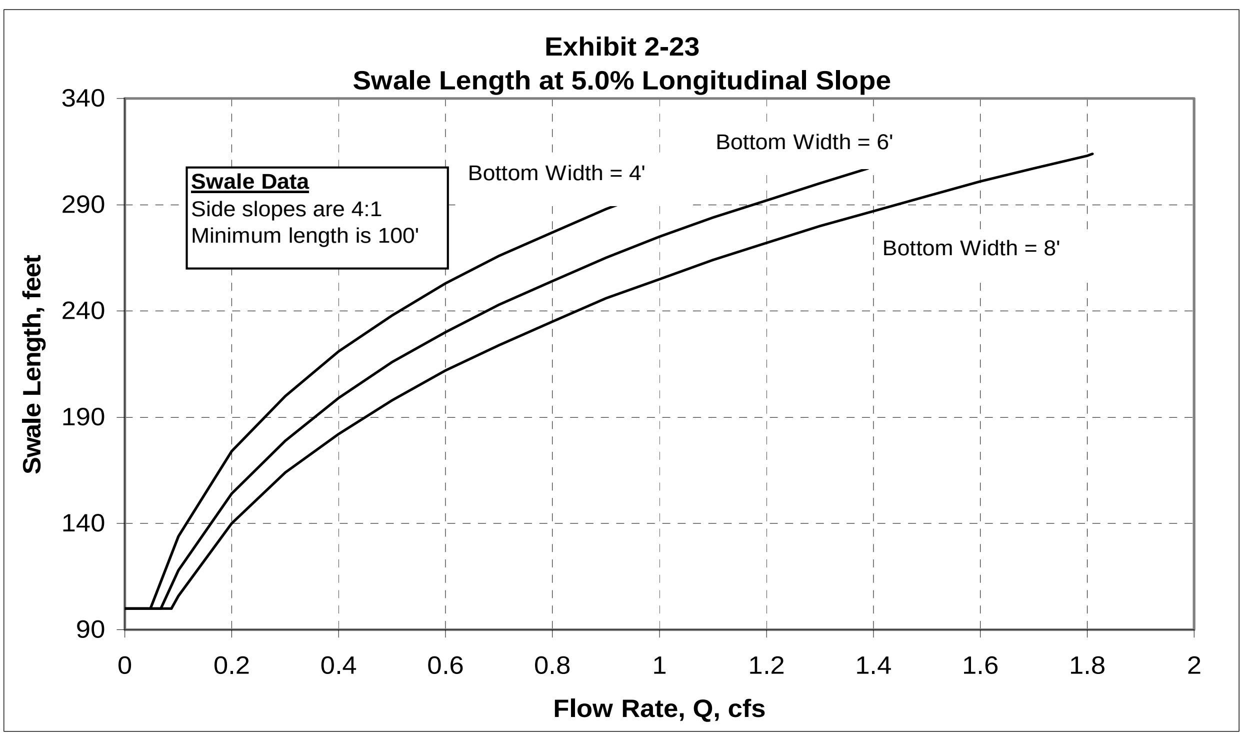


Exhibit 2-23
Swale Length at 5.0% Longitudinal Slope
Swale Data
Side slopes are 4:1
Minimum length is 100'
Bottom Width = 4'
Bottom Width = 6'
Bottom Width = 8'
Swale Length, feet
Flow Rate, Q, cfs
340
290
240
190
140
90
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

- **Dimensions and slopes:** The minimum grassy swale width on private property is 10 feet, with a minimum 2-foot flat bottom. The minimum grassy swale width on public property is 12 feet, with a minimum 4-foot flat bottom. Maximum side slopes for both are 4 horizontal to 1 vertical. The minimum length for both is 100 feet.

  When designing grassy swales, slopes and depth should be kept as mild as possible to avoid safety risks and prevent erosion within the facility. To minimize flow channelization, the grassy swale bottom shall be smooth, with uniform longitudinal slope. Maximum surrounding ground slopes shall not exceed 10 percent.

- **Growing medium:** Growing medium shall be used within the top 18 inches of the facility to support plant growth, per specifications in **Appendix F.3.**

- **Vegetation:** Grasses or sod shall be established as soon as possible after the swale is completed and before water is allowed to enter the facility. Unless vegetation is established, biodegradable erosion control matting appropriate for low-velocity flows (approximately 1 foot per second) shall be installed in the flow area of the swale before water is allowed to flow through the swale. **Exhibit 2-24** shows vegetation requirements for grassy swales.

Exhibit 2-24: Vegetation for Grassy Swales

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
1	**Evergreen tree**	200	Min height 6'	-
		OR		
1	**Deciduous tree**	200	Min caliper 1 ½" at 6" above base	-
		AND		
100%	**Native or swale seed mix coverage (completely cover bottom and side slopes)**			

For the swale flow path, approved native grass mixes are preferable and may be substituted for standard swale seed mix. Seed shall be applied at the rates specified by the supplier. The applicant shall have plants established at the time of facility completion (at least 3 months after seeding). No runoff shall be allowed to flow in the swale until grass is established. Trees and shrubs may be allowed in the flow path within swales if the swale exceeds the minimum length and widths specified. See **Appendix F.4** for more information.

Native wildflowers and grasses used for BES-maintained facilities shall be designed to not require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Lawn-type areas are not allowed for BES-maintained facilities; any exceptions require BES approval. Grassy swales in environmental zones shall meet requirements established by Title 33 for grass species in E-zones.

Submittal Requirements

Grassy swales require the applicant to submit a stormwater management plan under the Performance Approach.

Construction Considerations

No concentrated flows are allowed into the facility until the vegetation is fully established.

Maintenance

Access routes to grassy swales for maintenance purposes must be shown on the plans. Public swales need to provide a minimum 8-foot-wide access route, not to exceed a 10 percent slope.

See **Appendix G.2** **SW-230** through **SW- 234** for typical pond details.

Facility Description

Three types of ponds are described in this section: wet ponds, extended wet ponds, and dry ponds, all of which must be designed and submitted under the Performance Approach. (See **Section 2.2.3** for submittal requirements.) The facility must be able to provide 70 percent total suspended solids removal from 90 percent of the average annual runoff (as described in **Section 1.3.3**) and provide detention of the post-development peak runoff rates to less than pre-development peak runoff rates (as described **Section 1.3.2)**.

The City encourages applicants to design ponds to function as multipurpose facilities (e.g., parks, open space, or recreation facilities), provided that any alternative uses are compatible with the primary stormwater functions and maintenance standards.

Wet ponds are constructed with a permanent pool of water (commonly referred to as pool storage or dead storage). Stormwater enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biological processes. When the sizing criteria presented in this section are used, pollution reduction requirements are presumed to be met. Additional facilities may be required in order to meet flow control requirements, as applicable. An overflow mechanism to an approved discharge point (see **Section 1.3.1**) is required.

Extended wet ponds are also constructed with a permanent pool of water, but have additional storage above that fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to provide pollution reduction, and the additional storage above (extended detention area) is sized to meet flow control requirements. Pollutants are removed from stormwater through gravitational settling and biological processes. When the sizing criteria presented in this section are used, pollution reduction requirements are presumed to be met. The extended detention must be designed using acceptable hydrologic modeling techniques (see **Section 2.2**) to meet applicable flow control requirements (see **Section 1.3.2**). An overflow mechanism to an approved discharge point (see **Section 1.3.1**) is required.

Dry detention ponds are designed to fill during storm events and slowly release the water over a number of hours. Dry detention ponds must be designed using acceptable hydrologic modeling techniques (see **Section 2.2**) to meet applicable flow control requirements (see **Section 1.3.2**). Additional facilities are required in order to meet pollution reduction requirements, unless the bottom flow path of the pond is designed as a swale according to the swale sizing and design criteria. An overflow mechanism to an approved discharge point (see **Section 1.3.1**) is required.

Design Requirements

- **Location and Ownership:**
  - All open ponds to be maintained by the City of Portland shall be located in a separate open space tract with public sewer easements dedicated to the City.
  - Open ponds serving more than one tax lot or designed to function as multi-use/recreational facilities shall be located in a separate tract (e.g., Tract A), defined easement, or designated open space.
  - Instream ponds are not allowed.

- **Soil Suitability:** Wet and extended wet detention ponds are applicable in NRCS hydrologic soil group C and D soils (A and B soils with impermeable liner). Dry detention ponds are applicable in NRCS hydrologic soil group B, C, and D soils. Sites with type A soils should consider the use of an infiltration basin.

- **Setbacks:** Ponds shall be constructed to maintain the following setback distances from structures and other facilities. (All distances are measured from the edge of the maximum water surface elevation.

  - Minimum distance from the edge of the pond water surface to property lines and structures: 20 feet, unless an easement with adjacent property owner is provided.
  - Distance from the toe of the pond berm embankment to the nearest property line: one-half of the berm height (minimum distance of 5 feet).
  - Minimum distance from the edge of the pond water surface to septic tank, distribution box, or septic tank drain field: 100 feet.
  - Surrounding slopes shall not exceed 10percent. Minimum distance from the edge of the pond water surface to the top of a slope greater than 15 percent: 200 feet, unless a geotechnical report is submitted and approved by BES (see **Appendix G.2** **SW-230**).
  - Minimum distance from the edge of the pond water surface to a well: 100 feet (see **Appendix G.2** **SW-230**).

- **Dimensions and slopes:**
  - Slopes and depth should be kept as mild as possible to avoid safety risks. Slopes within the pond shall not exceed 3 horizontal to 1 vertical.
  - The maximum depth of the pond shall not exceed 4 feet. The 0- to 2-foot depth shall be distributed evenly around the perimeter of the pond.

- The distance between all inlets and the outlet shall be maximized to facilitate sedimentation. The minimum length-to-width ratio is 3:1, at the maximum water surface elevation. This ratio is critical to prevent "short-circuiting," where water passes directly through the facility without being detained for any length of time. If area constraints make this ratio unworkable, baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short-circuiting.
- Minimum freeboard shall be 1 foot above the highest potential water surface elevation (1 foot above the emergency overflow structure or spillway elevation).
- Dry detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area and shall provide at least 0.5 foot of dead storage for sediment accumulation.
- Wet and extended wet detention ponds shall be divided into a minimum of two cells. The first cell (forebay) shall contain approximately 10 percent of the design surface area.

- **Sizing:**
  - Wet and extended wet detention ponds should be designed for large drainage areas (5 to 150 acres) to help avoid problems associated with long periods of stagnant water.
  - For wet and extended wet detention ponds, a water budget shall be submitted for review. The water budget must demonstrate that the base flow to the pond is sufficient such that water stagnation/alga matting will not become a problem.

<u>Wet and Extended Wet Detention Permanent Pool Sizing</u>: The permanent pool (or dead) storage volume, V_{pond}, is equivalent to twice the runoff volume generated by a storm of 0.83 inch over 24 hours (NRCS Type 1A rainfall distribution). This volume can be approximated using the following formula:

Volume = 2 * (2,276 * Impervious Acreage)

Volume = permanent pool volume, cubic feet
Impervious Acreage = area of impervious surfaces to manage, acres

<u>EXAMPLE</u>
A 20-acre site is to be developed. After development, the site will be 60 percent impervious. What is the required volume for a wet pond to meet pollution reduction requirements?

For the post-development condition, the total area is 20 acres and the impervious area has increased to 60 percent, or 12 acres:

Permanent Pool Volume = 2 * (2,276 * 12) = <u>54,624 cubic feet</u>

- **Flow control for extended wet detention and dry detention ponds:** To restrict flow rates exiting the pond to those required by **Section 1.3**, a control structure must be used. For extended wet detention ponds, this control structure must be located above the permanent pool elevation. The outlet orifice shall be designed to minimize clogging.

  Note: Because of minimum orifice size requirements (2 inches for public facilities, 1 inch for private facilities), detention facilities that rely on orifice structures to control flows for small projects (under 15,000 square feet of impervious development footprint area) are not allowed. In these cases, rather than constructing a detention facility onsite, the applicant may apply to pay an offsite management fee for the flow control portion of offsite stormwater management through the special circumstances appeal process (see **Appendix D.7**). The appeal must clearly demonstrate that vegetated facilities (including ecoroofs) have been considered before the offsite management fee for detention will be considered.

Design Requirements

The following criteria apply to control structure design:
- Weir and orifice structures must be enclosed in a catch basin, manhole, or vault and must be accessible for maintenance.
- The control structure shall be designed to pass the 100-year storm event as overflow, without causing flooding of the contributing drainage area.

The methods and equations for the design of flow-restricting control structures, for use with extended wet detention ponds, and dry detention ponds are described below.

Orifices

- Orifices may be constructed on a "tee" riser section (see **Appendix G.2** **SW-263**) or on a baffle (see **Appendix G.2** **SW-264**).

- The minimum allowable diameter for an orifice used to control flows in a public facility is 2 inches. Private facilities may use a 1-inch-diameter orifice if additional clogging prevention measures are implemented. The orifice diameter shall always be greater than the thickness of the orifice plate.

- Multiple orifices may be necessary to meet the 2- through 25-year design storm performance requirements for a detention system. However, extremely low flow rates may result in the need for small orifices (< 1 inch for private facilities, < 2 inches for public) that are prone to clogging. In these cases, retention facilities that do not rely on orifice structures shall be used to the maximum extent practicable to meet flow control requirements (see **Section 1.3.2**). Where this is not practicable, the applicant must pay the offsite management fee rather than constructing a flow control facility. Large projects may also result in high flow rates that necessitate excessively large orifice sizes that are impractical to construct. In such cases, several orifices may be located at the same elevation to reduce the size of each individual orifice.

- Orifices shall be protected within a manhole structure or by a minimum 18-inch-thick layer of 1½ - 3-inch evenly graded, washed rock. Orifice holes shall be externally protected by stainless steel or galvanized wire screen (hardware cloth) with a mesh of ¾ inch or less. Chicken wire shall not be used for this application.

- Orifice diameter shall be greater than or equal to the thickness of the orifice plate.

- Orifices less than 3 inches shall not be made of concrete. A thin material (e.g., stainless steel, HDPE, or PVC) shall be used to make the orifice plate; the plate shall be attached to the concrete or structure.

Orifice Sizing Equation:

$$Q = C\,A\,\sqrt{2gh}$$

where:

Q = Orifice discharge rate, cfs
C = Coefficient of discharge, feet (suggested value = 0.60 for plate orifices)
A = Area of orifice, square feet
h = hydraulic head, feet
g = 32.2 ft/sec^2

The diameter of plate orifices is typically calculated from the given flow. The orifice equation is often useful when expressed as an equivalent orifice diameter in inches.

$$d = \sqrt{\frac{36.88\,Q}{\sqrt{h}}}$$

where:

Q = flow, cfs
d = orifice diameter, inches

h = hydraulic head, feet

Rectangular Notched Sharp Crested Weir:

$$Q = C(L - 0.2H) * H^{1.5}$$

where:

Q= Weir discharge, cubic feet per second (cfs)
C = 3.27 + 0.40*H/P, feet
P = Height of weir bottom above downstream water surface, feet
H = Height from weir bottom to crest, feet
L = Length of weir, feet*

* For weirs notched out of circular risers, length is the portion of the riser circumference not to exceed 50 percent of the circumference.

V-Notched Sharp Crested Weir:

$$Q = C_d \left(\mathrm{Tan}\,\frac{\theta}{2}\right) H^{\frac{5}{2}}$$

where:

Q = Weir discharge, cfs
C_d = Contraction coefficient, feet (suggested value = 2.5 for 90 degree weir)
θ = Internal angle of notch, degrees
H = Height from weir bottom to crest, feet

- **Outlet/overflow:**
  - If a riser pipe outlet is used, it shall be protected by a trash rack and anti-vortex plate. If an orifice plate is used, it shall be protected with a trash rack with at least 10 square feet of open surface area. In both cases, the rack must be hinged or easily removable to allow for cleaning. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.
  - All ponds shall have an emergency overflow spillway or structure designed to convey the 100-year, 24-hour design storm for post-development site conditions, assuming the pond is full to the overflow spillway or structure crest. The overflow shall be designed to convey these extreme event peak flows around the berm structure for discharge into the downstream conveyance system. The overflow shall be designed and sited to protect the

structural integrity of the berm. This will ensure that catastrophic failure of the berm is avoided, property damage is avoided, and water quality of downstream receiving water bodies is protected (see **Appendix G.2** **SW-232**).

– The subgrade of the spillway shall be set at or above the 100-year overflow elevation of the control structure. The spillway shall be located to direct overflows safely toward the downstream conveyance system and shall be located in existing soil wherever feasible. The emergency overflow spillway shall be armored with riprap or other flow-resistant material that will protect the embankment and minimize erosion. Riprap shall be designed in conformance with **Section 2.3** and shall extend to the toe of each face of the berm embankment. The emergency overflow spillway weir section shall be designed for the maximum design storm event for post-development conditions, using the following formula:

$$L = \frac{Q_{100}}{3.21H^{1.5}} - 2.4\,H$$

where:	L	= Length of bottom of weir, feet
	Q100	= 100-year post-development flow rate, cfs
	H	= Height of emergency overflow water surface, feet

- **Berm embankment/soil stabilization:**
  – Pond berm embankments shall be designed by a civil engineer licensed in the State of Oregon.
  – Pond berm embankments shall be constructed on native consolidated soil (or compacted and stable fill soil) that is free of loose surface soil materials, roots, and other organic debris. Topsoil is required over the consolidated soil to support required plantings.
  – Pond berm embankments shall be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width, measured through the center of the berm. The berm must be keyed into the native soil by excavating a trench below the berm. This keys the berm into the native soil and prevents it from sliding.

  – The berm embankment shall be constructed of compacted soil (95 percent maximum dry density, Modified Proctor Method per ASTM D1557) placed in 6- to 8-inch lifts with hand-held equipment, or 10- to 12-inch lifts with heavy equipment.

  – Anti-seepage collars shall be placed on outflow pipes in berm embankments that impound water greater than 8 feet in depth (see **Appendix G.2** **SW-233**). During construction, exposed earth on the pond side slopes shall be sodded or seeded with appropriate seed mixture. Establishment of protective vegetative cover shall be ensured with appropriate surface-protection best management practices (BMPs) and reseeded as necessary. See the City of Portland's *Erosion Control Manual*.

- Pond embankments shall be constructed with a maximum slope of 3H: 1V on the upstream and downstream face. Side slopes within the pond shall be sloped no steeper than 3H: 1V. The use of retaining walls in ponds requires pre-approval from BES. Retaining walls shall not exceed one-third of the circumference of the pond. Detailed structural design calculations must be submitted with every retaining wall proposal.

- Pond berm embankments 6 feet or less in height (including freeboard), measured through the center of the berm, shall have a minimum top width of 6 feet, or as recommended by a geotechnical engineer.

- Where maintenance access is provided along the top of berm, the minimum width of the top of berm shall be 15 feet.

- **Growing medium:** Because pond grading generally requires the topsoil to be removed to form the basin shape of the pond, the resulting top layers of soil must to be amended, or topsoil must be brought back in to ready the soil for planting. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F.3** to support plant growth.

- **Vegetation:** The planting design shall minimize solar exposure of open water areas. Trees or other appropriate vegetation shall be located around the east, south, and west sides of the facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, helping it maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop.

  The facility area is equivalent to the area of the pond, including bottom and side slopes, plus the 10-foot buffer around the pond. The emergent plant zone shall be at least 25 percent of the total pond water surface area. Minimum plant material quantities are shown in **Exhibits 2-25 and 2-26**.

Exhibit 2-25: Pond Vegetation - Emergent Plants

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
115	**Wetland plants**	100	6" plugs	1'
		OR		
100	**Wetland plants**	100		1'
4	**Small shrubs**	100	1 gallon	3'
		OR		
100%	**Seed coverage**			

Exhibit 2-26: Pond Vegetation – Side Slopes and Buffer

Number of plants	Vegetation type	Per square feet	Size	Spacing density (on center)
1	**Evergreen tree**	300	Min height 6'	-
		OR		
1	**Deciduous tree**	300	Min caliper 1 ½" at 6" above base	-
		AND		
4	**Large shrubs**	100	3 gallon or equivalent	4'
6	**Medium to small shrubs**	100	1 gallon or equivalent	2'
70	**Groundcover**	100	1 gallon or equivalent	1'

See **Appendix F.4** for more information.

Wildflowers, native grasses, and groundcovers used for BES-maintained facilities shall not require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions require BES approval.

- **Fencing and signage:** Fences are required for all City-maintained ponds with a permanent or temporary pool greater than 18 inches deep, interior side slopes steeper than 3H: 1V, or any walls/bulkheads greater than 24 inches high. The design shall address screening requirements for fencing. Fencing for privately owned facilities is at the discretion of the owner. The owner may, however, want to use the criteria for City-maintained facilities.

For both private and City-maintained facilities, Title 33 may prohibit fencing or require screening in some locations. The designer is responsible for determining which sections of Title 33 apply to the project. If fencing is prohibited by Title 33, the designer may have to modify the facility or site design to provide an alternate means of securing the site (for example, reducing the depth of water or side slopes of the facility to minimize safety concerns).

For both private and City-maintained facilities where fencing is used, fences shall be at least 6 feet high. The 6-foot height may not be required in situations where fences are not needed to prevent climbing (e.g., on steep slopes where they are needed to prevent slipping). For City-maintained facilities, a minimum of one vehicular locking access gate shall be provided. It shall be 10 feet wide, consisting of two swinging sections each 5 feet wide. At least one pedestrian gate shall be provided, with a minimum 4-foot width.

Fencing materials shall be complementary to the site design. If chain link fencing is proposed for a City-maintained facility, it shall be specified in accordance with the City of Portland *2007 Standard Construction Specifications.*

Submittal Requirements

Ponds require the applicant to submit the stormwater management plan under the Performance Approach. In addition to the submittal requirements included in the Stormwater Management report, all plans must show:

- Facility dimensions and setbacks from property lines and structures.
- Profile view of facility, including typical cross-sections with dimensions.
- All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Additional information may be required on the drawings during permit review, depending on individual site conditions.

Maintenance

Access routes to the pond for maintenance purposes must be shown on the plans. Public ponds must provide a minimum 8-foot-wide access route, not to exceed 10 percent in slope.

See **Appendix G.2** **SW-220** through **SW-222** for typical sand filter details.

Facility Description

Sand filters, like planters, are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater, allowing pollutants to settle and filter out as the water percolates through the sand and gravel. They can be constructed above, at, or below grade. Depending on site conditions, sand filters can be designed to completely infiltrate all the stormwater they receive or designed as flow-through facilities where only a portion of the flow is infiltrated, and overflow is directed to an approved discharge point.

If plants are used, sand filters can be used to help fulfill a site's required landscaping area requirement and should be integrated into the overall site design. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site.

Sand filters must be designed and submitted under the Performance Approach. (See **Section 2.2.3** for submittal requirements.) The facility must be able to provide pollution reduction of 70 percent total suspended solids removal from 90 percent of the average annual runoff (as described in **Section 1.3.3**) and provide detention of the post-development peak runoff rates to less than pre-development peak runoff rates (as described in **Section 1.3.2**).

Design Requirements

- **Soil suitability**: Existing infiltration rates will determine if the facility can be designed to achieve infiltration, partial infiltration, or allow the stormwater to flow through the facility. See **Appendix F.2** for infiltration testing procedures. If the tested infiltration rate is greater than or equal to 2 inches per hour, the sand filter must overflow to a subsurface infiltration facility. If the tested infiltration rate is less than 2 inches per hour, the sand filter should be designed as a partial infiltration or flow-through facility, with an overflow to an approved discharge point.

- **Setbacks:** Infiltration sand filters require 5-foot setbacks from property lines and 10-foot setbacks from building foundations. No setbacks are required for lined flow-through sand filters where the height above finished grade is 30 inches or less. Lined flow-through sand filters can be used next to foundation walls, adjacent to property lines, or on slopes when they include a waterproof lining.

- **Sizing:** Sand filters must be designed to meet the stormwater management requirements as specified in **Sections 1.3** and **2.2.3.** Sand filters shall be designed to pond water for less than 4 hours after each storm event.

- **Dimensions and slopes:** The minimum flow-through sand filter width is 18 inches, and the minimum infiltration planter width is 30 inches. The minimum sand filter depth is 18 inches. Sand filters are relatively flat facilities that shall not slope more than 0.5 percent in any direction. Where the facility is at or above grade, the storage depth must be at least 12 inches between the top of the filter medium and the base of the overflow, unless a larger-than-required planter square-footage is used. For subgrade facilities, the filter medium must be 30 inches deep, with 8 inches of gravel above and below for conveyance. A minimum of 2 inches of freeboard (vertical distance between the overflow inlet elevation and overtopping elevation) shall be provided.

- **Planter walls:** Planter walls shall be made of stone, concrete, brick, or other durable material. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

- **Waterproof liners:** Flow-through facilities require a waterproof liner. There are many liner options and installation varies. Liner shall be 30 mil PVC or equivalent.

- **Gravel drain rock:** Drain rock is required below the sand. For infiltration facilities where drain rock is specified to retain stormwater prior to infiltration, the specification is 1½-inch – ¾-inch washed drain rock. Where drain rock is specified primarily for detention and conveyance, the specification is ¾-inch washed drain rock. All flow-through facilities shall use ¾-inch wash drain rock. Drain rock and growing medium must be separated by filter fabric (see **Exhibit 2-4** for geotextile specifications) or use a 2- to 3-inch layer of ¾-inch – ¼-inch washed, crushed rock.

- **Piping:** For private property, piping shall be cast iron, ABS SCH40, or PVC SCH40. Three-inch pipe is required for facilities draining up to 1,500 square feet of impervious area; otherwise, a 4-inch pipe minimum is required. Piping installation must follow current Uniform Plumbing Code. For streets, 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe and perforated pipe are required. Refer to the City's *Sewer and Drainage Facilities Design Manual* for more information.

  Where a collector manifold with perforated lateral branch lines is used, lateral branch line spacing shall not exceed 10 feet. The underdrain laterals shall be placed with positive gravity drainage to the collector manifold. The collector manifold shall have a minimum 1 percent grade toward the discharge joint. All laterals and collector manifolds shall have cleanouts installed, accessible from the surface without removing or disturbing filter media.

- **Vegetation:** Plantings are recommended in sand filters. Plants enhance infiltration, prevent erosion, and compete with weeds.

For public sand filters, the following additional criteria apply:

The sand filter must consist of an inlet structure, sand bed, underdrain piping, and liner. Criteria for the inlet structure and sand bed are provided below.

- The **inlet structure** shall spread the flow of incoming water uniformly across the surface of the filter medium during all anticipated flow conditions. This flow shall be spread in a manner that prevents roiling or otherwise disturbing the filter medium.

- **Sand bed**
  - The length-to-width ratio shall be 2:1 or greater.
  - The effects of consolidation and/or compaction must be taken into account when placing medium materials. The surface of the filter medium shall be level.
  - Sand used as filter bed medium shall be certified by a testing laboratory as meeting or exceeding the filter bed specifications presented below.
  - **Filter bed** medium shall consist of clean medium to fine sand with no organic material or other deleterious materials, and shall meet the following gradation:

Sieve Size	Percent Passing
3/8″	100
#4	95-100
#8	80-100
#16	45-85
#30	15-60
#50	3-15
#100	< 4

Submittal Requirements

Sand filters require the applicant to submit the stormwater management plan under the Performance Approach.

Construction Considerations

Special attention should be paid to the structural waterproofing if the facility is constructed adjacent to building structures. The location of the infiltration sand filter shall not be subject to compaction prior to, during, and after the construction of the facility.

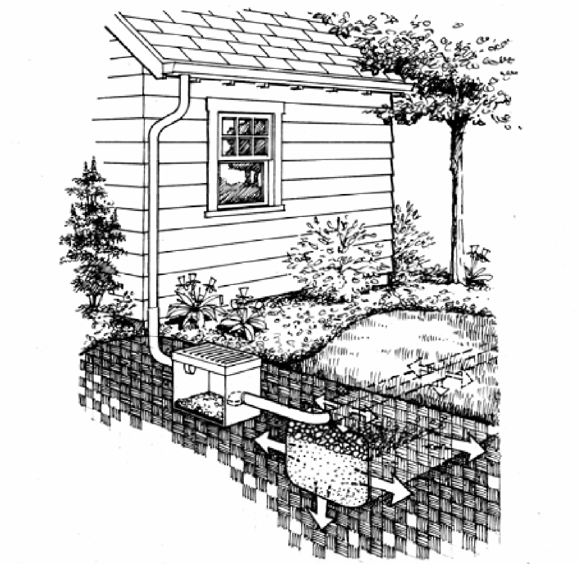


Exhibit 2-27: Soakage Trench illustration. See **Appendix G.1** **SW-180 and SW-181** for typical soakage trench details.

Facility Description

A soakage or infiltration trench is a shallow trench in permeable soil that is backfilled with washed drain rock and lined with filter fabric. The trench surface may be covered with grass, stone, sand, or plantings. Private soakage trenches can be used to provide stormwater discharge by collecting and recharging stormwater runoff into the ground. The use of soakage trenches is highly dependent on the soil type and height of the groundwater table. Soakage trenches are not allowed in the right-of-way.

> **Note:** Soakage trenches are "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be registered with DEQ and classified as exempt, authorized by rule, or authorized by permit. Since the UIC Program states that these types of trenches can have a direct impact on groundwater, pollution reduction is required before discharging stormwater into them (unless they are used exclusively for residential roof runoff from three units or less).
>
> For more information about the UIC requirements, refer to **Section 1.4** or visit DEQ's website: http://www.deq.state.or.us/wq/uic/uic.htm. For technical questions call the DEQ-UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189. Any modification to a trench that functions as a UIC must have prior approval from DEQ before modifications are made. Modifying any DEQ-approved soakage trench without DEQ approval voids the original approval.

There are two soakage trench configurations, one for the east side of the City and one for the west side. The distinction between east and west side soakage trenches is based on soil type and site characteristics rather than orientation to the Willamette River. The west side is often characterized with Cascade, Cornelius, and Powell silt loams where soils are "somewhat poorly drained" (*Soil Survey of Multnomah County, Oregon*, 1983) and frequently steeply sloped. The east side is dominated by the "well drained" Multnomah and Latourell loams and silt loams. The use of east and west side design specifications is based on site conditions, not necessarily geographic location.

Soakage trenches are excluded from use within the Columbia South Shore and Cascade Station/Portland International Center Plan Districts (see **Exhibit 1-8**). See **Section 4.3** for areas affected by source control requirements.

Design Requirements

- The maximum impervious area to be served by a soakage trench is 10,000 sq feet.

- Trenches shall not be constructed under current or future impervious surface.

- All trenches shall be constructed in native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.

- Minimum drawdown time for a soakage trench is 10 hours.

- Bureau of Development Services (BDS) Site Development, must approve any variation of design or installation.

- **Soil suitability**: Soil conditions are critical to the success of soakage trenches. Submission of infiltration test results is required and must be approved by Site Development. Infiltration test results must be recorded on the Simplified Approach Form where the Simplified Approach is applicable and otherwise in the Stormwater Management Report (see **Appendix D.3 and D.4**). Supporting geotechnical analysis is required for slopes of 20 percent or greater, or when requested.
  - A 2-inch/hour infiltration rate is required at the facility base.
  - There must be a 5-foot separation distance from the bottom of the trench to any impervious layer or water table. Soakage trenches are not allowed in areas of shallow groundwater where the separation distance from the bottom of the trench to seasonally high ground water is less than 5 feet.

- **Setbacks:** Soakage trenches require 5-foot setbacks from property lines and 10-foot setbacks from building foundations, unless an appeal is approved by BDS. One hundred-foot setbacks are required from slopes 20 percent or greater.

- **Sizing:** Simplified trench sizing is based on treating 90 percent of the average annual runoff, which is a storm event of 1.8 inches of precipitation as described in a storm analysis of City of Portland precipitation (see **Appendix E**). The sizing of trench facilities varies, based on site conditions.

  Soakage trench sizing is based on the SBUH method, with a 24-hour NRCS type 1A hyetographic distribution. East and west side trenches are designed with infiltration rates of 2.00 inches and 0.85 inch per hour, respectively. Pore space of the fill material was assumed to be 30 percent, with vertical infiltration area only. The trench shall infiltrate the entire design storm without overflow.

  Exhibit 2-28 shows soakage trench dimensions.

Exhibit 2-28: Soakage Trench Dimensions

		Sizing based on 1000 sf			Design Infiltration Rate (in/hr)
Trench Type	**Area Ratio**	**Length (ft)**	**Width (ft)**	**Height (ft)**	
East Side	5%	20	2.5	1.5	2.00
West Side	9%	30	3.0	1.0	0.85
Area ratio = 100 x area of trench/impervious area treated *Trench size is the product of the impervious area treated and the area ratio (1000sf x 0.09 = 90sf)*					

- **Gravel drain rock**: A minimum of 12 or 18 inches of washed ¾ – 2½-inch round or crushed rock separated from soil by one layer of filter fabric depending on trench type.

- **Filter fabric: S**ee **Exhibit 2-3** for geotextile specifications.

- **Piping:** The solid conveyance piping from a building or other source must be installed at a ¼-inch per linear foot slope prior to connection with perforated pipe.
  - A minimum 12-inch cover is required from the top of all piping to the finished grade.
  - All piping within 10 feet of a building must be 3-inch sch. 40 ABS, sch. 40 PVC, or cast iron for rain drain piping serving 1,500 square feet or less of

impervious area. For an area greater than 1,500 square feet, 4-inch pipe must be used.

- The pipe within the trench shall be either PVC D2729 or HDPE leach field pipe.
- Perforated pipe shall be laid on top of gravel bed and covered with filter fabric.
- Optional silt traps will greatly extend the life of the soakage trench. The silt trap shall be installed between the dwelling and the trench, a minimum of 5 feet from the dwelling.

Gravel Pits

Gravel pits shall be sized and permitted the same as soakage trenches but can only treat up to 250 square feet.

Manufactured Chamber Technologies

Corrugated plastic stormwater chambers are generally made of high-density polypropylene or polyethylene. They are arched systems that can be rated for H-10 or H-20 loading, depending on the manufacturer, amount of cover, and type of cover.

Chamber systems function similarly to the standard soakage trench, but are often used in areas with limited infiltration because of high groundwater or shallow (<5 feet) infiltration barriers such as dense silt and clay layers. They provide temporary storage of stormwater prior to infiltration and may be able to be used with soils that infiltrate less than 2 inches per hour, with Bureau of Development Services approval. Chambers are underground injection control systems (UICs) and require DEQ registration (unless they are used exclusively for residential roof runoff from three units or less).

Sizing:
Where the Simplified Approach can be used, the chambers must be designed to at least the same requirements as trenches. Chamber sizing shall be based on treating 90 percent of the average annual runoff, which is a storm event of 1.8 inches of precipitation as described in a 2004 storm analysis of City of Portland precipitation (see **Appendix E)**. The sizing below is based on the SBUH method with a 24-hour NRCS type 1A hyetographic distribution. The east and west sides are designed with infiltration rates of 2.00 inches and 0.85 inch per hour, respectively. Pore space of the fill material is assumed to be 0.30. **Exhibit 2-29** shows manufactured chamber technologies dimensions.

Exhibit 2-29: Manufactured Chamber Technologies Dimensions

Soil Type	Area Ratio	Sizing Based on Standard Chamber Size: Length (ft)	Width (in)	Height (in)	Design Infiltration Rate (in/hr)
East Side Chamber	1 per 600 sf IA*	~90	34	16 + 6″ base rock	2.00
West Side Chamber	1 per 400 sf IA	~90	34	16 + 6″ base rock	0.85

**IA = Impervious area treated*

Setbacks: All manufactured chambers must be 10 feet on center from all foundations and 5 feet from property lines.

Fill: Six inches of washed drain rock is required below chamber. Additional depth or length will be required for infiltration rates less than the infiltration rates specified.

Construction Considerations

- Soakage trench areas shall be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular construction traffic, except that specifically used to construct the facility, shall be allowed within 10 feet of soakage trench areas.
- The bottom of the soakage trench shall be level, or clay check dams may be used to prevent water from collecting near the downstream end.
- The drain medium shall have filter fabric between the medium and native soils and covering perforated pipe to prevent clogging.
- Soakage trench and perforated pipe must be installed level and parallel to the contour of the finish grade.

Resources

- Refer to OAR 340, Division 44: *Construction and Use of Waste Disposal Wells or Other Underground Injection Activities*, for additional design and regulatory requirements.

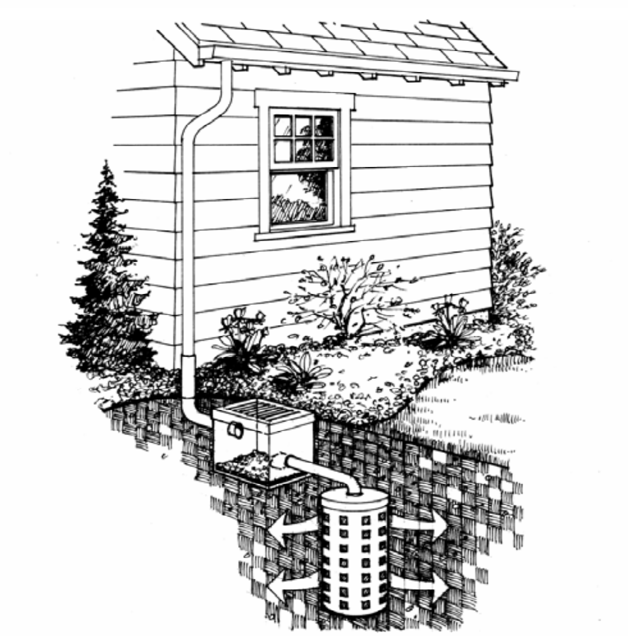


Exhibit 2-30: Drywell illustration. See **Appendix G.1** **SW-170** for typical drywell details.

Facility Description

The typical drywell is a pre-cast concrete ring in 5-foot-tall sections perforated to allow for infiltration. These facilities are vertical in nature, which prevents their use in areas that have limited infiltration because of seasonal high groundwater or a shallow infiltration barrier such as a dense silt, clay, or fragipan layer.

Note: Drywells are "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be registered with DEQ and classified as exempt, authorized by rule, or authorized by permit. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before discharging stormwater into them (unless they are used exclusively for residential roof runoff from three units or less).

For more information about UIC requirements, refer to **Section 1.4** or visit DEQ's website: http://www.deq.state.or.us/wq/uic/uic.htm. For technical questions, call the DEQ-UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189. Any modification to a drywell that functions as a UIC must have prior approval from DEQ before modifications are made. Modifying any DEQ-approved drywell without DEQ approval voids the original approval.

Drywell systems are prohibited from use within the Columbia South Shore and Cascade Station/Portland International Center Plan Districts (see **Exhibit 1-8**). See **Section 4.3** for areas affected by source control requirements. Since the bases of drywells are greater than 5 feet in depth, they are prohibited where permanent or seasonally shallow groundwater will exist within 10 feet of the bottom of the drywell, based on DEQ requirements and **Appendix F.1**.

Design Requirements

- **Soil suitability**: Soil conditions are critical to the success of drywells. Because of this, an infiltration test or bore-log feasibility test must be performed and the results submitted to the Bureau of Development Services (BDS) for approval. The Simplified Approach Form (See **Appendix D.3**) must be completed and signed by the applicant, where applicable; otherwise, the sizing and infiltration must be accounted for in the Stormwater Management Report. Drywells should be used only if the soils infiltrate at least 2 inches per hour or with documented approval from BDS Site Development. Installation of drywells in fill material is not permitted. All drywells must be installed in native soils. Supporting geotechnical evidence is required for all slopes of 20 percent or greater or when requested.

- **Setbacks:** The drywell must be 10 feet on center from all foundations and 5 feet from property lines. The top of the drywell shall be located downgrade from foundations and at a lower elevation than local basements.

- **Sizing:** The chart provided in **Exhibit 2-31** shall be used to appropriately size the drywell(s), based on the amount of impervious area that each drywell is designed to manage. This chart shall be used as guidance. It is based on field experience and should be used as minimums only.

- **Traps:** Silt traps are not required to be installed with drywells, but are strongly encouraged because they will lengthen the life of the facility.

Exhibit 2-31: Drywell Sizing Chart

Drywell Sizing: *Once BDS has issued approval for on-site infiltration, the following chart shall be used to select the number and size of drywells. Gray boxes indicate acceptable.*								
Impervious Area (sq-ft)	**28" Diameter**				**48" Diameter**			
	Drywell Depth				**Drywell Depth**			
	5'	**10'**	**15'**	**20'**	**5'**	**10'**	**15'**	**20'**
1000								
2000								
3000								
4000								
5000								
6000								
7000								
8000								
9000								
10000								
11000								
12000								
13000								
14000								
15000								
16000								
17000								
18000								
19000								
20000								

Manufactured Plastic Drywells

Manufactured plastic “mini-drywells” are made of hard plastic (foam polyolefin) and are very versatile. The excavations for theses facilities can be hand dug, the setbacks are not as great as typical drywells, and the drywells can be placed by hand rather than using equipment (as with typical concrete drywells).

> Dimensions: 2-foot diameter, 2-foot depth, plus 1-foot gravel lens below and on the sides.
> Sizing: 1 unit for every 500 square feet of impervious area, with BDS approval.
> Setbacks: From center: 5 feet to property line, 8 feet to any foundation, and 20 feet to existing cesspools.

Drywell Testing Procedure

Equipment needed:

- Water supply capable of filling drywell
- Tape measure to the base of the facility

- Stopwatch
- Flashlight

In the presence of a City inspector:

1) Place the measuring tape against the drywell wall, measuring to the bottom of the drywell or to the water table. Secure in place for the duration of the test.
2) Fill the drywell with clean potable water. Document the water level before starting the stopwatch.
3) Shut off the water supply and start the stopwatch.
4) Stop the stopwatch when the water level has dropped by 5 feet. Record the elapsed time.
5) Compare this time to the "Maximum Time in Minutes for Water to Drop by 5 feet in Drywell" from **Exhibit 2-32**. The diameter of the drywell and square footage of impervious site area that will flow into the drywell must be known to determine drawdown time. If the elapsed time is less than the time shown on the chart, one facility is sufficient. If the elapsed time is greater than the time shown on the chart, divide the elapsed time by the chart time and round to the nearest whole number. This is the number of drywells that will be required.
6) Results of the test shall be given to the inspector or sent in if the inspector is not onsite through completion of the test.

Exhibit 2-32: Drywell Testing Table

Maximum Time in Seconds for Water to Drop by 5 feet in Drywell
Drop time = Volume of drywell / (CIA x SF)

Impervious Area (sq ft)	28" Diameter Drywell Depth				48" Diameter Drywell Depth			
	5'	10'	15'	20'	5'	10'	15'	20'
1,000	180	180	180	180	534	534	534	534
2,000	90	90	90	90	270	270	270	270
3,000	60	60	60	60	180	180	180	180
4,000	48	48	48	48	132	132	132	132
5,000	36	36	36	36	108	108	108	108
6,000	30	30	30	30	90	90	90	90
7,000	24	24	24	24	78	78	78	78
8,000	24	24	24	24	66	66	66	66
9,000	18	18	18	18	60	60	60	60
10,000	18	18	18	18	54	54	54	54
11,000	18	18	18	18	48	48	48	48
12,000	18	18	18	18	42	42	42	42
13,000	12	12	12	12	42	42	42	42

Resources

Refer to OAR 340, Division 44: *Construction and Use of Waste Disposal Wells or Other Underground Injection Activities*, for additional design and regulatory requirements.

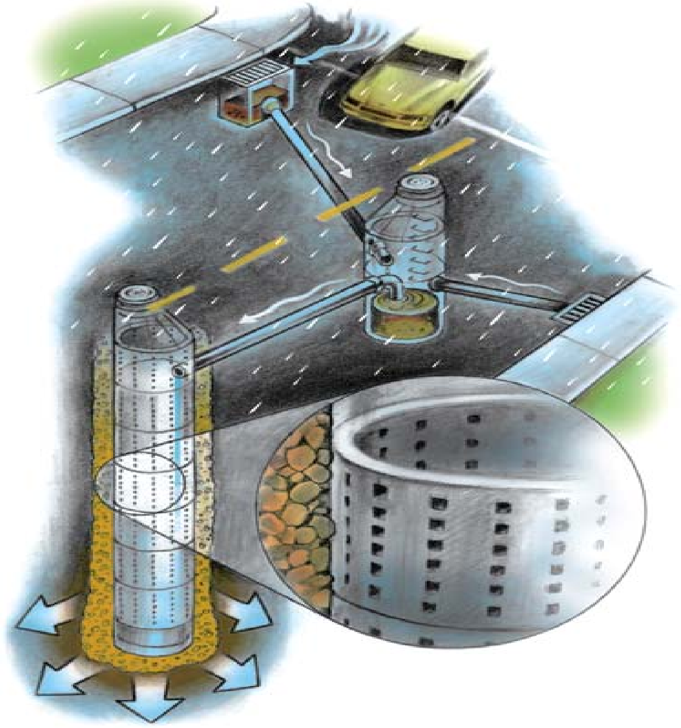


Exhibit 2-33: Sump Illustration. See City of Portland **Standard Plans 4-10 and 4-11** for typical details.

Facility Description

Public infiltration sump systems can be used to provide public street drainage by collecting and recharging stormwater runoff into the ground. The use of sumps is highly dependent on soil type and elevation of the groundwater table. Sumps are different from drywells in that they are typically 30 feet deep and in the public right-of-way.

Note: Sumps are "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be registered with DEQ and authorized by rule or authorized by permit. In the case of public sumps, BES administers the rule authorization process with DEQ. Because sumps can have a direct impact on groundwater, pollution reduction is required before discharging stormwater into them.

See **Section 1.4** for more information about UIC requirements or visit DEQ's website: http://www.deq.state.or.us/wq/uic/uic.htm. For technical questions, call the DEQ-UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189. Any modification to a sump that functions as a UIC must have prior approval from DEQ before modifications are made. Modifying any DEQ-approved sump without DEQ approval voids the original approval.

A sump system is the total of all sump components at a single location (e.g., an intersection) and consists of inlets, piping, a sedimentation manhole, and one or more sumps. If one sump lacks adequate capacity to handle the design flow, a second sump may be placed in series with the first to provide additional capacity.

Sedimentation manholes with oil traps receive runoff from inlets before stormwater enters the sumps. The sedimentation manholes settle out most of the large particulate material that can clog sumps' drainage holes, which decreases maintenance needs and increases long-term effectiveness. Detailed drawings of a standard sump and standard sedimentation manhole can be found in the Portland Office of Transportation Standards for Construction: Standard Drawings Environmental Services 4-10 (Sump) and 4-11 (Sedimentation Manhole).

When constructed according to the standard design procedures, the sump system achieves both flow control and some pollution reduction benefits. The sedimentation manhole reduces pollution through removal of sediment, oils, and grease. Additional pollution reduction facilities, such as street swales, planters or filters, must be used in non-residential streets or streets with over 1,000 average daily trips.

Design Requirements

Sumps are recognized as a disposal method for managing stormwater runoff. Sump systems are excluded from use within the following specific areas and land use types within the City:

- Columbia South Shore and Cascade Station/Portland International Center Plan Districts (see **Section 1.3.4).**
- Major City traffic streets (including district collectors) in combined sewer areas, or neighborhood collectors in commercially zoned areas (Refer to *Transportation Element, Comprehensive Plan,* Office of Transportation, 2000).
- Within 500 feet of municipal or domestic drinking water wells, or a 2-year time of travel zone, whichever is greater
- In areas with permanent or seasonally shallow groundwater (< 40 feet below the ground surface). See site evaluation maps in the **References and Resources** section.

- See **Section 4.3** for areas affected by source control requirements.

- **Soil suitability**: Soil conditions are critical to the success of sump systems. The use of sumps will not be approved without supporting geotechnical evidence and a documented sump test to demonstrate they will work in the particular area of interest. The geotechnical evidence shall include test sump data to provide information about local underground soil conditions and the potential infiltration capacity of the surrounding soil.

- **Sizing:** Public sump systems shall be designed to handle **twice** the flow from the calculated design storm.

- **Dimensions:**
  - A maximum of two sumps shall be used in series, unless approved by BES.
  - The minimum distance between sumps shall be 25 feet.
  - The desired distance between the sump and sedimentation manhole is 25 feet. This figure is a guideline and depends on site conditions.
  - Sumps shall not be located in areas with a constant or seasonally high groundwater table or shallow bedrock. The bottom of the sump shall be at least 10 feet above the seasonal high water table and at least 3 feet above bedrock.
  - Sumps shall not be located within 200 feet from the tops of slopes more than 10 feet high and steeper than 2h: 1v.
  - The sump depth shall be 30 feet, unless otherwise approved by BES.
  - The sedimentation manhole depth shall be 10 feet.

- **Piping:**
  - The diameter of pipe between the sump and sedimentation manhole shall be 12 inches. (Note: The pipe leaving the sedimentation manhole is fitted with a 90-degree short-radius elbow. See City of Portland **Standard Plans 4-10** and **4-11.)**
  - See the City of Portland's *Sewer and Drainage Facilities Design Manual* for acceptable pipe material types between the sump and sedimentation manhole.

Exhibit 2-34 provides standard sump notes.

Exhibit 2-34: Standard Sump Notes

SUMP NOTES for Plan Set

Design flows reflect a factor of safety of 2.

All sumps shall be tested by the contractor as directed and approved by the City inspector.

Sump testing shall take place after sump construction is complete and before the construction of the sedimentation manhole. Should a sump test fail to verify adequate capacity, an additional sump, constructed in series with the first sump (a maximum of two sumps per system) shall be required, as approved by BES. Should a test of two sumps in series fail to verify adequate capacity, an alternative public stormwater destination shall be required, as approved by BES.

Notify BES inspector or BES construction office at (503) 823-5728 at least 48 hours before beginning sump testing. A BES representative must be present during all sump capacity tests.

Contractor shall contact the City Water Bureau or applicable water district to arrange for sump test water supply. Contractor shall be responsible for obtaining necessary permits, authorization, and any fees.

Contractor may lease sump testing equipment from BES Materials Testing Laboratory, subject to leasing conditions and fees. Contact the laboratory, located at 1405 N River, at (503) 823-2340. Similar testing equipment from any vendor may be used, as approved by BES.

Provide water flow from fire hydrants to sump being tested, using 8-inch nominal diameter pipe. Deliver clean potable water to sump. Introduction of sediment is not acceptable and may result in failure of sump capacity test and reconstruction of sump.

Fill sump with water at an initial rate of 300 gallons per minute (gpm), and record water elevation below sump manhole lid every five minutes. When water surface reaches a constant elevation, increase flow rate to sump to 600 gpm. Record water surface elevations every five minutes. Continue to increase flow rate 300 gpm each time water surface elevation stabilizes, until maximum capacity is reached.

Immediately upon completion of the sump test, provide BES inspector with recorded test data. Contractor shall sign the results and submit to the BES inspector.

The closest fire hydrant for sump testing is located at the intersection of _____________ & ____________. Contact the Water Bureau to apply for a hydrant use permit.

Public Sump System Testing

Before being accepted by the City, all public sumps shall be tested after construction to ensure they meet or exceed the design capacity.

- Hydraulic calculations for public sumps shall be performed using the Rational Method. Information on the use and application of the Rational Method is found in BES's *Sewer and Drainage Facilities Design Manual.*
- Sumps shall be designed for a 10-year design storm, with a safety factor of 2.
- The time of concentration for sump design shall be 5 minutes.

Exhibit 2-35 shows a sump testing example.

Exhibit 2-35: Sump Testing Example

Example: What is the design percolation rate that a sump system must achieve to adequately dispose of runoff from 10,000 square feet of paved street area?

Rational Formula:	Q=C*I*A
Assume:	Time of concentration = 5 minutes for the street area
Where:	Q= Flow in cubic feet per second C= Runoff coefficient (0.9 for paved surfaces) I= Intensity (2.86 inches per hour for a 10-year storm event and a time of concentration of 5 minutes) A= Area in acres (10,000 square-feet = 0.23 acres) Q= (0.9) * (2.86) * (0.23) = 0.59 cfs
Apply safety factor of 2:	Q= 2 * 0.59 cfs = **1.18 cfs or 530 gallons per minute**

See *Sewer and Drainage Facilities Design Manual* Table 6.11 for rainfall intensity duration frequency at Portland International Airport.

Operations and Maintenance Requirements

- The applicant or contractor is required to maintain the public infiltration sump system for 2 years after construction is complete and signed off by BES.
- Turbid runoff from construction sites shall not be allowed to enter the system at any time.
- The sedimentation manhole shall be cleaned prior to BES acceptance of ownership and maintenance at the end of the warranty period.

Facility Description

BES has developed "Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies," located in **Appendix B**. For a manufactured stormwater treatment technology to be approved for general use within the City of Portland, the manufacturer must submit detailed performance testing data that meets the testing protocols included in that guidance.

For a facility to be approved for use as a public facility, the manufacturer must also submit detailed information about the facility's design criteria, construction techniques, operation and maintenance procedures, reliability, and cost. This information will be reviewed by BES's Standards and Practices Committee, which will decide whether or not the facility can be used for public projects.

Manufactured stormwater treatment technologies on BES's approved list must be designed and constructed in accordance with the manufacturer's recommendations. BES may have also placed special design conditions on the acceptance of the technology, such as sizing requirements that go beyond the manufacturer's recommendations, which must also be followed to obtain plan approval.

Manufactured stormwater treatment technologies on BES's approved list for general use may not be capable of meeting specific total maximum daily load (TMDL) requirements for certain watersheds. In that case, the treatment technology will not be accepted as a stand-alone pollution reduction facility. Instead, a pollution reduction facility presumed by BES to meet the TMDL requirement must be used.

Submittal Requirements

In addition to design calculations provided in the Stormwater Management Report (see **Appendix D.4**), the following must be submitted with each manufactured stormwater treatment technology project:

- Pollution reduction capacity of the facility.
- Flow-through conveyance capacity (i.e., how much flow can be passed through the facility without stirring up and releasing trapped pollutants).

The following additional information may be required, depending on site conditions.

- Facility dimensions and setbacks from property lines and structures.
- Profile view of facility, including typical cross-sections with dimensions.
- All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Resources

The approved vendor list is posted on the BES website at:
http://www.portlandonline.com/shared/cfm/image.cfm?id=187600

Exhibit 2-36: Rigler Rainwater Harvesting. See **Appendix G.2** **SW-250** for a typical rainwater harvesting detail.

Facility Description

Stormwater can be collected and reused for non-potable water uses within a house or building, or for landscape irrigation purposes. Uses can include reusing water in toilets (in multi-unit dwellings, a separate cistern is needed for each residence) and at hose bibs (a shared cistern can be used for landscape irrigation). All toilets and hose bibs must have permanent signage that notifies users of non-potable water. Any such system must obtain plumbing approval from the Bureau of Development Services (BDS).

The Water Bureau's Water Quality Inspections group also requires system containment backflow protection in the form of a reduced pressure (RP) type of backflow assembly. System containment RPs must be located on private property at the property line, immediately adjacent to the point of water service connection.

Rainwater harvesting can provide the following stormwater management benefits:

- Flow control: In many areas of the City (including much of the downtown district and inner east side) where onsite infiltration is not feasible and the only means of stormwater destination is offsite flow to a combination sewer system, rainwater harvesting can provide flow-reduction benefits. Depending on the size of the water storage facility and the rate of use, a percentage of the annual runoff volume can be reused. Where it is not feasible for rainwater harvesting to meet a development site's full flow control obligation, it can be used to manage a portion of the flow and lessen the overall flow control requirement.

- Pollution reduction: The reduction in offsite flow volume that can be achieved can also reduce the pollutants associated with stormwater.

Design Considerations

Exhibit 2-37 represents an analysis of a 5,000-square-foot project site with 100 percent impervious surface. The analysis used 8.5 months of 5-minute rainfall intensity data from the Fernwood rain gage in Portland and shows the relationship between water storage volume and average daily water use rate for average annual runoff capture goals of 30, 50, and 70 percent.

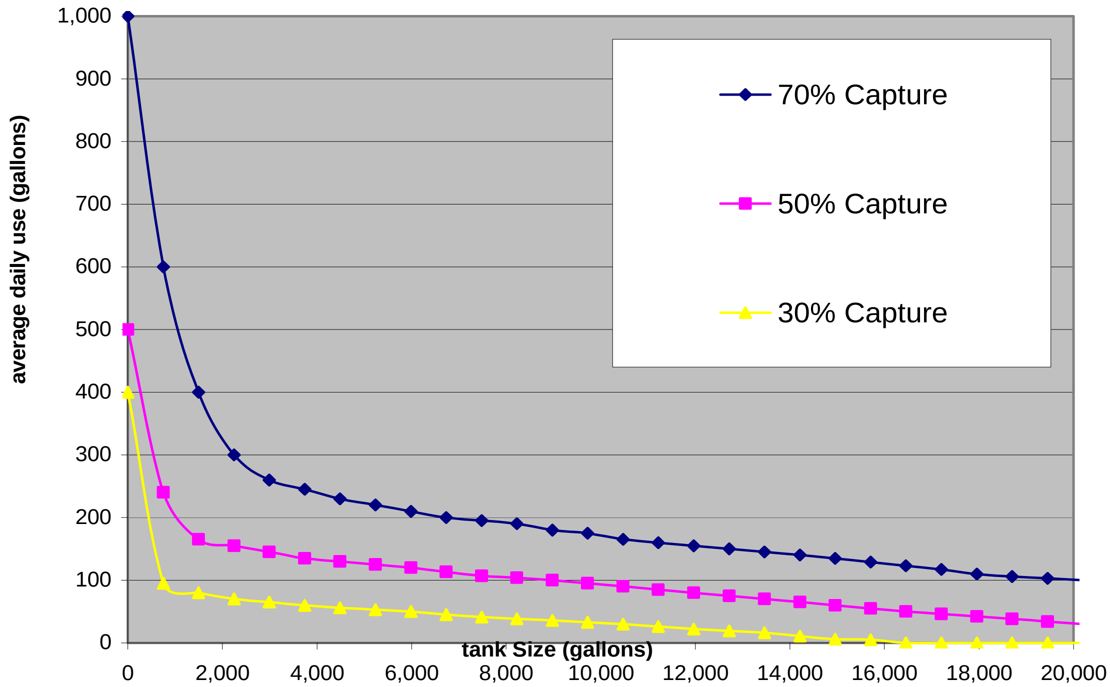
For example, if the stormwater management goal is 50 percent reduction of the annual release volume, the pink line shows that the average daily use would need to be approximately 160 gallons per day if a 2,000-gallon tank were used.. A larger tank would need a smaller average daily use rate to achieve the same stormwater management goal of 50 percent annual volume reduction.

Submittal Requirements

Rainwater harvesting must be submitted in the Stormwater Management Plan under the Performance Approach. The following information must be included:

- Tank size and material.
- Water storage facility details and specifications.
- Pollution reduction facility and efficiency details.
- Pump and associated electrical details and specifications.
- Piping size, material, and placement details and specifications.
- Average daily water use documentation.
- Hydraulic calculations demonstrating compliance with stormwater management requirements (pollution and flow control).
- Approximate setbacks from property lines and structures.
- Overflow connection to approved stormwater destination, per **Section 1.3.**
- Property line system containment backflow protection in the form of a reduced pressure type of backflow assembly.
- Description of how the facility meets pollution reduction and flow control requirements.

Exhibit 2-37: Rainwater Harvesting- 5,000 Square-foot Impervious Surface
Average Annual Stormwater Runoff Capture Rates



Resources

The BDS website provides more information on reuse guidelines:
http://www.portlandonline.com/shared/cfm/image.cfm?id=68621.

For more Water Bureau information, refer to the Water Bureau website at
http://www.portlandonline.com/water/index.cfm?c+29743, or call 503-823-7336.

For information from the Oregon Specialty Plumbing Code refer to the website:
http://www.cbs.state.or.us/external/bcd/programs/plumbing/2008opsc.html. See Appendix F.

See **Appendix G.2** **SW-260** through **SW- 265** for typical structural detention facility details.

Facility Description

Structural detention facilities such as tanks, vaults, and oversized pipes provide underground storage of stormwater as part of a runoff flow control system. As with any underground structure, they must be designed not only for their function as runoff flow control facilities, but also to withstand an environment of periodic inundation, potentially corrosive chemical or electrochemical soil conditions, and heavy ground and surface loadings. They must also be accessible for maintenance. Facilities in this section must be designed using acceptable hydrologic modeling techniques (See **Section 2.2**) to meet applicable flow control requirements. Additional facilities will be required to meet applicable pollution reduction requirements. Tanks and vaults can be used in conjunction with other detention storage facilities, such as ponds, to provide initial or supplemental storage.

Tanks and vaults typically do not have a built-in design feature for containing sediment, as do multi-cell ponds. Therefore, when tanks or vaults are used for detention storage, either a sedimentation manhole or surface sediment containment pond shall be placed upstream of the tank or vault, or the tank/vault shall be oversized to allow for the temporary accumulation of sediment.

Design Requirements

The following criteria apply to detention tank, vault, and oversized pipe design.

- All areas of a tank or vault shall be within 50 feet of a minimum 36-inch-diameter access entry cover. All access openings shall have round, solid locking lids.

- Publicly owned detention tanks, vaults, and pipes are permitted within public rights-of-way. If developments are served with publicly operated and maintained tanks and vaults that are not located within the right-of-way, the tanks/vaults shall be located in separate open space tracts with public sewer easements that are dedicated to the City of Portland. All privately owned and maintained facilities shall be located to allow easy maintenance and access. (**See Chapter 3** Operation and Maintenance)

- All tanks and vaults shall be designed as flow-through systems.

- Minimum size for a public detention pipe shall be 36 inches. If the collection system piping is designed also to provide storage, the resulting maximum water surface elevation shall maintain a minimum 1-foot of freeboard in any catch basin below the catch basin grate. Pipe capacity shall be verified using an accepted methodology approved by the City (see City of Portland's *Sewer and Drainage Design Manual*). The minimum internal height of a vault or tank shall be 3 feet, and the minimum width shall be 3 feet. The maximum depth of the vault or tank invert shall be 20 feet. Pipe material and surface treatment shall conform to the standards for detention tanks and vaults (see **Appendix G.2** **SW-260** and **SW-262**).

- Where the tank or vault is designed to provide sediment containment, a minimum of ½ foot of dead storage shall be provided, and the tank or vault shall be laid flat (see **Appendix G.2** **SW-260** and **SW-262**).

- To restrict flow rates, a flow control structure must be used (see specifications below).

Materials and Structural Stability:

- For public facilities, pipe materials and joints shall conform to the City of Portland *Sewer and Drainage Design Manual*. For private facilities, the pipe material shall conform to the Unified Plumbing Code.

- All tanks, vaults, and pipes shall meet structural requirements for overburden support and traffic loadings, if appropriate. H-20 live loads shall be accommodated for tanks and vaults under roadways and parking areas. End caps shall be designed for structural stability at maximum hydrostatic loading conditions.

- Detention vaults shall be constructed of structural reinforced concrete (3000 psi, ASTM 405). All construction joints shall be provided with water stops.

- In soils where groundwater may induce flotation and buoyancy, measures shall be taken to counteract these forces. Ballasting with concrete or earth backfill, providing concrete anchors, or other counteractive measures shall be required. Calculations shall be required to demonstrate stability.

- Tanks and vaults shall be placed on stable, consolidated native soil with suitable bedding. Tanks and vaults shall not be allowed in fill slopes, unless a geotechnical analysis is performed for stability and construction practices.

Flow Control Structures for Detention Systems

This section presents the methods and equations for the design of flow-restricting control structures, for use with and structural detention facilities. It includes details and equations for the design of orifices and equations for rectangular sharp crested weirs and v-notch weirs.

Note: Because of minimum orifice size requirements (2 inches for public facilities, 1 inch for private facilities), detention facilities that rely on orifice structures to control flows for small projects (under 15,000 square feet of impervious development footprint area) are not allowed. In these cases, rather than constructing a detention facility onsite, the applicant may apply to pay an offsite management fee for the flow control portion of offsite stormwater management through an appeal process (see **Appendix D.7**). The appeal must clearly demonstrate that vegetated facilities (including ecoroofs) have been considered before the offsite management fee for detention will be considered.

Design Requirements

The following criteria apply to control structure design:

- Weir and orifice structures must be enclosed in a catch basin, manhole, or vault and must be accessible for maintenance.
- The control structure shall be designed to pass the 100-year storm event as overflow, without causing flooding of the contributing drainage area.

Orifices

- Orifices may be constructed on a "tee" riser section (see **Appendix G.2** **SW-263**) or on a baffle (see **Appendix G.2** **SW-264**).
- The minimum allowable diameter for an orifice used to control flows in a public facility is 2 inches. Private facilities may use a 1-inch-diameter orifice if additional clogging prevention measures are implemented. The orifice diameter shall always be greater than the thickness of the orifice plate.
- Multiple orifices may be necessary to meet the 2- through 25-year design storm performance requirements for a detention system. However, extremely low flow rates may result in the need for small orifices (< 1 inch for private facilities, < 2 inches for public) that are prone to clogging. In these cases, retention facilities that do not rely on orifice structures shall be used to the maximum extent practicable to meet flow control requirements (see **Section 1.3.2**). Where this is not practicable, the applicant must pay the offsite management fee rather than

constructing a flow control facility. Large projects may also result in high flow rates that necessitate excessively large orifice sizes that are impractical to construct. In such cases, several orifices may be located at the same elevation to reduce the size of each individual orifice.

- Orifices shall be protected within a manhole structure or by a minimum 18-inch-thick layer of 1½ - 3-inch evenly graded, washed rock. Orifice holes shall be externally protected by stainless steel or galvanized wire screen (hardware cloth) with a mesh of ¾ inch or less. Chicken wire shall not be used for this application.

- Orifice diameter shall be greater than or equal to the thickness of the orifice plate.

- Orifices less than 3 inches shall not be made of concrete. A thin material (e.g., stainless steel, HDPE, or PVC) shall be used to make the orifice plate; the plate shall be attached to the concrete or structure.

Orifice Sizing Equation:

$$Q = C A \sqrt{2gh}$$

where:

Q = Orifice discharge rate, cfs
C = Coefficient of discharge, feet (suggested value = 0.60 for plate orifices)
A = Area of orifice, square feet
h = hydraulic head, feet
g = 32.2 ft/sec^2

The diameter of plate orifices is typically calculated from the given flow. The orifice equation is often useful when expressed as an equivalent orifice diameter in inches.

$$d = \sqrt{\frac{36.88\,Q}{\sqrt{h}}}$$

where:

Q = flow, cfs
d = orifice diameter, inches
h = hydraulic head, feet

Rectangular Notched Sharp Crested Weir:

$$Q = C\,(L - 0.2H) * H^{1.5}$$

where:

Q= Weir discharge, cubic feet per second (cfs)
C = 3.27 + 0.40*H/P, feet
P = Height of weir bottom above downstream water surface, feet
H = Height from weir bottom to crest, feet
L = Length of weir, feet*

* For weirs notched out of circular risers, length is the portion of the riser circumference not to exceed 50 percent of the circumference.

V-Notched Sharp Crested Weir:

$$Q = C_d \left(\text{Tan } \frac{\theta}{2}\right) H^{\frac{5}{2}}$$

where:

Q = Weir discharge, cfs
C_d = Contraction coefficient, feet (suggested value = 2.5 for 90 degree weir)
θ = Internal angle of notch, degrees
H = Height from weir bottom to crest, feet

Submittal Requirements

Structural detention facilities require the applicant to submit the Stormwater Management Plan under the Performance Approach. All plans must show:

- Facility dimensions and setbacks from property lines and structures.
- Profile view of facility, including typical cross-sections with dimensions.
- All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Additional information may be required on the drawings during permit review, depending on individual site conditions.

Facility Description

Oil/water separator facilities are used for two main purposes: spill control (where a hazardous spill could contaminate downstream assets) and pollution reduction of runoff prior to discharge. All units use the same principles of separation and coalescence of oil/grease from water, which are based on the different properties of the miscible liquids. The result is distinct layers that can be discharged to separate disposal points.

There are various types of generally accepted oil/water separators, which are required for various kinds of applications. Oil/water separators must meet the design criteria in **Section 4.3.3**.

- Spill control manholes (see **Appendix G.5 SW-500)** are usually 4 feet in diameter and 5 feet deep. The outlet is through a trap 18 inches below the inlet.

- Coalescing plate separators (CPS) and American petroleum Institute (API) type separators (see **Appendix G.5 SW-501)** can provide separation of oil from water by providing additional coalescing surfaces and slower flows, respectively.

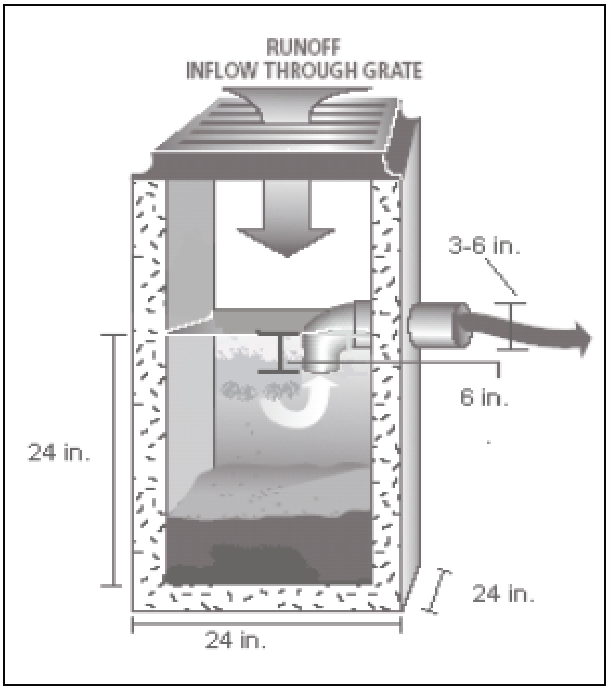
API or spill control manholes must be used in the following applications:
- Fueling stations
- Wash racks/pads

CPS units must be used in the following applications:
- Vehicle/heavy equipment repair, sales, or fueling yards,
- Impound yards
- Where high concentrations of oil or grease are expected to discharge to the storm only sewer system

(See **Section 1.3.3** and **Sections 4.7** and **4.9.)**

- "Trapped" or "lynch" catch basins (see **Exhibit 2-38**) are oil/water separators designed for collection and conveyance of runoff. They are not adequate facilities to meet pollution reduction or flow control requirements, and are not approvable alternatives to meet the oil/water separator requirements in this manual. They hold water below the ¼ bend outlet pipe, or elbow pipe (a.k.a. 90 degree invert). During low-intensity rain events, the standing water allows some larger sediment to settle out. Oil or grease washed into the basin will float to the top of the water level, above the elbow pipe. The catch basin is only effective for oil and grease separation if the water level is maintained above the elbow pipe intake and if it is cleaned regularly.

Exhibit 2-38: Standard “Lynch-style” Catch Basin



Design Considerations

The estimated peak stormwater flow rate dictates the number and size of separators needed on a site. The percent impervious surface, slope, average rainfall, and rainfall intensity are all factors in calculating the peak flow rate.

Several factors contribute to the capture efficiency of oil/water separators. These include placement, design, maintenance frequency, oil concentration, flow rate, pollutant loading, sedimentation rate, and particle size (sediment and oil).

The sump in a separator captures settleable solids under low flow conditions. Separators are not designed to remove total suspended solids (TSS) or soluble pollutants. Resuspension and discharge of sediments previously collected in these facilities is a potential problem during large storm events or “first flush” scenarios. In many units, efficiency can be improved by frequent maintenance and implementation of BMPs.

Pollution Reduction Requirements

All types of oil/water separators must be used in combination with vegetated treatment systems, such as swales, ponds, or planters (as applicable to the requirements of this manual) to meet pollution reduction and flow control requirements prior to discharge. The type of separator and design requirements are prescribed in **Section 1.3.3** and **Section 4.3.3** of this manual and in Oregon State Plumbing Specialty Code. The applicant may elect to install added oil controls in problematic areas, such as high-traffic areas, of the project site. Proposals installed per the requirements of this manual must be approved by the Bureau of Environmental Services (BES) and the Bureau of Development Services (BDS) plumbing division. Elected controls must be approved by the BDS plumbing division.

Submittal Requirements

- The pollutant loading and spill potential of the area drained.
- The type and size of the receiving facility.
- The outlet location and type.
- The schedule of maintenance.
- Other best management practices (BMPs) the facility has implemented.
- Available stormwater monitoring data and oil/water separator data.

The following additional information may be required, depending on site conditions.

- Manufacturer testing information that supports the requirements in **Section 4.3.3**.
- Facility dimensions and setbacks from property lines and structures.
- Profile view of facility, including typical cross-section details with dimensions. These details shall match manufacturer's specifications and details.
- All piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Facility Description

Spill control manholes rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. They consist of a simple underground manhole with a tee outlet designed with dead volume storage to trap small spills. See **Appendix G.5** **SW-500** for typical spill control manhole details.

Spill control manholes are required for fueling areas, per **Chapter 4**. Spill control manholes will not be given credit for pollution reduction requirements.

There may be other acceptable oil controls (e.g., oil/water separators), and applicants may propose an alternative oil control option. However, proposal of a new oil control will require an additional review process for approval, which may delay issuance of related building permits.

Design Requirements

- The spill control manhole tee section must extend 18 inches below the outlet elevation, and 60 cubic feet of dead storage volume must be provided below the outlet elevation for storage of oil, grease, and solids. The manhole must be located on private property. The spill control manhole is not designed for and cannot be used for oil treatment purposes. The spill control manhole is strictly used to capture and store contents from a spill.

- Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification.

- Engineered calculations are required, using the Rational Method (Q=C*I*A).

Submittal Requirements

- The pollutant loading and spill potential of the area drained.
- The type and size of the receiving facility.
- The outlet location and type.
- The schedule of maintenance.
- Other best management practices (BMPs) the facility has implemented.

The following additional information may be required, depending on site conditions.

- Facility dimensions and setbacks from property lines and structures.
- Profile view of facility, including typical cross-section details with dimensions. These details shall match manufacturer's specifications and details.
- All piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

Chapter 3 OPERATIONS AND MAINTENANCE

This chapter presents operations and maintenance (O&M) requirements for the stormwater management facilities in this *Stormwater Management Manual* (SWMM). It includes applicability information, submittal requirements, and guidance for developing an appropriate stormwater management O&M plan.

3.1 APPLICABILITY OF O&M REQUIREMENTS

The O&M requirements in this chapter apply to all stormwater management facilities and related facility components identified in Chapters 1, 2, and 4 of this *Stormwater Management Manual*.[1]

- When the **Simplified Approach** is used for design, the O&M Specifications provided in this chapter can be used.

- When the **Presumptive Approach** or **Performance Approach** is used, a site-specific O&M Plan must be developed.

- If a stormwater facility that is not included in this manual is used (such as a manufactured stormwater treatment technology), the applicant must still prepare and submit an O&M Plan that includes facility-specific O&M activities in compliance with this chapter and with manufacturer requirements.

It is essential to maintain facilities so they function as intended and limit offsite environmental impacts. Owners are required to check their facilities regularly to determine maintenance needs. Routine inspection and maintenance can help keep overall maintenance costs low by detecting problems early and avoiding large repair or replacement costs.

The key goals of any O&M plans and specifications are to:

- Relay information between the designer/engineer and those actually providing the maintenance.
- Identify all facilities, runoff sources, and discharge points that require maintenance. Show the integration of site stormwater design and related regular operations.
- Provide long-term guidance on items to address in order to prevent system deterioration and failure.
- Provide a schedule for maintenance and regular operation.
- Designate and clarify responsibilities.
- Establish fiscal responsibility.
- Provide logs to be filled out by maintenance personnel.

[1] See Portland City Code, Title 17.38.040 for the relevant code requirements.

Access for Operation and Maintenance

Stormwater facilities must be accessible for monitoring and maintenance. Maintain paths, gates, and covers to ensure access is adequate to safely and efficiently locate and enter facilities. Public facilities must have access routes at least 8 feet wide, less than 10 percent in slope, and located adjacent to public right-of-way wherever feasible. Where structural surfaces are needed to support maintenance vehicles, access routes must be constructed of gravel or other permeable paving surface where possible. Public facility vehicular access routes must be designed for H-20 loading.

3.2 O&M REQUIREMENTS

Every permitted project with at least one stormwater facility is required to submit the **Operations & Maintenance Form** provided in **Appendix D**. The O&M Form must identify:

- Owner's name, address, and phone number.
- Site address.
- Financial method used to cover future operation and maintenance.
- Parties responsible for inspecting and maintaining the facility.
- Size and sources of runoff entering the facility and ultimate stormwater discharge point.

The O&M Form also provides a space to insert a site plan. The site plan must identify:

- Type and size of the facility.
- Location of the facility, using reference to an easily identified permanent point or geo-coordinates.

The O&M Form must be included with every stormwater management facility permit application and must be **recorded with the applicable county** before permit issuance.

Additional submittal requirements differ, based on how the facility was sized (using the Simplified Approach, Presumptive Approach, or Performance Approach described in **Chapter 2**) and whether the facility is public or private:

- Private facilities that use the Simplified Approach can use the O&M Specifications (described in **Section 3.2.1** and provided in **Section 3.3.1**).

- Private facilities that use the Presumptive Approach or Performance Approach must provide a site-specific O&M Plan (described in **Section 3.2.2** and outlined in **Section 3.3.2**).

- Public facilities that use the Presumptive Approach or Performance Approach must provide a O&M Plan to cover the warranty period (described in **Section 3.2.3** and outlined in **Section 3.3.2**).

City Code requires facility owners to keep an inspection and maintenance log. In general, the log should note all inspection dates, the facility components inspected, and any maintenance or repairs made. The O&M Form should serve as a checklist for what to include in the log. **Page 3-4** provides an example of an inspection and maintenance log.

Exemptions from O&M Requirements

Single or dual family unattached residences are not required to provide the O&M Form if a drywell or soakage trench is the only stormwater facility on the permit.

A contract with the Watershed Revegetation Program (WRP) does NOT exempt facilities from O&M requirements. The WRP can accept maintenance of only the vegetation.

3.2.1 Simplified Approach for Private Facilities

When the Simplified Approach is used to design stormwater management facilities on private property, the required O&M submittal to BES is:

- A completed O&M Form (including sketched or attached site plan) that has been recorded with the appropriate county.
- Associated O&M Specifications.

Section 3.3.1 provides facility-specific O&M Specifications for the Simplified Approach. These specifications correspond with the permitted stormwater facility unless a revised specification or an addendum stormwater management plan is submitted for review. The property owner should keep a copy of the recorded site plan and the appropriate O&M Specifications onsite. The date of county record for the O&M Form defines the appropriate version of the *Stormwater Management Manual* and the associated O&M Specifications.

3.2.2 Presumptive and Performance Approach for Private Facilities

When the Presumptive or Performance Approach is used to design stormwater management facilities on private property, the required O&M submittal to BES is:

- A completed O&M Form (including sketched or attached site plan) that has been recorded with the appropriate county.
- A site-specific O&M Plan.

Using the outline provided in **Section 3.3.2**, an O&M Plan must be prepared for review by BES. The O&M Plan must describe each type of facility servicing the site, the impervious area draining to the facilities, the facilities' discharge points, and the frequency and timing of maintenance. It must address in detail the procedures necessary to maintain each facility type in good working condition. Scheduling or time intervals between maintenance procedures must be part of the plan. An integral element is a description of how the O&M Plan will be implemented.

Section 3.3.2 also includes a sample O&M Plan that can be used for guidance.

3.2.3 Presumptive and Performance Approach for Public Facilities

A stormwater management facility that receives stormwater runoff from a public right-of-way becomes a public (City-maintained) facility unless the right-of-way is not part of the City's road maintenance system. Facilities that will become City-maintained must be constructed under a public works permit and must go through a warranty period prior to transfer.

For public facilities, the required O&M submittal to BES is:

- An O&M Plan

A preliminary O&M Plan must be submitted before construction, as part of the applicant's public works permit application package. This plan will be finalized and in effect during the warranty period, when the City holds no responsibility for operations and maintenance. If a contract has been established with the Watershed Revegetation Program, the O&M Plan does not need to address those services provided (see **Section 2.3.2** under the Watershed Revegetation Plan heading). The applicant must also demonstrate on the O&M Plan that the City can achieve the specified O&M activities. This may involve the construction of maintenance access roads and the dedication of public access easements.

Warranty Period Responsibilities and Inspections for Public Facilities

The contractor/permit authority that builds stormwater management facilities under a public works permit is responsible for maintaining all site stormwater management features during the maintenance warranty period. This includes maintaining, repairing, and/or replacing the associated vegetative components; any structural or functional repairs; and the general maintenance of the facility. The contractor/permit authority is also responsible for reporting to BES on the condition of the facility on a scheduled basis over the warranty period, as outlined in **Exhibit 3-1**. BES will inspect the facility to verify that the information in the reports is accurate. The warranty period is 2 years. The City reserves the right to perform any work necessary to correct deficiencies in the facility should the contractor/ permit authority fail to perform the work after given notice. The City shall seek reimbursement from the contractor/ permit authority for all costs associated with performance of the work to bring the facility into compliance with the permit conditions.

Facility condition reports must be submitted to the BES Watershed Revegetation Program (WRP phone no. 503-823-2335). WRP staff will use the report to inspect the facility and finalize the report and will send confirmation of inspection to the contractor.

Exhibit 3-1: Schedule of Warranty Period Reports for Public Facilities

1. **3-month establishment report and inspection:** Contractor/permit authority shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and/or observations.

2. **10-month establishment report and inspection:** Contractor/permit authority shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and/or observations.

   If the facility does not pass BES inspection, BES will submit a letter to the contractor/ permit authority describing necessary remedial actions to be performed. This letter shall serve as final notice to the contractor/permit authority and its sureties that failure to correct the deficiencies in accordance with the permit conditions and prior to the end of the warranty period will result in the City performing the work and seeking reimbursement from the contractor/permit authority for all costs associated with the City performing the work.

3. **18-month establishment report and inspection:** Contractor/permit authority shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and/or observations.

4. **24-month establishment report and inspection**: Contractor/permit authority shall report on the condition of the facility, including landscape maintenance activities conducted to date and the schedule of anticipated upcoming activities, plant health and mortality, current percent cover of non-desirable vegetation, and any structural or functional concerns and/or observations.

   *At this time, if **all** inspections have passed, the warranty period ends and the facility is turned over to BES for long-term maintenance.*

3.3 O&M SUBMITTAL DOCUMENTS AND GUIDANCE

3.3.1 O&M Specifications: Simplified Approach

The specifications on the following pages can be used for private facilities that use the Simplified Approach.

The main objectives of the O&M Specifications are to:

- Identify all facilities, runoff sources, and discharge points that require maintenance.
- Provide long-term guidance on what items to address in order to prevent system deterioration and failure.
- Provide a schedule for maintenance and regular operation.

Simplified Operations and Maintenance Specifications
ECOROOFS

What To Look For	What To Do
Structural Components, including the waterproof membrane, shall be operated and maintained in accordance with the manufacturer's and design specifications.	
➢ Clogged drains	➢ Repair any leaks or structural deficiencies. ➢ Remove sediment and debris if necessary
➢ Tears or perforation of membrane	➢ Contact manufacturer for repair or replacement.
Vegetation shall cover 90% of the facility.	
➢ Dead or stressed vegetation	➢ Replant per original planting plan, ➢ Irrigate and mulch as needed.
➢ Dry grass or other plants	➢ Prune tall, dry grasses and remove clippings.
➢ Weeds	➢ Manually remove weeds. Do not use pesticides.
Growing Medium shall sustain healthy plant cover and infiltrate within 48 hours.	
➢ Exposed soil	➢ Cover with plants and mulch as needed.
➢ Eroded soils and gullies	➢ Fill, hand tamp or lightly compact, and plant vegetation to disperse flow.
➢ Crusting, dry, or shrinking medium	➢ Rake or amend to restore filtration or flow.
➢ Ponding or excessive moisture	➢ Amend soils and clear drains.

Annual Maintenance Schedule
Summer: Make necessary repairs. Improve growing medium as needed. Clear drains. Irrigate as needed.
Fall: Replant exposed soil and dead plants. Remove sediment and debris from drains. Provide erosion control for bare soil if necessary.
Winter: Monitor infiltration/flow-through rates. Clear drains as needed.
Spring: Replant exposed soil and dead plants. Remove sediment and debris from drains.
All seasons: Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Irrigation: Adjust irrigation program or consult professional to set system at correct watering system.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous wastes from contaminating stormwater. Record time/date, weather, and site conditions when site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Ecoroof shall not harbor mosquito larvae or rodents that pose a threat to public health or that undermine the facility structure. Record time/date, weather, and site conditions when vector activity observed. Record when vector abatement started and ended.

Simplified Operations and Maintenance Specifications
SWALES

What To Look For	What To Do
Structural Components, including inlets and outlets/overflows, shall freely convey stormwater.	
➢ Clogged inlets or outlets	➢ Remove sediment and debris from catch basins, trench drains, curb inlets, and pipes to maintain at least 50% conveyance capacity at all times.
➢ Cracked drain pipes	➢ Repair/seal cracks. Replace when repair is insufficient.
➢ Check dams	➢ Maintain 4- to 10-inch-deep rock check dams at 12- to 20-foot intervals.
Vegetation shall cover 90% of the facility.	
➢ Dead or strained vegetation	➢ Replant per original planting plan, or substitute from SWMM **Appendix F.4** plant list. ➢ Irrigate as needed. Mulch banks annually. DO NOT apply fertilizers, herbicides, or pesticides.
➢ Tall grass and vegetation	➢ Cut back grass and prune overgrowth 1-2 times a year.
➢ Weeds	➢ Manually remove weeds. Remove all plant debris.
Growing/Filter Medium, including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.	
➢ Gullies	➢ Fill, lightly compact, and plant vegetation to disperse flow.
➢ Erosion	➢ Replace splash blocks or inlet gravel/rock.
➢ Slope slippage	➢ Stabilize 3:1 slopes/banks with plantings from SWMM **Appendix F**.4 plant list.
➢ Ponding	➢ Rake, till, or amend to restore infiltration rate.

Annual Maintenance Schedule

Summer: Make structural repairs. Improve filter medium as needed. Clear drains. Irrigate as needed.
Fall: Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter: Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
Spring: Remove sediment and plant debris. Replant exposed soil and replace dead plants. Mulch.
All seasons: Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Simplified Operations and Maintenance Specifications

PLANTERS

What To Look For	What To Do
Structural Components, including inlets and outlets/overflows, shall freely convey stormwater.	
➢ Clogged inlets or outlets	➢ Remove sediment and debris from catch basins, trench drains, curb inlets, and pipes to maintain at least 50% conveyance capacity at all times.
➢ Liner and foundation ➢ Cracked drain pipes	➢ Repair/seal cracks. Replace when repair is insufficient.
Vegetation shall cover 90% of the facility.	
➢ Dead or strained vegetation	➢ Replant per original planting plan, or substitute from SWMM **Appendix F.4** plant list. ➢ Irrigate as needed. Mulch annually. DO NOT apply fertilizers, herbicides, or pesticides.
➢ Tall or overgrown plants	➢ Prune to allow sight lines and foot traffic.
➢ Weeds	➢ Manually remove weeds. Remove all plant debris.
Growing/Filter Medium, including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.	
➢ Gullies	➢ Fill, lightly compact, and plant vegetation to disperse flow.
➢ Erosion	➢ Replace splash blocks or inlet gravel/rock. ➢ Stabilize soils with plantings from SWMM **Appendix F4**.
➢ Ponding	➢ Rake, till, or amend to restore infiltration rate.

<u>Annual Maintenance Schedule</u>

Summer. Make any structural repairs. Improve filter medium as needed. Clear drain. Irrigate as needed.
Fall. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter. Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
Spring. Remove sediment and plant debris. Replant exposed soil and replace dead plants. Mulch.
All seasons. Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Simplified Operations and Maintenance Specifications

BASINS

What To Look For	What To Do
Structural Components, including inlets and outlets/overflows, shall freely convey stormwater.	
➢ Clogged inlets or outlets	➢ Remove sediment and debris from catch basins, trench drains, curb inlets, and pipes to maintain at least 50% conveyance capacity at all times.
➢ Cracked drain pipes or grates	➢ Repair/seal cracks. Replace when repair is insufficient.
➢ Check dams	➢ Maintain 4- to 10-inch-deep rock check dams at 12- to 20-foot intervals.
Vegetation shall cover 90% of the facility.	
➢ Dead or strained vegetation	➢ Replant per original planting plan, or substitute from SWMM **Appendix F.4** plant list. ➢ Irrigate as needed. Mulch banks annually. DO NOT apply fertilizers, herbicides, or pesticides.
➢ Tall grass and vegetation	➢ Cut back grass and prune overgrowth 1-2 times a year.
➢ Weeds	➢ Manually remove weeds. Remove all plant debris.
Growing/Filter Medium, including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.	
➢ Gullies	➢ Fill, lightly compact, and install plant vegetation to disperse flow.
➢ Erosion	➢ Replace splash blocks or inlet gravel/rock.
➢ Slope slippage	➢ Stabilize 3:1 slopes/banks with plantings from SWMM **Appendix F.4**.
➢ Ponding	➢ Rake, till, or amend to restore infiltration rate.

Maintenance Schedule:
Summer. Make any structural repairs. Improve filter medium as needed. Clear drain. Irrigate as needed.
Fall. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter. Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
Spring. Remove sediment and plant debris. Replant exposed soil and replace dead plants. Mulch.
All seasons. Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress, including access roads, to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Simplified Operations and Maintenance Specifications
DRYWELLS AND SOAKAGE TRENCHES

What To Look For	What To Do
Structural Components include pipes, manholes (drywells), and rock/sand reservoirs (soakage trenches), storm chambers, and silt traps (soakage trenches).	
➢ Clogged inlets, reservoirs, manholes, or silt traps ➢ Debris or garbage build up ➢ Cracked drain pipes or manholes	➢ Clean gutters, rain drains, and silt traps twice a year. ➢ Clear piping to facility when blockage occurs. ➢ Repair/seal cracks. Replace when repair is insufficient.
Vegetation includes surface cover and nearby plantings.	
➢ Large shrubs and trees	➢ Prevent large root systems from damaging subsurface structural components.
Filter Layer includes rock/gravel bed.	
➢ Ponding water	➢ Clear piping through facility when ponding occurs. ➢ Replace rock/sand reservoirs as necessary. ➢ Tilling of subgrade below reservoir may be necessary (for trenches) prior to backfill. ➢ May require decommissioning and replacement (for drywells or trenches).

Maintenance Schedule:

Summer. Make necessary structural repairs. Clean silt traps.
Fall. Clean gutters and rain drains.
Winter. Monitor infiltration rate.
Spring. Clean gutters and rain drains.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Simplified Operations and Maintenance Specifications

PERVIOUS PAVEMENT

What To Look For	What To Do
Structural Components, including surface materials, shall evenly infiltrate stormwater.	
➢ Clogged surface	➢ Vacuum sweep at least twice a year. ➢ Powerwash annually or as needed. Do not use surfactants.
➢ Cracked or moving edge restraints ➢ Cracked or settled pavement	➢ Repair per manufacturer's specifications.
Vegetation	
➢ Large shrubs or trees	➢ Sweep leaf litter and sediment to prevent surface clogging and ponding. ➢ Prevent large root systems from damaging subsurface structural components.
➢ Weeds	➢ Permeable pavers: manually remove weeds. Do not use herbicides. Mow, torch, or inoculate with preferred vegetation. Many pavers are designed to have pore space vegetation.
Filter Medium	
➢ Aggregate loss in pavers from settling and from powerwashing	➢ Replace paver pore space with aggregate from original design.

Maintenance Schedule:
Summer. Make necessary structural repairs.
Fall. Vacuum sweep.
Winter. Monitor infiltration rate.
Spring. Powerwash, with proper disposal. Vacuum sweep.
All seasons. Weed as necessary.

Maintenance Records. Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Simplified Operations and Maintenance Specifications
VEGETATED FILTERS

<table>
<tr><th>What To Look For</th><th>What To Do</th></tr>
<tr><td colspan="2">Structural Components, including inlets and outlets, check dams, and flow spreader, shall slowly and evenly treat and infiltrate stormwater.</td></tr>
<tr><td>➢ Clogged inlets or outlets

➢ Ineffective flow spreaders
➢ Cracked drain pipes</td><td>➢ Remove sediment, debris, and vegetation blockage from catch basins, trench drains, curb inlets, and pipes to maintain at least 50% conveyance capacity at all times.
➢ Clear accumulated silt.
➢ Repair/seal cracks. Replace when repair is insufficient.</td></tr>
<tr><td colspan="2">Vegetation shall cover 90% of the facility.</td></tr>
<tr><td>➢ Dead or strained vegetation

➢ Tall grass
➢ Weeds</td><td>➢ Manually remove sediment accumulation.
➢ Replant per planting plan, or substitute from SWMM Appendix F.4 plant list.
➢ Irrigate as needed. Mulch annually. DO NOT apply fertilizers, herbicides, or pesticides.
➢ Cut back to 4-6 inches 1-2 times each year.
➢ Manually remove weeds. Remove plant debris.</td></tr>
<tr><td colspan="2">Growing/Filter Medium, including soil and gravels, shall sustain healthy plant cover and infiltrate within 48 hours.</td></tr>
<tr><td>➢ Erosion and gullies

➢ Slope slippage
➢ Ponding</td><td>➢ Fill, lightly compact, and install flow spreader/plant vegetation to disperse flow. Restore or create outfalls, checkdams, or splash blocks where necessary.
➢ Stabilize slopes.
➢ Rake, till, or amend to restore infiltration rate.</td></tr>
</table>

Maintenance Schedule:
Summer. Make any structural repairs. Improve filter medium as needed. Clear drain. Mow. Irrigate as needed.
Fall. Replant exposed soil and replace dead plants. Remove sediment and plant debris.
Winter. Monitor infiltration/flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
Spring. Remove sediment and plant debris. Replant exposed soil and replace dead plants.
All seasons. Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity was observed.

Operations and Maintenance Specifications
SAND FILTERS

What To Look For	What To Do
Structural Components, including inlets and outlets/overflows, shall freely convey stormwater.	
➢ Clogged inlets or outlets	➢ Remove sediment and debris from silt traps, trench drains, inlets, and pipes to maintain at least 50% conveyance capacity at all times. ➢ Manually remove sediment accumulation.
➢ Cracked drain pipes, liners, walls, or traps	➢ Repair/seal cracks. Replace when repair is insufficient.
Vegetation	
➢ Weeds	➢ Manually remove weeds. Remove all plant debris.
➢ Large shrubs and trees	➢ Prevent large root systems from damaging subsurface structural components. ➢ DO NOT apply herbicides or pesticides.
Filter Medium, including sand and gravels or similar material, shall infiltrate within 48 hours.	
➢ Ponding	➢ Rake and remove layer of oil and sediment and restore infiltration rate.
➢ Gullies	➢ Fill, lightly compact, and install flow spreader/plant vegetation to disperse flow.
➢ Erosion	➢ Restore outfalls or splash blocks where necessary.

Maintenance Schedule:
Summer. Make necessary structural repairs.
Fall. Rake to remove oil and sediment.
Winter. Monitor flow-through rates. Clear inlets and outlets/overflows to maintain conveyance.
Spring. Rake to remove oil and sediment.
All seasons. Weed as necessary.

Maintenance Records: Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities. Keep work orders and invoices on file and make available upon request of the City inspector.

Access: Maintain ingress/egress to design standards.

Infiltration/Flow Control: All facilities shall drain within 48 hours. Record time/date, weather, and site conditions when ponding occurs.

Pollution Prevention: All sites shall implement best management practices to prevent hazardous or solid wastes or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance responding to spills. Record time/date, weather, and site conditions if site activities contaminate stormwater.

Vectors (Mosquitoes & Rodents): Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance to eradicate vectors. Record time/date, weather, and site conditions when vector activity observed.

Catch Basins

The performance of catch basins for removing sediment and other pollutants depends on routine maintenance to retain the storage available in the sump in order to capture sediment and most floatables.

- Remove debris and sediment every 6 months (or when one-third full of sediment).
- Dewater and dispose of sediment properly. Test sediment that has a heavy oil sheen and/or odors to determine the appropriate disposal.
- Maintain the hooded outlet to prevent floatable materials, such as trash and debris, from entering the storm drain system.
- Maintain the grate as designed for safety reasons and to prevent trash and debris from collecting in the catch basin.
- Repair/seal cracks. Replace when repair is insufficient.
- Keep a log of the amount of sediment collected and the date of removal.

3.3.2 O&M Plan for Presumptive and Performance Approach

A site-specific O&M Plan is required for:

- Private facilities that use the Presumptive Approach or Performance Approach.
- Public facilities are required to have an O&M Plan during the warranty period (see **Section 3.2.3**). The O&M Plan for these facilities is preliminary and is in effect until the facility is turned over to the City.

If the applicant enters into an agreement with the Watershed Revegetation Program, the owner is not responsible for establishing the vegetation. Refer to **Section 2.3.2** for the list of services the WRP provides.

The site-specific O&M Plan is a component of the Stormwater Management Report. It defines the O&M procedures, schedule, and persons responsible for implementing and documenting O&M activities. The O&M Plan must fully assess the requirements of the site and the proposed stormwater infrastructure.

Exhibit 3-2 outlines the requirements for a site-specific O&M Plan. The following text then gives additional information about each of the outline sections.

Exhibit 3-2: O&M Plan Outline

I. Description
- Summary of overall Stormwater Management Plan.
- Table identifying each stormwater facility, including stormwater source, square footage treated, and discharge point.
- Specific location of stormwater facilities.
- Identification of who will assume responsibility for ongoing operations.

II. Schedule
- When and how often facilities will be inspected.
- Specific intervals between particular O&M duties.
- Definition of what size storms require additional inspections.
- Irrigation schedule.

III. Procedures
- Specific procedures for each facility type.
- Likely deficiencies and corrective actions.
- Course of action for unexpected deficiencies.

IV. Who Shares Financial Responsibility

V. Inspection and Maintenance Logs
- Example and instructions for maintaining required logs.

I. Description

The summary of the Stormwater Management Plan (SMP) should adequately describe the overall objectives and expectations. The extent of the summary will depend on the intricacy of the stormwater design. The summary should include the Stormwater Hierarchy, specifically whether the treated stormwater is infiltrated onsite or discharged offsite.

A table must be included that identifies each stormwater facility, including the facility type, size, location, source of stormwater (rooftop, parking lot, or road runoff), source area (square footage) treated by the facility, discharge point, and accessibility.

The location of each stormwater facility must be identified on a site map. The location must be clarified by a measurement from a permanent structure or GPS coordinates.

The party responsible for current and ongoing O&M activities must be identified. The name of the responsible party must be updated as needed whenever the facility is inspected under BES's Maintenance Inspection Program (MIP).

II. Schedule

Facilities must be inspected at least:

- Quarterly for the first 2 years
- Twice a year thereafter
- Within 48 hours of major rainfall events (more than 1 inch of rain over a 24-hour period)

Some inspections are recommended more often, as noted under the **Facility Maintenance Guidelines** beginning on page **3-21**. For at least the first 2 years, inspections should be conducted with the facility drawings and the O&M Plan in hand to help the inspector understand how the facility is supposed to function. The O&M Plan will help the inspector recognize signs that indicate diminished performance (for example, sediment accumulation, vegetation die-off, or ponding water for more than 48 hours after a storm).

An irrigation schedule must also be provided.

III. Procedures

Each type of facility must have its own section that describes the duties required to maintain that facility and keep it in working order. It is expected that variations in facilities as well as variations in sources (rooftop, parking lot, or roadway runoff) will result in different procedures. The **Facility Maintenance Guidelines** beginning on page **3-21** detail the types of procedures necessary for facility maintenance. Probable deficiencies or typical problems and their solutions must also be described.

IV. Financial Responsibility

The party fiscally responsible for operating and maintaining the stormwater facility must be designated.

V. Inspection and Maintenance Logs

City Code requires facility owners to keep an Inspection and Maintenance Log. In general, the log should note all inspection dates, the facility components that were inspected, and any maintenance or repairs performed. The intent is to demonstrate compliance with O&M requirements.

If there is a manufactured facility or a maintenance contract with the manufacturer, the manufacturer's maintenance logs should generally include the same type of information and level of detail shown in the sample monitoring log that is included in the **Sample O&M Plan** on page **3-36**. Owners who are not sure their log sheet is sufficient can call Environmental Services at 503-823-7740 to get review and approval of their forms.

Facility Maintenance Guidelines

This section contains specific procedures for each type of maintenance activity.[2] These documents should be used for guidance in developing a site-specific O&M Plan under the Presumptive Approach or Performance Approach.

[2] These procedures are excerpted directly from BES's *Operations & Maintenance for Private Property Owners* (Publication WS 0646).

FACILITIES AND SYSTEM COMPONENTS THIS APPLIES TO

- **Vegetated facilities:** ecoroofs, infiltration basins, planters, ponds, sand filters, swales, trees, vegetated filters, and wetlands.
- **Structural facilities:** catch basins, curb cuts, inlets, manufactured facilities, piping, sedimentation manholes, and vaults.
- **Underground infiltration facilities:** soakage trenches and drywells.
- **Pervious pavement**

IMPORTANCE TO FACILITY PERFORMANCE

The purpose of a stormwater treatment facility is to remove pollutants, including suspended solids, by capturing sediment. Sediment can include dirt, leaves, and litter. These materials can restrict or clog the facility. Timely removal of sediment will improve infiltration rates and water quality and prevent clogging and flooding.

WHAT TO LOOK FOR

Check the depth of accumulated sediments. Sediment markers can be placed in the facility to help identify depths. Remove sediment when:

Vegetated Facilities:

- Sediment is filled to 30% of capacity (4 inches deep in a vegetated facility),
- Sediment depth is damaging or killing vegetation, or
- Sediment is preventing the facility from draining in the time specified in the O&M Plan.

Structural Facilities:

- At least once a year, or when
- Sediment is filled to 30% of capacity (1½ feet deep in a sediment manhole or 6 inches deep in a vault).

Underground Infiltration Facilities and Pervious Pavement:

- Sediment is preventing the facility from draining in the time specified in the O&M Plan.

WHAT TO DO

Sediment often can be removed by hand. Large facilities and underground facilities will need to be cleaned with heavy equipment by trained professionals.

- Remove sediment during dry months when it is easier to remove, weighs less, and creates fewer secondary environmental impacts (such as wet sediment running off the site).

Note: *It is illegal to hose sediments through your system.*

WHAT TO DO (continued)

Vegetated Facilities:
- Use rakes and shovels to dig out accumulated sediment.
- Avoid damage to existing vegetation.
- If sediment is deep, plants may need to be removed in order to excavate sediment.
- Reseed and mulch disturbed areas to prevent erosion.
- Excavate sand or gravel and clean or replace.

Structural Facilities, Soakage Trenches, and Pervious Pavement:
- Catch basins: Clean debris off the grate and bars. Lift the grate and use a bucket to remove water and a shovel to dig out sediment.
- Curb cuts, piping, and other conveyance facilities: Use a shovel, router, air hose, or other dry method to clear sediment and debris.
- Soakage trenches: Excavate sand or gravel and clean or replace.
- Pervious pavement: Remove accumulated sediment from the surface with a dry broom, vacuum system, or other hand tools.

HIRING PROFESSIONALS
Cleaning certain facilities will require professional assistance:

- Underground facilities, such as manholes, drywells, and manufactured facilities, must be cleaned by a vactor truck. Do not enter these facilities. They are defined by the Oregon Occupational Safety and Health Division as confined spaces and require proper certification to enter.
- Certain components, such as collection basins, piping, or pervious pavement systems, may require vacuuming with a vactor truck or street sweeping equipment.

DISPOSAL
When deciding how to dispose of sediment, consider the types of activities and pollutants onsite. Sediment from commercial or industrial sites is usually not considered hazardous waste. However, as the generator of this waste, you are responsible for deciding how to properly manage the removed solids.

Contaminated Water and Sediment
Catch basins and stormwater facilities in areas used for chemical or hazardous waste storage, material handling, or equipment maintenance may collect the chemicals used in these activities from spills or via stormwater runoff. If you observe an oily sheen, odors, discoloration, or other signs of pollution, hire a

Contaminated Water and Sediment (continued)
professional laboratory or sampling firm to assess whether the material needs specialized hauling, treatment, or disposal to comply with Oregon State Department of Environmental Quality (DEQ) rules. If you need assistance deciding whether the solids should be managed as hazardous waste, contact DEQ.

Non-Contaminated Water and Sediment
Dispose of the water in a sanitary sewer through a shop drain, sink, toilet, or other appropriate drain. If the pollutant load is non-hazardous, water may also be spread across onsite vegetation. Let the solids dry out, then properly dispose of them. Temporary erosion control measures may be needed to contain the material onsite. Dry materials may be reused elsewhere on your site, may be eligible for reuse by others, or can be disposed of at a designated solid waste facility.

REDUCING SEDIMENT ACCUMULATION AND POLLUTION IN THE FACILITY

- Minimize outside sources of sediment, such as eroding soil upstream of the facility.
- Sweep paved areas on the property regularly.
- Make sure chemical and waste storage areas are not exposed to rainfall and stormwater runoff.
- Do not let water from washing vehicles or equipment drain to the stormwater facility.

ADDITIONAL RESOURCES

Catch basin cleaning, material handling, and other best management practices:
Bureau of Environmental Services, Industrial Stormwater Section
www.portlandonline.com/bes/index.cfm?c=34618

Hazardous waste:
DEQ 503-229-5913, email hw@deq.state.or.us,
www.deq.state.or.us/wmc/hw/hw.htm

Sediment removal:
Look in yellow pages under “Sewage” or “Waste Disposal.”

FACILITIES THIS APPLIES TO

- **Vegetated facilities:** ecoroofs, infiltration basins, planters, ponds, sand filters, swales, trees, vegetated filters, and wetlands.

IMPORTANCE TO FACILITY PERFORMANCE

Plants play an important role in stormwater facilities. They absorb water, improve infiltration rates of soil, prevent erosion by stabilizing soil, cool water, and capture pollutants. Plants create habitat for birds and other wildlife and provide aesthetic value to a property. Proper maintenance of vegetation improves the appearance and performance of facilities.

WHAT TO LOOK FOR

When identifying maintenance needs, it is helpful to have a copy of the landscape plan; this shows the required plants for the facility. Facilities should be checked for maintenance needs quarterly for the first 2 years and twice a year after that.

A facility needs maintenance when:

- Areas of soil are bare.
- Vegetation is buried by sediment.
- Vegetation appears unhealthy or has died.
- Nuisance and invasive plants are present.
- Vegetation is compromising the facility’s structure by blocking inlets or outlets, or roots are intruding into a component of the facility.
- Dropped leaves and other debris are contributing to sediment accumulation or are blocking inlets or outlets.

WHAT TO DO

Maintenance activities can easily be incorporated into existing site landscape maintenance contracts. Vegetation can be maintained with a formal or more natural appearance, depending on your preference.

General Maintenance

- Remove dropped leaves, dead plants, and grass and other plant clippings. Plant debris adds nutrient pollution as it breaks down and can clog facility piping and reduce infiltration.
- Avoid using fertilizers, herbicides, or pesticides in the facility. These products add to the pollution problems the facilities are designed to remedy.

General Maintenance (continued)

- Use mulch to inhibit weed growth, retain moisture, and add nutrients. Replenish when needed. Ensure that mulch does not inhibit water flow in the flow path.
- Irrigate all new plantings as needed for the first 2 years.

Caring for Wanted Vegetation

Facility owners are responsible for maintaining healthy vegetation and must replace any plants that have died or been removed.

- You are required to maintain vegetation to the density approved on your landscape plan or specified in the facility description in **Chapter 2**.
- Replant with vegetation approved for use in the original planting plan or from the recommended plant list in **Appendix F.4**.
- Plant in late fall or early spring so plant roots can establish during the cool, rainy seasons, before summer.
- Amend, aerate, and/or till compacted soils before replanting by adding compost to increase nutrients and enhance soil texture.
- If plants are not surviving, determine the reason for the plant die-off. Survivability may be improved by planting vegetation better suited for the site conditions or by irrigating more. You may need to test planting bed soils for pH, moisture, and other factors such as nutrient levels, soil structure, and organic matter content.
- Grassy facilities are designed for routine mowing. Mow at least twice a year.
- Grass should be mowed to keep it 4 to 9 inches tall.
- Grass that is at least 4 inches tall captures more pollutants and is hardier. Grass over 10 inches tall is considered a nuisance by City regulations.

Nuisance and Unwanted Vegetation

- Remove nuisance and invasive vegetation such as Himalayan blackberry, English ivy, and reed canarygrass before it goes to seed in the spring. Do additional weeding in the fall. A list of nuisance plants can be found in the Portland Plant List. (See Additional Resources, below.)
- Immediately remove vegetation that is clogging or impeding flow into the facility.
- Remove potentially large and deep-rooted trees or bushes when they might impede the flow path or compromise facility structures.
- Provide erosion control on any dirt exposed by vegetation removal.

Wildlife
Vegetated facilities create habitat, especially for birds. The Migratory Bird Treaty Act protects all native bird species. Birds and other animals will generally adjust to human activity. However, there are simple measures that should be taken to avoid disturbance:

- Walk the site before you do maintenance. Look for nests, burrows, and animals in the facility. Reroute around animal areas by at least a few yards.

ADDITIONAL RESOURCES

City of Portland resources:
Naturescaping courses, native and invasive plant posters:
www.portlandonline.com/bes/index.cfm?c=dcbec

Environmental Services Watershed Revegetation Program:
www.portlandonline.com/bes/index.cfm?c=dffci

Portland Plant List (native and nuisance plants)
www.portlandonline.com/shared/cfm/image.cfm?id=58951

Plant identification:
Native Plant Society: 503-460-3198
www.npsoregon.org/
Master Gardeners:
www.orst.edu/extension/mg/

Native plant nurseries:
Plant Native:
www.plantnative.org

FACILITIES THIS APPLIES TO

- **Vegetated facilities:** ecoroofs, infiltration basins, planters, ponds, sand filters, swales, trees, vegetated filters, and wetlands.

IMPORTANCE TO FACILITY PERFORMANCE

Stormwater flowing through a facility can cause erosion. Erosion can increase sediment buildup, clog outlets, reduce water quality benefits, add to pollution, and cause facility components to fail. Eroded channels create an easy path for water to travel down, reducing the ability of the facility to filter pollutants and infiltrate water.

WHAT TO LOOK FOR

Any area with erosion more than 2 inches deep needs maintenance. Signs of erosion and common locations are:

- The formation of flow-restricting channels in the bottom of the facility, around inlet pipes and curb cuts, or at overflows.
- Undercutting, scouring, and slumping along banks or berms.
- Channels and undercutting through check dams. (Check dams are small berms built across a facility to slow water and create small areas of ponding.)

WHAT TO DO

- Fill the eroded area with soil, compact it lightly, and cover with mulch, compost, seed, sod, or other erosion prevention materials.
- Plant banks with deep or heavily rooted plants to permanently stabilize soil.
- Plant the bottom of the facility with grass or grass-like plants to slow water and stabilize soil.
- Install or repair structures designed to dissipate energy and spread flow, such as splash blocks on downspouts, or riprap around inlet pipes and curb cuts.
- Install temporary erosion prevention and sediment control measures in accordance with the *City of Portland Erosion Control Manual* until the problem is resolved and permanent measures are fully established.
- If erosion continues to be a problem, consult a professional to determine the cause and a solution.

FACILITIES THIS APPLIES TO

Most stormwater facilities have some structural components. Some facilities, such as vaults, drywells, and sediment manholes, are completely structural. In vegetated facilities, structural components often control how water enters, travels through, or exits a facility. Common structural components include:

- Inflow and outflow pipes, curb cuts, and trenches
- Valves, orifices, trash racks, and pipes
- Concrete, metal, and plastic structures and components such as curbs, retaining walls, manholes, drywells vaults, and filters
- Earthworks such as embankments, check dams, dikes, berms and side slopes
- Riprap and other flow-spreading elements
- Access roads, gates, and signs

IMPORTANCE TO FACILITY PERFORMANCE

These elements need to be in good working order to route flows into a facility and for the facility to function properly.

WHAT TO LOOK FOR

Look at the general condition of these elements. Do they need repair or replacement? Are they still properly aligned? Look for:

- Cracks, scratches, dents, rust, or other conditions of wear.
- Loose fittings, broken or missing components.
- Insufficient oil/grease for moving parts.
- Appropriate gravel cover or bedding to support the structures.
- Misaligned parts or other impediments to the component's ability to still pass flow and contain sediment.

MAINTENANCE

- Immediately repair or replace any major damage to prevent catastrophic failure. This includes any structural component that is cracked, loose, or askew. You may need to consult a professional engineer or hire a trained contractor to design and perform any repairs.
- Minor damage, such as dents or rust spots, may not need immediate replacement, but should be monitored.

Maintain access to the facility by keeping the access route open and structurally sound, fence gates and vault lids oiled, and locks functioning. Access must be available in an emergency.

FACILITIES THIS APPLIES TO

- **Vegetated facilities:** dry ponds, infiltration basins, planters, sand filters, swales, and vegetated filter strips.
- **Underground infiltration facilities:** soakage trenches and drywells.
- **Structural facilities:** manufactured facilities and pervious pavement.

***Note**: Some facilities are specifically designed to always hold water, such as wet ponds, spill control manholes, and sedimentation manholes.*

IMPORTANCE TO FACILITY PERFORMANCE

Most facilities are designed to drain in a certain amount of time. This varies from 2 to 48 hours, depending on the type of facility. This time is stated in the facility design description in **Chapter 2** and in the O&M Plan. Ponding water for over 48 hours is usually a sign that the facility's outlet is clogged or the facility is not infiltrating properly.

WHAT TO LOOK FOR

- Clogging of overflows or outlets with debris, trash, or other obstructions.
- Fine sediments filtering into the soil or other filtration media (such as sand or gravel) that can prevent proper infiltration.
- Water that has remained ponded for more than 48 hours.

MAINTENANCE

- For surface facilities, first try raking the top few inches of soil to break up clogged sections and restore water flow.
- Clean out overflows and outlets with hand tools, if possible. Difficult or hard-to-access blockages may require a professional contractor.
- Identify sources of sediment and debris to prevent them from entering the facility. Simple actions such as sweeping a parking lot regularly can keep sediment out of facilities.
- Make sure the facility has enough vegetation. Vegetation absorbs water, and roots help keep soil loose so it can infiltrate water.

For more thorough instructions on removing sediment, see Sediment and Oil Removal and Disposal, above. Sediment accumulated in stormwater facilities may be considered hazardous waste and must be handled and disposed of properly. If ponding still occurs, contact a landscape architect or engineer for more assistance.

FACILITIES THIS APPLIES TO

- All types of facilities.

IMPORTANCE TO FACILITY PERFORMANCE

Mosquitoes can breed in ponded or other stagnant water. Vegetated areas can be attractive habitat for rats, nutria, beaver, and a variety of birds and amphibians. While some species are desirable, others can be public health or nuisance concerns. In particular, mosquitoes and rats can breed quickly and cause a public health hazard if not removed. The presence of pests does not necessarily impact the ability of your facility to treat and manage stormwater, but may indicate maintenance needs, such as lack of proper infiltration.

WHAT TO LOOK FOR

- Check for mosquito larvae in any system with open, slow, or non-moving waters, especially during warmer weather. Larvae look like tiny wiggling sticks floating perpendicular to the water's surface.
- Look for nutria, rat, and other animal droppings year round. Also check for structural indicators such as beaver dams and rodent holes and burrows.

WHAT TO DO

Mosquitoes

- The best way to avoid breeding mosquitoes is to prevent ponding water. Mosquitoes need standing water to lay their eggs and for their larvae and pupae to develop. Most stormwater facilities are designed to drain in at least 48 hours. If your facility is not draining properly, see Ponding Water and Sediment and Oil Removal and Disposal, above.
- As a temporary control for mosquitoes, the county or other licensed professionals can apply pesticides to kill mosquito larvae in the water or adult insects in the air.
- Enclosed facilities, such as ponds, may be eligible to receive gambusia fish (also known as mosquito fish) from the county. Gambusia feed on mosquito larvae. See Additional Resources, below, for contact information.

Rats

Rats need shelter, food, and water to survive.

- Remove plant debris that may provide shelter for rats from the facility.
- Remove fruits and nuts that fall to the ground.
- Fill in burrows.
- Contact Multnomah County Vector Control for trapping and removal.

Other Wildlife
Other non-native and invasive animal species may take up residence in your facility. Contact the Oregon Department of Fish and Wildlife (ODFW) to help identify these species and suggest removal processes. Permits from ODFW are required to capture and relocate native wildlife.

Some common non-native species are:

- Opossum
- Eastern cottontail
- Bullfrog
- Fox squirrel
- Nutria
- Red-eared slider turtle
- Eastern gray squirrel
- Egyptian goose
- Snapping turtle

ADDITIONAL RESOURCES

Rats and mosquitoes:
Multnomah County Vector Control
Online: www.mchealth.org/vector
Phone: 503-988-3464
email: vector.nuisance@co.multnomah.or.us

Other wildlife:
Oregon Department of Fish and Wildlife
Online: www.dfw.state.or.us/wildlife/
Main Phone 503-947-6000 or
800-720-ODFW (6339)

FACILITIES THIS APPLIES TO

- All types of facilities.

IMPORTANCE TO FACILITY PERFORMANCE

Stormwater facilities often collect a variety of trash and debris. Trash and debris, especially floating debris, can clog pipes or treatment media. It can also cause odors through decay or by collecting spilled or dumped materials. Stormwater facilities are designed to help prevent pollutants from entering rivers and streams. Any visible water quality pollutants may wash out of the facility, spreading the pollution problem.

WHAT TO LOOK FOR

- Check monthly for trash and debris.

- Check for any unusual or unpleasant smells from sources, such as:
  - Natural plant decay or algae
  - A spill or leak (e.g., gasoline or sewage)

- Check for visible pollution, such as:
  - Sheens
  - Turbid (cloudy) water
  - Access
  - Discoloration
  - Other pollutants on the surface of the water

WHAT TO DO

- Regularly remove trash and plant debris.
- Remove accumulated sediment. (See Sediment and Oil Removal and Disposal, above.)
- Make sure inlets and outlets are not clogged.
- Identify the source of trash, debris, or pollutants, such as a spill, leak, or illicit discharge. Store hazardous material under cover. Ensure garbage bins are closed on solid waste containers.
- If there is evidence of a spill or leak, contact a professional laboratory or sampling firm to assess whether the material needs specialized removal, treatment, and disposal. Use trained professional staff for any cleanup and remediation.

SAFETY

In addition to keeping the facility in good working order, maintenance should also strive to meet safety and aesthetic goals that benefit the community and protect site workers. Consider establishing maintenance triggers and practices that respond to the following issues. Keep in mind the safety of both the employees who maintain the facility and the general public.

WHAT TO LOOK FOR

Site Conditions
Conditions such as steep slopes, slick surfaces, covers in disrepair, and vegetation debris can create a falling hazard to employees and visitors.

Public Safety
Some facilities, such as ponds and wetlands, can be "attractive nuisances" that attract undesirable activity, vandalism, or use that could be harmful to public safety. Consider the safety features now in place at the facility.

WHAT TO DO

- Use barrier plantings or fencing to bar entry into the facility area.
- Install road bollards, lighting, and signage to discourage illegal dumping.
- Avoid maintaining facilities in wet weather to reduce the risk of injuries from slipping. Always make sure that appropriate safety gear (e.g., harness, gloves, face shields, safety line) is used.
- For underground facilities, avoid entering anything defined as a confined space. Vaults, deep ponds, manufactured facilities, or manholes are examples of confined spaces. These areas require special permits, training, and entry techniques. Some can be inspected and cleaned from above without entering. Always use caution when working with underground facilities. You are legally required to meet Oregon Occupational Safety and Health Division (OR-OSHA) requirements for such activities.

Note: *Remember that any modifications made to the facility must also be addressed in the site's O&M Plan.*

ADDITIONAL RESOURCES

Confined space entry:
OR-OSHA (confined space entry requirements)
503-229-5910
www.orosha.org/subjects/confined_spaces.html

PAYING FOR MAINTENANCE

Specific maintenance costs depend on the characteristics of the facility, the site, and the area draining to the facility. The general rule of thumb is that annual maintenance costs will be 5 to 10 percent of the facility's total capital cost. Routine, scheduled maintenance can help keep overall costs down by addressing problems before they require major attention.

FINANCING MAINTENANCE

Clearly designate the entity responsible for long-term operations and maintenance.

Determine how to finance maintenance needs. A facility maintenance fund is recommended for both capital maintenance procedures (e.g., facility replacement and non-routine maintenance such as sediment removal, facility component repair or replacement, major replanting, or safety structure construction) and operating maintenance procedures (routine activities such as facility inspection, debris removal, and vegetation management). For homeowner associations, this could be a portion of homeowner fees or a specific assessment.

HOW MUCH TO SAVE

- An average of 5 to 10 percent per year of the facility's capital cost for annual routine maintenance.
- A percentage of the non-routine maintenance costs per year (e.g., for sediment removal, vegetation replacement), based on the needed frequency. For example, if the facility is designed to need mechanical sediment removal every five years, 20 percent of the total cost should be put aside each year.
- An additional 3 to 5 percent of the facility's capital cost per year for eventual facility replacement (based on the facility's life expectancy). Most of these facilities have a life expectancy of 25 to 50 years.

Vegetated Facilities

- Most required routine maintenance (excluding major repair and replacement) is estimated to have an annual cost of $200 to $600 dollars per acre of facility, above current landscape maintenance costs. Costs can vary, depending on the types and level of maintenance practices used.
- The cost and intensity of maintenance activities are usually higher during the 2-year plant establishment period. During that time, plants will need additional watering, and plants that die will need to be replaced.

Stormwater Operations & Maintenance Plan
Ulysses S. Grant Middle School
2008 Gym with Parking and Play Area Expansion

February 29, 2008

Prepared by: Mr. Consultant
Project Manager
Stormwater Consulting LLC
Portland, OR 97222

RESPONSIBILITY
The facility is to be maintained by Portland Public Schools. The preparer has worked closely with PPS personnel to design a system that can be easily maintained by maintenance staff and as educational projects for students.

PPS contact is Jane Doe, PPS Maintenance Manager, (503) 555-0884.

A copy of the O&M Plan shall be provided to all property owners and tenants.

DESCRIPTION
All of the runoff from the new gym rooftop will infiltrate into the ground through onsite swales and basins or overflow to an existing drywell. Water from the parking lot and paved areas will be treated by an infiltration planter with maximum infiltration; overflow will be directed to the combined sewer overflow. *See attached site plan.*

FACILITIES DESCRIPTION TABLE

Facility Name	Type	Size (sf)	Area Treated	IA Treated (sf)	Discharge Point
SW - A	Swale	360	Roof	3,000	Infiltration with overflow to trench – B
TR – B	Infiltration trench	100	Roof	3,000	Overflow from SW– A
BA – C	Basin	300	Roof	2,400	Infiltration with overflow to existing drywell
PL – D	Infiltration planter	250	Parking lot	3,200	Infiltration with overflow to sewer
PL – E	Flow-through planter	150	Playground	2,200	To sewer
PP – F	Pervious pavers	1,200	Playground & parking	1,200	Infiltration

- Infiltration planters are landscaped reservoirs used to detain and filter stormwater runoff, allowing pollutants to settle and filter out as stormwater infiltrates into the ground. Higher flows are allowed to overflow the planter and flow to a trench.

- Flow-through planters are landscaped reservoirs used to detain and filter stormwater runoff, allowing pollutants to settle and filter out as stormwater percolates through the growing medium and landscaped area. Water is collected from the base and directed to the sewer. Higher flows are allowed to overflow the planter and flow to the combined sewer.

- Swales are vegetation-lined depressions with a longitudinal slope. They are used to detain, filter, and infiltrate stormwater. They are also used to direct stormwater away from the foundation and to the trench through two vertical 4-inch overflow pipes.

- Basins are vegetation-lined depressions used to detain, filter, and infiltrate stormwater. The basin is sized to infiltrate all of the water directed to it, but it does have two vertical 4-inch overflow pipes directed to an existing drywell.

- Permeable pavers are a pervious pavement with an underlying stone reservoir that temporarily stores and treats surface runoff, with final discharge through infiltration.

- Infiltration trenches are excavated areas lined with filter fabric, filled with gravel, and covered; water is piped to the top of the gravel lens. The trench detains the stormwater and allows for full infiltration.

INSPECTION/MAINTENANCE SCHEDULE

Each part of the system shall be inspected and maintained quarterly and within 48 hours after each major storm event. For this O&M Plan, a major storm event is defined as 1.0 inches of rain in 24 hours or more. All components of the storm system as described above must be inspected and maintained frequently or they will cease to function effectively. The facility owner shall keep a log, recording all inspection dates, observations, and maintenance activities. Receipts shall be saved when maintenance is performed and there is record of expense.

INSPECTION / MAINTENANCE PROCEDURES

The following items shall be inspected and maintained as stated:

Planters and Swales

- Vegetation or roots from large shrubs and trees that limit access or interfere with planter operations shall be prevented.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed biannually.
- Nuisance and prohibited vegetation of all species shall be removed biannually. Invasive vegetation shall be removed and replaced.
- Dead vegetation shall be removed to maintain less than 10% of area coverage or when planter function is impaired. Vegetation shall be replaced within 3 months or immediately if the season is appropriate in order to maintain cover density and control erosion where soils are exposed.
- The infiltration planter shall infiltrate within 48 hours after a storm event. If water continues to pond after that time, sources of possible clogging shall be identified and corrected. If necessary, the top layers shall be tilled and amended with compost; if this is not sufficient, they shall be removed and replaced with new freely draining growing medium.
- Inlets and outlets shall be inspected quarterly and after any large rain even.
- Any trash or debris that collects in the planter and may inhibit planter function shall be removed quarterly.

Permeable Pavers

- Vegetation, large shrubs, and trees that limit access or interfere with porous pavement operations shall be pruned.
- Vacuum sweeping of the pavers and the area draining to the pavers shall be implemented.
- More aggregate material shall be added to refill drainage voids in pavers if necessary after cleaning.
- Leaves and debris shall be raked and removed biannually.
- Poisonous, nuisance, dead, or odor-producing vegetation shall be removed.
- Pavers or pavement settling more than ½ inch or visible damage shall be replaced or repaired.

Catch Basins, Trench Drains, and Piped Storm System

- Sediment shall be removed biannually.
- Debris shall be removed from inlets and outlets quarterly.
- Quarterly inspection for clogging shall be performed.
- Grates shall be tamper proof.

Source Control measures prevent pollutants from mixing with stormwater. Typical non-structural control measures include raking and removing leaves, street sweeping, vacuum sweeping, and limited and controlled application of pesticides, herbicides, and fertilizers.

- Source control measures shall be inspected and maintained quarterly.
- Signage shall be maintained.

Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater. Virtually all sites, including residential and commercial, present dangers from spills. It is important to exercise caution when handling substances that can contaminate stormwater. Activities that pose the chance of hazardous material spills shall not take place near collection facilities.

- The proper authority and the property owner shall be contacted immediately if a spill is observed.
- A spill kit shall be kept near spill-prone operations and refreshed annually.
- Employees shall be trained on spill control measures.
- Shut-off valves shall be tested quarterly.
- Releases of pollutants shall be corrected within 12 hours.

Insects and Rodents shall not be harbored in any part of the storm system.

- Pest control measures shall be taken when insects/rodents are found to be present. Standing water and food sources shall be prevented.
- If sprays are considered, a mosquito larvicide such as Bacillus thurendensis or Altoside formulations can be applied only if absolutely necessary and shall not be used where it will enter groundwater or come into contact with any standing water. Sprays shall be applied only by licensed individuals or contractors.
- Holes in the ground located in and around the storm system shall be filled.
- Outfalls draining into vegetated swales shall be inspected and cleaned regularly to ensure no rodent activity, which can clog or decrease the efficiency of the storm system.

Access shall be maintained for all facilities so operations and maintenance can be performed as regularly scheduled.

- Existing drywells shall be raised with a locking manhole cover to ensure access.

SAMPLE STORMWATER FACILITY MONITORING LOG

Infiltration/Flow Control - All facilities shall drain within 48 hours. Time/date, weather, and site conditions when ponding occurs shall be recorded.

Pollution Prevention - All sites shall implement best management practices to prevent hazardous wastes, litter, or excessive oil and sediment from contaminating stormwater. Contact Spill Prevention & Citizen Response at 503-823-7180 for immediate assistance with responding to spills. Record time/date, weather, and site conditions if site activities are found to contaminate stormwater.

Vectors (mosquitoes and rodents) - Stormwater facilities shall not harbor mosquito larvae or rats that pose a threat to public health or that undermine the facility structure. Monitor standing water for small wiggling sticks perpendicular to the water's surface. Note holes/burrows in and around facilities. Call Multnomah County Vector Control at 503-988-3464 for immediate assistance with eradicating vectors. Record time/date, weather, and site conditions when vector activity is observed.

Maintenance:
Record date, description, and contractor (if applicable) for all structural repairs, landscape maintenance, and facility cleanout activities.

SAMPLE

Date: 10/1/07 Initial BJK
Work performed by: AAA Landscaper under 3yr contract.
Work performed: Replanted parking lot swale with sedges & rushes.
____
Details: *Work Order on file and available upon request.
____

Date:____________ Initials:___________
Work performed by:_______________________________________
Work performed:____
____
Details:____
____

Date:____________ Initials:___________
Work performed by:_______________________________________
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Date:____________ Initials:___________
Work performed by:____
Work performed:____
Details:____

3.4 O&M ENFORCEMENT

The City has the right to ensure site compliance with the recorded O&M Form filed with BES and the county Department of Assessment and Taxation. City Code section 17.38.040.C.2 states:

> Failure to properly operate or maintain the water quality or quantity control facility according to the operation and maintenance plan may result in an enforcement action, including civil penalty, as specified in 17.38.045, Enforcement.

The enforcement section of City Code authorizes BES right of entry to the property for inspections of the facility, the ability to issue a code violation, and the ability to take enforcement actions (such as compliance orders, stop work orders, etc.) and levy civil penalties of up to $500 a day per violation. The details of the BES enforcement process can be found in the stormwater discharge enforcement rules available in the City of Portland policy documents on the City Auditor's Office website at: http://www.portlandonline.com/auditor/index.cfm?c=28044&a=154207

In general, BES inspectors will strive to work with site owners and operators to ensure proper facility operation and maintenance. If technical assistance still does not yield tangible operation or maintenance improvements, however, BES may take enforcement action. BES staff will provide technical assistance every 1 to 5 years. The inspector provides a report addressed to the property owner and/or site manager and follows up on the prescribed corrective action plan (if any) first by telephone and second by written notice.

3.5 O&M REVISIONS

Any proposed revisions or modifications made to an approved O&M Form and site plan requires a **new O&M Form and site plan to be recorded with the county and resubmitted to BES for O&M review and approval**. Facility owners may opt to modify their O&M Form to make it consistent with updated O&M procedures in revised versions of the *Stormwater Management Manual.*

Modifications include changes to the point of discharge, source of runoff, structural or vegetated components. For example, decommissioning a catch basin or drywell or retrofitting a swale to a basin to capture additional roof or lot runoff must be documented via a recorded O&M Form. Owners/managers can send updated site maps and maintenance contacts to BES stormwater staff (ph: 503-823-5559).

Chapter 4 SOURCE CONTROLS

This chapter presents storm and sanitary source controls required for site uses and characteristics that generate, or have the potential to generate, specific pollutants of concern.

4.1 OVERVIEW

Goals

Some site characteristics and uses may generate specific pollutants of concern or levels of pollution that are not addressed solely through implementation of the pollution reduction facilities identified in Chapter 2. The site characteristics and uses in this chapter have been identified as potential sources for chronic loadings or acute releases of pollutants such as oil and grease, toxic hydrocarbons, heavy metals, toxic compounds, solvents, abnormal pH levels, nutrients, organics, bacteria, chemicals, and suspended solids. This chapter presents structural source controls for managing these pollutants at their source.

Stormwater discharge benchmarks for pollutants exist in NPDES industrial stormwater general permits issued by the State of Oregon for facilities with industrial activities that are exposed to rainfall and stormwater runoff. The state also has water quality standards listed in Oregon Administrative Rules (OAR) 340 Division 041 for discharges to surface waters. The City used the state standards and industrial stormwater NPDES benchmarks in developing this manual's source controls to better enable stormwater discharges to meet those state criteria.

The specific source control requirements are based on the following goals and objectives:

1) Prevent stormwater pollution by eliminating pathways that may introduce pollutants into stormwater.

2) Protect soil, groundwater, and surface water by capturing acute releases and reducing chronic contamination of the environment.

3) Segregate stormwater and wastewater flows to minimize additions to the sanitary and combined sewer systems.

4) Direct wastewater discharges and areas with the potential for relatively consistent wastewater discharges (such as vehicle washing facilities) to the sanitary or combined sewer system.

5) Direct areas that have the potential for acute releases or accidental spills and are not expected to regularly receive flow or require water use (such as covered fuel islands or covered containment areas) to an approved method of containment or discharge.

6) Safely contain spills onsite, avoiding preventable discharges to sanitary or combined sewers, surface water bodies, groundwater, and underground injection control structures (UICs).

7) Emphasize structural controls over operational procedures. Structural controls are not operator dependent and are considered to provide more permanent and reliable source control. Any proposals for operation-based source controls need to follow the special circumstances review process and/or appeals process located in **Appendix D.9.** A proposal for operation-based controls must describe the long-term viability of the maintenance program in the **Source Control Special Circumstances Form**.

Laws

The requirements of this chapter are separate from requirements or conditions required by state or federal regulations or permits and in some areas are or can be more stringent.

Some discharges are prohibited from entering the City's storm sewer systems; those prohibitions are listed in City Code Chapter 17.39. See our website at http://www.portlandonline.com/auditor/index.cfm?c=28866

Section Overview and Use

Section 4.3 lists the site uses and characteristics that are subject to the requirements of this chapter and will therefore be subject to Bureau of Environmental Services (BES) Source Control review. **Sections 4.4 through 4.13** then provide detailed information about the required source controls. **Appendix D.8** and **Appendix D.9** outline the procedures and requirements for dewatering and source control special circumstances, respectively. **Appendix G.5, SW-511 and SW-510** includes an example of the sign and trash requirements.

1) Determine if the project has any of the characteristics or site uses listed in **Section 4.3.**

2) If yes, go to the applicable section for that characteristic or site use (**Sections 4.4 through 4.13**) and follow the requirements to design source controls for the project.

3) The site use may require submittal of the **Source Control Special Circumstances Form** with the permit application, as discussed in **Appendix D.9,** or submittal of the **Dewatering Form 4** and any associated applications, as outlined in **Section 4.4** and **Appendix D.8**.

4.2 APPLICABILITY

These source controls apply to all projects with the defined or proposed uses or characteristics listed in **Section 4.3**, including new development, redevelopment, tenant improvements, violation cases, and existing sites proposing new offsite discharges.

For tenant improvements, only those areas of a structure or activity area being disturbed are required to make the relevant structural changes identified in this chapter. Existing activity areas that will have new activities that are listed in any of this chapter's sections must meet the requirements of the applicable section(s).

For facilities with new offsite discharges, only those proposed areas draining offsite are subject to these regulations.

The requirements of this chapter are in addition to the applicable pollution reduction, flow control, and infiltration/discharge requirements identified in **Chapter 1.**

Development sites discharging to combined sewers are required to provide pollution reduction and flow control for stormwater in accordance with the standards outlined in **Chapter 1**, and onsite storm and sanitary flows must remain separated until the offsite connection point.

Dewatering

Commercial building permit applications for new construction, additions, or improvements that will perform below grade excavation or discharge groundwater; or perform work during the winter months (Oct - May) and discharge construction-related stormwater (channelized/collected or pumped) to a City sewer system; or have a long-term discharge, must comply with **Section 4.4** and must submit the **Dewatering Form 4** located in **Appendix D.8.**

Special Circumstances

Applicants may propose alternatives to the source controls identified in this chapter. In that case, the applicant must complete the **Source Control Special Circumstances Form** located in **Appendix D.9**. Proposal of an alternative source control or alternative design element will require an additional City administrative review process and may delay issuance of related building or public works permits.

Chapter 4 sections are grouped into different categories for the purpose of special circumstances reviews:

- A technical review process applies to **Sections 4.5, 4.6, 4.7, 4.9,** and **4.12.**

- An advanced technical and engineering review process applies to **Sections 4.4, 4.8, 4.10, 4.11,** and **4.13.**

If the alternative source control is not approved and the applicant wishes to appeal the decision, the appeal process is described in **Appendix D.9**.

Note: Developments that cite special circumstances in prior chapters are not exempt from the source control requirements of this chapter.

4.3 REQUIREMENTS

4.3.1 Site Uses and Characteristics That Trigger Source Controls

Projects with the following site uses and characteristics are subject to the requirements of this chapter:

- Site Dewatering and Discharges (**Section 4.4**)
- Solid Waste Storage Areas, Containers, and Trash Compactors (**Section 4.5**)
- Material Transfer Areas/Loading Docks (**Section 4.6**)
- Fuel Dispensing Facilities and Surrounding Traffic Areas (**Section 4.7**)
- Above-Ground Storage of Liquid Materials, Including Tank Farms (**Section 4.8**)
- Equipment and/or Vehicle Washing Facilities (**Section 4.9**)
- Exterior Storage of Bulk Materials (**Section 4.10**)
- Soil, Stormwater, and Groundwater Management for Development on Land with Suspected or Known Contamination or Adjacent to Contaminated Sites (**Section 4.11**)
- Covered and Uncovered Vehicle Parking Areas (**Section 4.12**)
- Water Reclaim and Reuse Systems (**Section 4.13**)

Detailed descriptions of these site uses and characteristics are found in each applicable section. Definitions of terms used are provided in **Definitions**.

Applicants are required to address all of the site characteristics and uses listed in **Sections 4.4** through **4.13**. For example, if a development includes both a fuel dispensing area and a vehicle washing facility, the source controls in both **Section 4.7** and **Section 4.9** will apply.

4.3.2 Groundwater Facility Design Requirements

Section 4.4 requires the use of infiltration facilities for long-term groundwater discharges and in some cases construction-related stormwater or temporary groundwater discharges. The facility is required to be sized adequately to account for the anticipated flows. The design, depending on the receiving system, may need to incorporate water quality and flow control. An O&M agreement is required for long-term discharges and must follow the same standards as stormwater facilities, which are outlined in **Chapter 3** and **Appendix D.2**.

4.3.3 Oil/Water Separator Design Requirements

Oil/water separators are required in **Chapter 1 Section 1.3.3** and **Chapter 4 Section 4.9**. When an oil/water separator is required, then the following design criteria must be followed. See **Chapter 2 Section 2.3.2** for additional information about oil/water separators.

Areas Protected with a Cover or Located Inside a Structure:
Sanitary dischargers are allowed to use a baffled/API oil/water separator or a coalescing plate separator that must be designed to achieve 100 parts per million (ppm) non-polar oil and grease in the effluent from the peak flow generated by the activity. Manufacturer testing information that supports the 100-ppm effluent standard at the calculated flow rate must be submitted with the plans. See the typical detail in **Appendix G.5, SW-501.**

- Standard flow from a 5/8-inch hose is estimated to be 10 gallons per minute (gpm).
- For specially designed washing units, check the vendor specifications for maximum flow rates.

Any pumping devices must be installed downstream of the separator to prevent oil emulsification.

Separator details must be shown on the building plans submitted at the time of the building permit application and must match manufacturer specifications and details, including the unit flow rate, effluent water quality, and maximum process flow rate.

Areas Exposed to Rainfall:
In addition to the above requirements, a coalescing oil/water separator (no baffles) in an area exposed to rainfall must be designed with a high-flow bypass to route flows greater than the operational rate around the unit, unless the operational rate exceeds the flow rate generated by a 10-year storm, as calculated with the Rational Method ($Q=C*I*A$, $I=2.86''$/hour for 10-year storm). A separator discharging to the storm system must be designed to achieve 10 parts per million (ppm) total oil and grease in the storm effluent in the peak flow generated by the activity. Manufacturer testing information that supports the 10-ppm effluent standard at the calculated flow rate must be submitted with the plans. See the typical detail in **Appendix G.5, SW-501.**

Washing and fueling areas exposed to rainfall will be accepted by approval of a special circumstance only. See **Appendix D.9** for the special circumstance submittal requirements. The City will charge the owner sanitary volume charges for the stormwater discharged to sanitary or combined sewer systems. The sanitary volume charges will be based on the impervious area and average rainfall minus the onsite stormwater management impervious area charge or by the installation of a discharge meter through the BES submeter program. The discharge will be charged at sanitary sewer volume rates, per City Code Chapter 17.36.

4.3.4 Laboratory Testing Requirements

Laboratory reports are required for dewatering discharges, development on or near contaminated sites, or water reclaim and reuse systems, as specifically outlined in **Sections 4.4, 4.11** and **4.13**.

Laboratory analysis reports are required to identify the characteristics and levels of pollutants or contamination in the soils, stormwater, or groundwater.

The analytical data is required to be submitted with the development plans, and is required as part of the BES Source Control review. The data will be used to determine appropriate pretreatment, volume control, and discharge location requirements. The sampling plan must be comprehensive and representative of the media being evaluated. The analytical data must provide information on the contaminants of concern (COCs). Sometimes a current Environmental Site Assessment Phase II contains the needed analytical data or can provide guidance on where additional sampling is needed.

The laboratory analytical results will be assessed and compared against City code, water quality standards, local limits, or additional or other applicable standards for the media type, or receiving system.

Depending on the receiving system and media, a DEQ or City permit may be required if pollutants or contaminants are found or if a discharge that there is a reasonable potential the discharge may become polluted in the future. This may delay issuance of related building permits because BES Source Control will not sign off on permits that are still being evaluated for pollutants or contaminants in the stormwater, groundwater, or soils.

Laboratory analysis reports must include the following information:

- The method of laboratory testing, the detection level and analytical method for detection, and the depth of any contaminants found in the soils must be identified;

- Minimum test parameters for baseline contaminants must include metals (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, and zinc), TPH (total petroleum hydrocarbons), and BTEX (benzene, toluene, ethyl benzene and xylene);

- Test parameters for known contaminates of concern;

- Test parameters may be required to include other contaminants identified through historical data, research, and environmental assessments (as required under **Section 4.11**);

- The elevation of the seasonal water table and identify the depth of any perched water tables (aquifers) must be identified.

4.3.5 Signage Design Requirements

Informational signage is required for some site uses and activities that have the potential to contaminate stormwater. **Sections 4.6, 4.7, and 4.8** require signage. Signage addresses good housekeeping rules and provides emergency response measures in case of an accidental spill.

Any applicable spill response supplies need to be clearly marked and located where the signage is posted and near the high-risk activity area. More than one spill response kit may be necessary to accommodate larger activity areas. The City expects spill response supplies, such as absorbent material and protective clothing, to be available at all potential spill areas. Employees should be familiar with the site's operations and maintenance plan and/or proper spill cleanup procedures.

All signage must conform to the requirements described below. Signage requirements for specific activities are noted in applicable sections, and spill signage examples are provided in **Appendix G.5**, **SW 5-11**

- Signs must be located where they are plainly visible from all activity areas. More than one sign may be needed to accommodate larger activity areas.

- Signs must be water-resistant.

- Signs must provide safety precautions.

- Signs must provide immediate spill response procedures—for example: "Turn the valve located at. . ." and "Use absorbent materials."

- Signs must have emergency contact(s) and telephone number(s)—for example: "Call 911" and "City of Portland (BES) Spill Response Number 503-823-7180."

4.3.6 Other Requirements

Conformance with this chapter's requirements does not relieve the applicant of other applicable local, state, or federal regulatory or permit requirements. This chapter is intended to complement any additional requirements and is not expected to conflict with, exclude, or replace those requirements. In case of a conflict, the most stringent local, state, or federal regulations generally apply. Any conflict will be resolved by a City review representative in consultation with appropriate agencies. Some of the more common additional requirements that may apply are summarized below.

Stormwater and Wastewater Discharge Permit Requirements
Some facilities may be required to obtain a State of Oregon NPDES industrial stormwater permit, City of Portland discharge permit, or enter into a discharge authorization with the City of Portland before discharging to the City's separated storm sewer system or to waters of the state. Applicants may also be required to obtain an industrial wastewater permit for discharges to the sanitary sewer system.

Facilities subject to these requirements are generally commercial or industrial. Typical discharges include process wastewater, cooling water, groundwater, or other discharges generated by some of the sources in this chapter that drain to a City sewer system (storm, sanitary, or combined).

Industrial Discharge and Development Permit Review Process:
An evaluation will be performed during the building permit review process to determine if an industrial discharge permit is required. If a discharge permit is required, the permit application process will be independent of the building permit review/issuance process, except for the DEQ 1200-C NPDES general construction permit. The 1200-C permit must be issued prior to BES Source Control's approval of the development permit(s). In addition, the BES Source Control plan reviewer of the building permit application(s) may require revisions to accommodate industrial permitting compliance requirements (e.g., sampling points, pretreatment facilities). If industrial permitting is not applicable at the time of building permit submittal, changes in regulations or site activities could trigger industrial permitting requirements in the future.

For questions regarding these requirements, contact BES Industrial Source Control Division Plan Review at 503-823-7122.

Private Underground Injection Control (UIC)
If discharge to a private UIC (drywells, sumps, and piped soakage trenches) is desired, the federal Safe Drinking Water Act requires a state-issued UIC Authorization by Rule or a Water Pollution Control Facility permit for facilities that have subsurface discharges of stormwater or wastewater. These permits must be obtained from DEQ before any subsurface injection system is constructed. Site uses that are classified as high risk under this chapter are generally not allowed to use UICs for stormwater discharge. The use of UICs for stormwater discharge is prohibited for:

- **Section 4.6:** Material Transfer Areas/Loading Docks
- **Section 4.7:** Fuel Dispensing Facilities and Surrounding Traffic Areas
- **Section 4.9:** Equipment and/or Vehicle Washing Facilities

See **Chapter 1, Section 1.4** for information on infiltration prohibitions in certain areas of the City and additional UIC requirements.

Wellhead Protection Program
The storage, use, and transportation of hazardous/toxic materials in designated wellhead areas is regulated under the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003). The manual can be found on the Water Bureau's website at http://www.portlandonline.com/water/index.cfm?c=29602 See the SWMM **Section 1.3.5** for additional information.

Other Local, State, and Federal Regulations
The requirements presented in this chapter do not exclude or replace the requirements of other applicable codes or regulations, such as the hazardous substances storage requirements of articles 79 and 80 of the Oregon State Fire Code, the spill prevention control and containment (SPCC) regulations of 40 CFR 112 (EPA), the Resource Conservation and Recovery Act (RCRA), or any other applicable local, state, or federal regulations or permit requirements.

4.4 SITE DEWATERING AND DISCHARGES

4.4.1 Overview

Ground water may be pumped and put to beneficial use under statutes regulating the use of waters of the State. For purposes of development, however, ground water is increasingly pumped to waste (discharge of groundwater as a waste). BES has substantial concerns with long-term pumping of groundwater for dewatering and long-term groundwater remediation. Pumping groundwater has the following potential consequences:

- Subsidence (soil settlement that may compromise City infrastructure or adjacent structures).
- Lack of watershed recharge.
- Exacerbating migration of hazardous substances (pollutant/contaminant) onsite or on adjacent properties.
- Exceeding the design capacity of the sewer system. The existing City sewer system was designed to accept only stormwater and/or sanitary flows, depending on the receiving system. It was not designed to accommodate groundwater discharges and therefore has limited capacity.

In addition, BES has been implementing programs to remove stormwater from the combined sewer system in order to reduce combined sewer overflow (CSO) events and treatment costs at the wastewater treatment plant. BES also has established the stormwater hierarchy in this manual to dispose of stormwater onsite in order to ensure the availability of conveyance system capacity for future urban growth and anticipated increased densities and to mimic pre-development hydrologic conditions to meet the goals of the *Portland Watershed Plan*. Pumping groundwater and discharging to a City conveyance system counters the policy decisions that BES has promulgated in the past and foresees for the future.

For these reasons, sites that are proposing or are required to install temporary or long-term groundwater dewatering systems, including dewatering wells, perimeter drains or piping around, under, or near a structure, are required to meet the criteria in this section.

4.4.2 Applicability

This section applies to temporary or long-term dewatering pumping and discharge to waste of ground water (discharge of groundwater as a waste), typically associated with development or remedial action activities. This includes, commercial building permit applications for new construction, additions, or improvements that will perform below grade excavation or discharge groundwater; or perform work during the winter months (Oct - May) and discharge construction-related stormwater (channelized/collected or pumped) to a City sewer system; or have a long-term discharge. These discharges must comply with this section and must submit the **Dewatering Form 4** located in **Appendix D.8.** In addition, there are requirements in this section for structures located in flood areas.

Private discharges to a City UIC system <u>are prohibited</u>. Other alternatives must be selected, which include onsite discharge, sanitary sewer discharge, or hauling the water offsite to an approved discharge location.

If the property is known or suspected to have contamination or is adjacent to a property with known or suspected contamination, refer to **Section 4.11** for additional requirements.

Not Applicable

This section does not apply to stormwater-only sheet flow discharges that are covered under a NPDES 1200-C state permit or City Code Chapter 10 and the City *Erosion Control Manual.*

USING THE DEWATERING & DISCHARGES SECTION:

1. Discharges associated with flood waters are required to design their mechanical systems to meet the requirements as described in **Sub-Section 4.4.3** below. The other sub-sections are not applicable to flood waters but are applicable to the temporary or long-term groundwater discharges that may be part of the project design.

2. Discharges that are temporary only (as defined in the **Definitions** Section) must comply with **Sub-Sections 4.4.4, 4.4.6, 4.4.7 and 4.4.8.**

3. Discharges that are long-term (as defined in the **Definitions** Section) must comply with **Sub-Section 4.4.5, 4.4.6, 4.4.7, 4.4.8**.

4.4.3 Requirements for Structures Designed to Flood

Structures designed to flood during a flood event (also called wet flood proofing) are typically designed to allow flood water to enter the structure (i.e., snorkel system). For this type of design, the sewer ejector sumps must be shut down when water is allowed to accumulate in the structure. Typically, the snorkel (or similar device) is equipped with a sensor that trips the power and turns the sewer ejector sumps off. Once the flood waters subside, the pumps must be manually turned on.

The discharge is subject to the City's discharge authorization program requirements. A batch discharge authorization and discharge approval granted by the City is required prior to discharging this water to a City system.

Signs must be posted next to the sumps' control panel, outlining the discharge procedure for the accumulated water. The sumps must be designed to limit the pumping rate to 50 gallons per minute or another site-specific, approved flow rate.

4.4.4 Discharge Assessment for Temporary Discharges into City Systems

The following standards apply to proposed temporary discharges. Temporary discharges include both stormwater and groundwater as defined in the applicability section above.

1. The applicant for a Batch Discharge must demonstrate that they have reduced the proposed discharge to the greatest extent practical.

2. The City will not accept private discharges to its Underground Injection Control facilities (UICs).

3. The City will not accept discharges that are prohibited by Titles 17.34 and 17.39 do not meet Water Quality Standards or do not meet other rules or limitations.

4. In general, the City will accept temporary discharges into its systems only if the system has sufficient capacity to handle the discharges. In areas where the existing City conveyance system has limited capacity for the proposed temporary dewatering discharge, the City may deny the request or require the discharger to substantially reduce the discharge to a deminimis standard or require additional detention, limited discharge rates, or impose day/time restricted discharge requirements.

4.4.5 Discharge Assessment for Long-Term Discharges

The following standards apply to proposed long-term discharges. Long-term discharges usually only include groundwater discharges.

1. The City will not accept private discharges to its Underground Injection Control facilities (UICs).

2. The City will not accept discharges that are prohibited by Titles 17.34 and 17.39 do not meet Water Quality Standards or do not meet other rules or limitations.

3. In areas where there is limited capacity to accept additional flows and in areas that are required to detain stormwater under other parts of this SWMM, groundwater discharges will also be held to the same or more stringent detention requirements as those found in other parts of the SWMM.

4. In general, the City will allow long-term groundwater pumping and discharge to waste only after the applicant has demonstrated the development will fully implement, in priority order described here, measures designed to substantially reduce flows to a deminimis standard. Measures that must be implemented in priority order include:

   a. The proposed discharger has first reduced, to the greatest extent practical, the rate and volume of required pumping and discharge. This can include building design and construction measures that substantially reduce infiltration of water into buildings, such as dry waterproofing with membrane liners and waterstops at all the points of connections or other technologies that will substantially dry waterproof without the need for piping or drainage. The reductions must, at a minimum, remove seepage that is greater than a cumulative four (4) inches of water over a continuous 24-hour period. The calculation will be based on the total square footage of each floor the water seepage/weeping will be occurring on.

   b. The proposed discharger must establish management policies designed to allow effective use of structures and properties in the presence of some groundwater infiltration. For instance, BES may disapprove pumping and discharges when the groundwater pumping is to prevent or reduce cosmetic or aesthetic effects of groundwater infiltration, rather than to protect structures or to allow reasonable use of structures.

c. When pumping and discharge to waste is permitted, to the greatest extent practical discharge shall be on-site through, for instance, vegetated swales and other infiltration facilities. The responsible party must consult with the DEQ to determine what private discharge methods are appropriate. BES will also coordinate with the DEQ. Failure of DEQ or other regulatory bodies to grant specific permits for such discharges does not automatically justify discharges into City systems. Failure of DEQ or other regulatory bodies to grant permits for such discharges does not automatically constitute adequate justification for discharge into the City system.

   (Note: On contaminated sites, to ensure migration of contaminates from the soil do not contaminate groundwater, or to ensure the increased hydrologic loadings do not further exacerbate or migrate groundwater contamination, infiltration facilities may be required to be lined with an impervious liner, which, creates a flow through facility. These sites are assessed on a case-by case basis by the DEQ and the BES. Required lining will depend on the level and type of contamination and the contaminants mobility in groundwater and stormwater. In addition, injection facilities may not be allowed due to the possibility of further exacerbating and mobilizing soil and groundwater contaminates. For contaminated sites, please also reference **Section 4.11**.)

d. If on-site discharge is not practical for all the pumped groundwater, the discharger shall, to the greatest extent practical, use a private conveyance system and dispose of the discharge directly to a surface water body. The responsible party must consult with the DEQ to determine if proposed discharge methods are appropriate. BES will also coordinate with the DEQ. Failure of DEQ or other regulatory bodies to grant specific permits for such discharges does not automatically justify discharges into City systems.

5. The City will accept groundwater discharges into its own sewer systems only if the proposed discharge has been reduced to the greatest extent practical and there is adequate capacity in the intended City receiving system to convey the discharges.

   Groundwater discharges to a City sanitary sewer or combined sewer system is prohibited if there is a storm only sewer or other alternative available.

Capacity will be evaluated by City modeling staff and others. Depending on the receiving system, capacity calculations will consider future development that will need capacity for the 10-yr stormwater event or future sanitary domestic and industrial needs. Groundwater discharges will not take precedence over future developments capacity needs for stormwater or domestic/industrial discharges. Capacity is defined in the *Sewer and Drainage Facilities Design Manual* and in **Appendix A.1** of this Manual. If the existing City conveyance system has limited or no available capacity for a long-term dewatering discharge, the City may accept ground water discharges only after sewer or drainage conveyance systems are constructed or extended through the public works permitting process.

4.4.6 Choosing the Proper City System for Discharge

After the applicable requirements in **Sub-Sections 4.4.4 and/or 4.4.5**, located directly above, have been met and if discharge to a City system is still needed, the proposed dewatering discharges will be evaluated and assessed by using the regulatory review described below. Based on the regulatory review, BES will determine whether it will accept discharges into its system and which conveyance system may accept the proposed discharge.

Regulatory Review: Laboratory analysis reports are required to be submitted and are used to identify the characteristics and levels of possible pollutants or contaminants in the soils, stormwater, and groundwater at a site. See **Section 4.3.4** for minimum laboratory testing and analyte requirements. The analytical data is required to be submitted with the development plans, and will be used to determine appropriate pretreatment, volume control, and discharge location requirements. The sampling plan must be comprehensive and representative of the flow/discharge being evaluated. The analytical data must provide information on the contaminants of concern (COCs). Sometimes a current Environmental Site Assessment Phase II contains the needed analytical data or can provide guidance on where additional sampling is needed.

The laboratory analytical results will be assessed and compared against City code, water quality standards, local limits, or additional or other applicable standards for the receiving system. Based on the assessment of the data, the City will determine the best system to accept the discharge and choose the appropriate system below using the criteria specified throughout the Dewatering and Discharges Section.

The discharge will be directed to the City storm only system:

In general, uncontaminated discharges will typically be directed to an available storm only sewer system and after all requirements in the applicable Sections above are met.

If discharging to a drainageway as defined in City code Chapter 17.38, the requirements in that Chapter also apply and must be met before approval of discharge can be granted.

Depending on the receiving system, a City or State permit may be required. If a City or State permit is not issued at this time, a City and/or State permit may be required in the future as discharge characteristics, circumstances or rules change.

The discharge will be directed to the City sanitary or combined system:
Discharge to the City sanitary sewer is allowed only if the discharge is considered to be contaminated and can not discharge to the storm sewer. If the discharge is not contaminated, it is not allowed to discharge into the sanitary or combined sewer (if alternatives exist) unless a Special Circumstance has been granted through the Source Control Administrative Advanced Technical and Engineering Review process in **Appendix D.9.**

Contaminated discharges or regulated flows into the sanitary sewer system may need to be regulated under a City pretreatment permit. If a pretreatment permit is not required, a batch discharge is required for temporary discharges and a long-term authorization is required for long-term discharges. See **Sub-Section 4.4.7** for batch discharge and long-term discharge requirements.

A pretreatment permit may be required in the future as discharge characteristics, circumstances or rules change.

4.4.7 Compliance and Submittal Requirements

The sampling point below is required to monitor continued compliance with the City's requirements. The O&M and property deed recording of the Notice of Conditions are also compliance related requirements; in addition, these items along with the forms must be addressed and submitted at the time of building plan review.

1. **Sampling points.** A sampling point for both temporary and long-term discharges is required in order to obtain samples of the discharge and ensure compliance with all applicable regulations and discharge limitations. The sampling point must be in an area that receives the representative flow and is not commingled with other flows. The City reviewer will coordinate the sampling structure location with the

applicant. An acceptable sample location includes a sampling manhole, 6-inch clean-out, or sample box/vault.

2. **Submittal Package**. **Appendix D.8** outlines the materials and information that must be submitted as part of the building and/or connection permit package submittal. Some of the requirements include: analytical data, identification of source controls, treatment devices, sampling points, and the discharge location. Rates, volumes, and a discharge timeline must also be submitted in order for the City to assess capacity in the receiving system. All connections to a public system require a BES connection permit and are subject to connection requirements. In addition, the following discharge specific requirements apply.

   Additional requirements that apply to specific discharges:

   Temporary Discharges

   Authorization Forms: When a temporary discharge of groundwater or construction-related stormwater (channelized/collected or pumped) is proposed to a City conveyance system, AND section 4.4.4 above has been met, a City Batch Discharge Authorization must be issued by the BES Source Control Division. The Batch Discharge Authorization Application located in **Appendix D.8, Form 5** must be completed and submitted with the building or connection permit application. The batch authorization procedures are outlined and implemented by the appropriate work group within the BES Source Control Division.

   Long-Term Discharges

   Authorization Forms: When a long-term discharge is proposed to a City system, AND section 4.4.5 above has been met, the Long-Term City Discharge Authorization located in **Appendix D.8, Form 7** must be completed and submitted with the building or connection permit application. The Long-Term Authorization procedures are outlined by the appropriate work group within the BES Source Control Division.

   O&M Agreement: Infiltration is required for long-term discharges. The responsible party must submit a recorded O&M agreement for the groundwater infiltration facility and meet the same requirements as stormwater infiltration facilities, which are outlined in **Chapter 3** and **Appendix D.2.** For infiltration facility design requirements, see **Section 4.3.2**.

   Recording Notice of Conditions against the property deed: Long-term dewatering dischargers must record a notice of conditions of the discharge against the property.

The conditions notice will inform property owners of the groundwater discharge, the City's authorization of the discharge, and provide the City's notification mailing address to inform the City when the characteristics of the discharge change, or when there is a new owner of the property. See **Appendix D10** for a sample Notice of Conditions form. This Notice must be submitted during the plan review process.

4.4.8 Associated Charges

1. **Submeter program and volume fees**: Temporary and long-term groundwater discharges are subject to the submeter program, and procedures identified within that program. Stormwater discharges associated with construction may also incur volume fees. The installation of a charge submeter must be placed on the final discharge (after the final treatment, if applicable) to the City sewer system in order to assess volume charge fees. Depending on the receiving conveyance system, volume fees may not apply. The fees and requirements are located in City Code Chapter 17.36. If the submeter is located inside a building, a remote reader must be placed outside the building on private property, in a location easily accessible to City personnel. The Submeter Program Application is required to be submitted at the time of plan review and is located in **Appendix D.8, Form 6.**

2. **Sewer Development Charge (SDC)**: Payment of the SDC fee at the time of issuance of the building permit, or if no building permit, before the issuance of the BES connection permit for long-term dewatering connections. The approved groundwater discharge will be assessed the receiving systems applicable SDC which will be based on the requirements in City Code Chapter 17.36 and associated rules.

4.5 SOLID WASTE STORAGE AREAS, CONTAINERS, AND TRASH COMPACTORS

4.5.1 Applicability

A solid waste storage area is an indoor or outdoor place where solid waste containers are collectively stored. Solid wastes include both food and non-food waste or recycling. Solid waste containers include compactors, dumpsters, compost bins, grease bins, recycling areas, and garbage cans.

Applicable

- All commercial and industrial development with facilities that store solid wastes, both food and non-food.
- Indoor and outdoor solid waste storage areas.
- Multi-family residential sites if a shared trash collection area is proposed.
- Activity areas used to collect and store refuse or recyclable materials, such as can or bottle return stations and debris collection areas.

New Buildings (Including Shell-only Permits) or Activity Area Construction
New constructed buildings and storage areas will house or accept many different activities over the structure's life; therefore, all new construction must meet all of the requirements of this section and cannot follow the tenant improvement track below, unless accepted through the administrative review process outlined in **Appendix D.9**.

Tenant Improvements
Because of different tenant activities, solid waste characteristics change; therefore, all tenant improvements must have the facility's solid waste categorized as low or high risk by BES Plan Review, using the following definitions.

- **High-risk** solid wastes are putrescible, toxic, greasy or oily; or attract vectors, such as flies and rodents; or have an odor or high moisture content. Some examples of uses that generate high-risk solid waste include, but are not limited to, restaurant, deli, bakery, grocery store, hotel, hospital, and metal fabrication.

- **Low-risk** solid wastes are non-putrescible (or very low) or nontoxic and free of excessive liquids. Some examples of uses that generate low-risk solid wastes include, but are not limited to, realtor office, dental office, shoe store, or movie store.

If the stored waste generated by the tenant is categorized as high-risk, all of the structural changes outlined in this section apply. This is required even if no plumbing changes are proposed as part of the overall improvements.

If the stored waste generated by the tenant is categorized as low-risk, all of the structural changes outlined in this section apply if the solid waste storage area is new, is being moving from its existing location, or is being changed or altered.

Not Applicable

- Single-family homes.
- Debris collection areas used only for the storage of wood pallets or cardboard. Facilities that are processing/recycling wood pallets or cardboard, and that is their business, are not exempt and will need to follow the requirements.

A trash area detail is provided in **Appendix G.5, SW-510**. This detail is for reference only. Note that the BES regulation does not require walls and screening.

4.5.1 Requirements

The table below summarizes the design requirements that apply to the areas described above and are required for an approval of solid waste storage and handling activity areas in the City of Portland. The following text provides additional information about each requirement.

ACTIVITY/USE	**REQUIREMENTS**		
	(1) Cover	(2) Pavement	(3) Drainage
Multi-family (with shared trash areas)	X	X	X*
Commercial	X	X	X
Industrial	X	X	X
Compactors (regardless of use)		X	X
Can and bottle return stations	X	X	X
* If gravity service to the sanitary sewer lines cannot be obtained, a special request can be made to direct the drainage from the hydraulically isolated activity area to the development's stormwater pollution reduction facility. This applies only to multi-family uses. For more information, refer to the **Administrative Review** section below.			

COVER

A permanent canopy, roof, or awning must be provided to cover the solid waste storage activity area. It must be constructed to cover the activity area so rainfall cannot come in contact with the waste materials being stored.

The cover must be sized relative to the perimeter of the hydraulically isolated activity area it is to cover.

Runoff must be directed from the cover to a stormwater discharge point that meets all applicable code requirements.

PAVEMENT

The area beneath the cover must be a hydraulically isolated area (no stormwater run-on or liquids running off this area) and paved with asphalt or concrete. The paved area must be sized adequately to cover the activity area intended for refuse storage or the trash compactor(s) and associated equipment.

DRAINAGE

The area beneath the cover must be a hydraulically isolated area, which means the area must be designed to prevent uncontaminated stormwater run-on from entering the sanitary drain or entering the storage area and carrying pollutants away in runoff. This can be accomplished by grading or berms.

Drainage must be provided for the hydraulically isolated area and directed to a sanitary sewer.

Runoff occurring outside the hydraulically isolated area must be directed to a stormwater discharge point that meets all applicable code requirements. This can be achieved by reverse grading at the perimeter of an activity area, perimeter curbing or berming, or the use of area drains to collect and divert runoff.

Non-gravity option: Activity areas that do not have gravity sanitary sewer service may be allowed to install a pressurized system. With these types of installations, the following items must be provided at the time of building permit application:

- Verification or evidence that gravity service cannot be obtained.
- Details of an electronic sump pump system equipped with a float switch.

Pressurized system installations are considered "permanent equipment" and deemed the property owner's liability in the event of system failure or if the property becomes vacated.

The Bureau of Development Services (BDS) Commercial Plumbing Division will review all sump pump or sewage ejector installations for compliance with the Uniform Plumbing Code and Oregon State Plumbing Specialty Code.

ADMINISTRATIVE REVIEW

Multi-family developments with shared trash areas may be allowed an alternative to the sanitary drain for the hydraulically isolated solid waste storage area. This activity area may be allowed to drain to the site's privately owned and operated stormwater pollution reduction facility if gravity service to the sanitary sewer pipe of the development cannot be obtained. For the alternative to be considered information showing that gravity service cannot be obtained and a completed **Source Control Special Circumstances Form** located in **Appendix D.9** must be submitted. All other requirements previously outlined for multi-family uses apply.

4.6 MATERIAL TRANSFER AREAS/LOADING DOCKS

4.6.1 Applicability

Applicable

The requirements in this section apply to all developments proposing the installation of new material transfer areas or structural alterations to existing material transfer areas (e.g., access ramp regrading, leveler installations) with the following characteristics.

- The area is designed (size, width, etc.) to accommodate a truck or trailer being backed up to or into it, and

- The area is expected to be used specifically to receive or distribute materials to and from trucks or trailers.

Two standard types of material transfer areas associated with buildings are:

- Loading/unloading facilities with docks
- Large bay doors without docks

The requirements apply to all material transfer areas, including loading/unloading docks, bay doors, and any other building access point(s).

Not Applicable

The requirements do not apply to areas that are used strictly for mid-sized to small-sized passenger vehicles and that are restricted by lease agreements or other regulatory requirements to storing, transporting, or using materials that are classified as domestic use. Examples of domestic uses include primary educational facilities (elementary, middle, or high school), buildings used for temporary storage (a lease agreement must be provided), and churches. Contact BES's Industrial Source Control Division at 503-823-7122 for help in determining if requirements apply.

4.6.2 Requirements

PAVEMENT

A paved material transfer area of asphalt or concrete must be placed underneath and around the loading and unloading activity area and must meet all applicable building code requirements. This will reduce the potential for soil contamination and associated impacts on groundwater.

DRAINAGE

Loading Docks: The first 3 feet of the paved area, measured from the building or dock face, must be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away.

Drainage from the hydraulically isolated area must be directed to an approved City sanitary sewer or authorized pretreatment facility. Drainage from the hydraulically isolated area is not allowed to discharge to a stormwater management facility or storm system. Surrounding runoff and drainage from the access ramp must be directed away from the hydraulically isolated area to a stormwater discharge point that meets all applicable requirements of this manual.

Bay Doors and Other Interior Transfer Areas: Bay doors and other interior transfer areas must be designed so that stormwater runoff does not enter the building. This can be accomplished by grading or drains.

Because interior material transfer areas are not expected to accumulate precipitation, installation of floor drains is not required or recommended. It is preferable to handle these areas with a dry mop or absorbent material. If interior floor drains are installed, they must be plumbed to an approved City sanitary sewer or authorized sanitary pretreatment facility.

Non-gravity Drainage Option: Activity areas that do not have gravity sanitary sewer service may be allowed to install a pressurized system. With these types of installations, the following items must be provided at the time of building permit application:

- Verification or evidence that gravity service cannot be obtained.
- Details of an electronic sump pump system equipped with a float switch.

Pressurized system installations are considered "permanent equipment" and deemed the property owner's liability in the event of system failure or if the property becomes vacated.

The BDS Commercial Plumbing Division will review all sump pump or sewage ejector installations for compliance with the Uniform Plumbing Code and Oregon State Plumbing Specialty Code.

BES may waive the requirement for drainage from the hydraulically isolated area of the loading dock to be directed to an approved City sanitary sewer or authorized sanitary pretreatment facility if it determines there is no gravity sanitary service available and an appropriately sized, underground temporary storage structure (such as a catch basin with no outlet or dead-end sump) is provided. For the exception and alternative to be considered, a completed **Source Control Special Circumstances Form,** located in **Appendix D.9**, must be submitted, with information showing that gravity service cannot be obtained.

Shut-Off Valves

Shut-off valves are required to protect the City sewer system or onsite infiltration facilities from spills of chemicals and other constituents that may provide a danger of widespread contamination, system damage, or risk to public health.

A shut-off valve may be required for the sanitary drainage facilities of the material transfer area. BES will make this determination, based on the type of material being transferred and the proposed system receiving the discharge.

Shut-off valves are required for any of the following situations:

- Site activity areas that are exposed to corrosives or oxidizers (such as battery acid) that can harm conveyance system components.

- Substances (such as oil and grease) that do not settle or that remains in one location and are capable of being dissolved in or floating on top of water. These substances can spread rapidly into downstream systems, causing widespread impacts and difficult cleanup situations.

- Substances that are known to infiltrate through soils and contaminate groundwater.

Valves located in material transfer areas are typically left open to facilitate drainage during normal conditions and immediately closed in the event of a spill.

The valves must be closed prior to transfer activities of harmful substances and reopened only after the transfer is complete. The shut-off valves must be located on private property and downstream of the exposed area's collection system.

All valves must be installed and maintained in accordance with manufacturer specifications. For more information about shut-off valves and associated valve boxes, contact the BDS Commercial Plumbing Department at 503-823-7302.

SIGNAGE

Signage must be provided at the storage area and at shut-off valves if hazardous materials or other materials of concern are stored (as determined by BES). Signage must be located so it is plainly visible from all storage activity areas and located next to the shut-off valve. More than one sign may be needed to accommodate large storage areas. Additional information is provided in **Section 4.3.5**, and signage examples are located in **Appendix G.5, SW-511**.

ADDITIONAL REQUIREMENTS

Wellhead Protection Areas: Transport and handling of hazardous materials in designated wellhead protection areas are subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003).

4.7 FUEL DISPENSING FACILITIES AND SURROUNDING TRAFFIC AREAS

4.7.1 Applicability

Applicable

The requirements in this section apply to all development where vehicles, equipment, or tanks are refueled on the premises, whether a large-sized gas station, a single-pump maintenance yard, or a small-sized fuel tank. These requirements also apply to truck loading and off-loading areas located at bulk fuel terminals.

A fuel dispensing facility is defined for this section as the area where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above- or below-ground fuel tanks, fuel pumps, and the surrounding pad).

If any improvements are made to the fueling activity area and/or pad, such as regrading or surface replacement, retrofits are required to comply with all fueling activity source controls identified in this chapter.

Not Applicable

Propane and oxygen tanks are exempt from these requirements.

Existing fueling areas are not required to install source controls identified in this section if the scope of work is limited to the following:

- A new canopy installation over an existing fuel pad that is not being upgraded.
- An underground tank replacement for compliance with state regulations.
- Replacement of a fuel pump on an existing fuel pad that is not being upgraded.

Temporary fueling areas associated with construction activities are exempt from these requirements. These activities require implementation of the associated best management practices (BMPs) outlined in the City's *Erosion Control Manual* (in the section titled "Development Activity Control BMPs"). The *Erosion Control Manual* can be found online at http://www.portlandonline.com/shared/cfm/image.cfm?id=94539

4.7.2 Requirements

COVER

The fuel dispensing area must be covered with a permanent canopy, roof, or awning so precipitation cannot come in contact with the fueling activity area. Rainfall must be directed from the cover to a stormwater discharge point that meets all applicable code requirements.

- Covers **10 feet high or less** must have a minimum overhang of 3 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

- Covers **higher than 10 feet** must have a minimum overhang of 5 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated fueling activity area it is to cover.

The requirement to cover the fuel dispensing area can be appealed if the fuel dispensing area is generally used to service oversized equipment (e.g., cranes) that cannot maneuver under a roof or canopy. An Administrative Review is required. See **Appendix D.9** for the Administrative Review process.

PAVEMENT

A paved fueling pad of asphalt or concrete must be placed under and around the fueling activity area and must meet all applicable building code requirements. Sizing of the paved area must be adequate to cover the activity area, including placement and number of the vehicles or pieces of equipment to be fueled by each pump. Fuel pumps or fuel islands must be located a minimum of 7 feet from the edge of the fueling pad.

DRAINAGE

- The paved area beneath the cover must be hydraulically isolated through grading, berms, or drains. This will prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area must be directed to an approved City sanitary sewer or authorized sanitary pretreatment facility.

- A spill control manhole must be installed on the sanitary discharge line of the fueling pad (before the domestic waste line tie-in). The tee section must extend 18 inches below the outlet elevation, and 60 cubic feet of dead storage volume must be provided below the outlet elevation for storage of oil, grease, and solids. The manhole must be located on private property. The spill control manhole is not designed for or to be used for oil treatment purposes. The spill control manhole is strictly used to capture and store contents from a spill.

For more information about spill control manholes, see **Chapter 2.3.3** and for examples **Appendix G.5, SW-500**. An oil/water separator may be used instead of the spill control manhole. The oil/water separator must be sized appropriately and meet the requirements for oil/water separators in **Section 4.3.3**.

Shut-Off Valves

- A shut-off valve is required on the sanitary discharge line of the fueling pad, downstream of the spill control manhole. Valves installed on sanitary sewer systems must be installed before the domestic waste line tie-in. These valves must be kept closed, and opened only to allow incidental drainage activities that do not pose a threat or risk to the discharge point system. The valve must be closed <u>immediately</u> after drainage activities are completed.

  Shut-off valves must be located on private property and downstream of the exposed area's collection system. All valves must be installed and maintained as per manufacturers' recommendations. For more information about shut-off valves and associated valve boxes, contact the City's Commercial Plumbing Department at 503-823-7302.

- Surrounding runoff must be directed away from the hydraulically isolated fueling pad to a stormwater discharge point that meets all stormwater management requirements of this manual and other applicable code requirements.

  Traffic pathways that surround fueling pads are considered high-use/high-risk areas and will require a valve on the storm drainage system. Valves installed on storm drainage systems must be installed downstream of all applicable private stormwater quality facilities to accommodate spill containment. These valves must be left open to facilitate stormwater flows during normal conditions, and <u>immediately</u> closed in the event of a spill.

SIGNAGE

Signage must be provided at the fuel dispensing area and must be plainly visible from all fueling activity areas. Signage must also be provided at the shut-off valve areas directing personnel to turn the valve in the event of a spill. Additional information is provided in **Section 4.3.5,** and signage examples are located in **Appendix G.4, SW-511**

ADDITIONAL REQUIREMENTS

- Installation, alteration, or removal of above-ground fuel tanks larger than 55 gallons, and any related equipment, is subject to additional permitting requirements by the Portland Fire Marshall's Office. For technical questions and permitting, call the Fire Marshall's Office permit center at 503-823-3712, or visit the permit center at 1300 SE Gideon, Portland, Oregon 97202.

- If applicable, the requirements in **Section 4.8** (Above-Ground Storage of Liquid Materials, Including Tank Farms) must be met in addition to other relevant sections of this manual.

- Underground fuel tanks less than 4,000 gallons in size are subject to additional permitting requirements by DEQ, and tanks larger than 4,000 gallons are referred to the federal Environmental Protection Agency (EPA). For technical questions and permitting, call DEQ's Northwest Region main office at 503-229-5263 and ask for the Underground Storage Tank Permitting Department.

4.8 ABOVE-GROUND STORAGE OF LIQUID MATERIALS, INCLUDING TANK FARMS

4.8.1 Applicability

Applicable

The requirements in this section apply to all development where there is any exterior permanent or temporary storage of liquid chemicals, food products, waste oils, solvents, process wastewaters, or petroleum products in above-ground containers, in quantities of 50 gallons or more.

Not Applicable

Underground storage tanks or installations that require a water pollution control facility (WPCF) permit are exempt from these requirements, but must comply with DEQ's WPCF permit process.

Quantity thresholds of products that are exempt from these spill containment measures include:

- Janitorial and cleaning supplies of less than 100 pounds net weight or 15 gallons net volume. These supplies must be packaged for consumer use in containers of 5 gallons or less or having a net weight of less than 30 pounds per container.

  Cleaners or solvents used for cleaning machinery or motor vehicle and machine parts are NOT exempt.

- Office and stationery supplies of less than 100 pounds net weight. These supplies must be packaged for consumer use in containers of less than 5 gallons in size or 30 pounds in weight.

Double-walled containers are exempt from the 110% or 10% of total volume containment requirements in subsection 1, below. All other requirements apply.

Temporary storage areas associated with construction activities are exempt from these requirements. These activities require implementation of the associated best management practices (BMPs) outlined in the City's *Erosion Control Manual* (in the section titled "Development Activity Control BMPs"). The *Erosion Control Manual* can be found online at http://www.portlandonline.com/shared/cfm/image.cfm?id=94539

4.8.2 Requirements

CONTAINMENT

Liquid materials must be stored and contained in such a manner that if the container(s) is ruptured, the contents will not discharge, flow, or be washed into a receiving system.

- A containment device and/or structure for accidental spills must have enough capacity to capture a minimum of 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

- City Code Title 17.39 states that water coming in contact with coupling areas is defined as process wastewater. Therefore, <u>there must be a separate containment area for all valves, pumps, and coupling areas,</u> with sub-bermed areas either in front of or inside the main containment areas. These sub-bermed areas must have rain shields and be directed to a City sanitary sewer system for disposal. If no City sanitary sewer is available, drainage must be directed to a temporary holding facility for proper discharge and may require a WPCF permit from DEQ's Water Quality Division.

COVER

Storage containers (other than tanks) must be completely covered so rainfall cannot come in contact with them. Runoff must be directed from the cover to a stormwater discharge point that meets all applicable code requirements.

- Covers **10 feet high or less** must have a minimum overhang of 3 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated activity area.

- Covers **higher than 10 feet** must have a minimum overhang of 5 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated activity area.

PAVEMENT

The storage area must be paved with asphalt or concrete and must meet all applicable building code requirements. The floors must be sealed (e.g. with epoxy) to prevent spills from contaminating the groundwater. The floor materials and sealant must be compatible with the material being stored. Sizing of the paved areas must be adequate to cover the area intended for storage.

DRAINAGE

All paved storage areas must be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater run-on to a storage area.

Covered storage areas: Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the contained area beneath the cover.

- If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area must be directed to an approved City sanitary sewer or authorized pretreatment facility.

- A shut-off valve will be required for the covered storage area if the applicant elects to install drainage facilities to an approved City sanitary sewer.

Uncovered storage areas with containment, such as tank farms (also called bulk fuel terminals):

- Water will accumulate in uncovered storage areas during and after rain. Before the accumulated water is drained and to determine proper discharge location, the water must be collected, inspected for oil sheen and/or a low or high pH. If it is contaminated, depending on the level of contaminants, discharge to the sanitary sewer may be required or treatment may be necessary prior to storm discharge.

- A shut-off valve must be installed on the drainage line for the storage area. This will allow the excess stormwater to be collected and inspected. If free of contaminants, the stormwater can be drained out of the activity area and directed to the storm drainage facilities. If contaminated, the stormwater must be pumped from the containment area and hauled offsite for disposal at a permitted treatment storage and disposal (TSD) facility, discharged to the City sanitary sewer, or discharged to an authorized sanitary pretreatment facility.

- Except when excess stormwater is being discharged, the valve must always be kept closed so any spills within the activity area can be effectively contained.

Short-term and intermittent discharges (less than 6-months in duration) to the sanitary sewer are considered to be batch discharges and require approval and possible pretreatment prior to discharge. Pretreatment requirements are set as part of the discharge approval process and are based on the types and quantities of the material to be discharged.

A discharge evaluation must be performed before discharge and connection to a sanitary sewer. Testing may be required to establish characteristics of the wastewater or contaminated stormwater and to verify that local discharge limits are not exceeded. For batch discharge applications, call BES Industrial Source Control Division at 503-823-5320.

Shut-Off Valves

Shut-off valves are required to protect City sewer systems or onsite infiltration facilities from spill risks from chemicals and other constituents that pose a danger of widespread contamination, system damages, or risk to public health.

Shut-off valves are required for the following situations:

- The stormwater draining from the immediate area around the above-ground storage tank (AST) must be equipped with a valve on the storm drainage system. In the event of a spill, the valve must be closed to adequately isolate the area and contain the spill. Valves installed on storm drainage systems must be installed downstream of all applicable private stormwater quality facilities to accommodate spill containment. These valves must be left open to facilitate stormwater flows during normal conditions, and immediately closed in the event of a spill.

- Valves are required for site or activity areas that are exposed to corrosives or oxidizers (such as, but not limited to, battery acid) that can harm conveyance system components.

- Valves are required for substances (such as, but not limited to, oil and grease) that do not settle or remain in one location and are capable of being dissolved in or floating on water. These substances can spread rapidly into downstream conveyance and discharge systems, causing widespread impacts and difficult cleanup situations.

- Valves are required for substances that are known to react with or leach through the asphalt or pavement and/or infiltrate through soils into the groundwater.

SIGNAGE

Signage must be provided at the liquid storage area and must be plainly visible from all surrounding activity areas. Signage must also be provided at the shut-off valve areas directing personnel to turn the valve in the event of a spill. More information is provided in **Section 4.3.5,** and signage examples are located in **Appendix G.4, SW-511.**

ADDITIONAL REQUIREMENTS

- Storage of hazardous materials located in designated wellhead protection areas is subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003). The manual can be found on the Water Bureau website at http://www.portlandonline.com/water/index.cfm?c=29602

- Storage of reactive, ignitable, or flammable liquids must comply with the Uniform Fire Code as adopted by the State of Oregon. Source controls presented in this section are intended to complement, not conflict with, current fire code requirements. Contact the Portland Fire Bureau (503-823-7366) and/or BES Industrial Source Control Division (503-823-7122) for further information and requirements.

4.9 EQUIPMENT AND/OR VEHICLE WASHING FACILITIES

4.9.1 Applicability

Applicable

The requirements in this section apply to all development with a designated equipment and/or vehicle washing or steam cleaning area. This includes smaller activity areas, such as wheel-washing stations.

Not Applicable

Single-family and duplex residential sites are exempt.

Temporary washing areas associated with construction activities are exempt. These activities require implementation of the associated best management practices (BMPs) outlined in the City's *Erosion Control Manual* (in the section titled "Development Activity Control BMPs). The *Erosion Control Manual* can be found online at http://www.portlandonline.com/shared/cfm/image.cfm?id=94539

4.9.2 Requirements

COVER

The washing area must be covered with a permanent canopy or roof so precipitation cannot come in contact with the washing activity area. Precipitation must be directed from the cover to a stormwater discharge point that meets all applicable code requirements.

- Covers **10 feet high or less** must have a minimum overhang of 3 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.
- Covers **higher than 10 feet** must have a minimum overhang of 5 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.

Cover Exception: If a washing activity area is generally used to service oversized equipment that cannot maneuver under a roof or canopy (cranes, sail boats, etc.), an exception to the roof or canopy requirement will be granted. A **Source Control Special Circumstances Form**, located in **Appendix D.9**, must be submitted as part of the building permit application to evaluate exception qualifications.

PAVEMENT

A paved wash pad of asphalt or concrete must be placed under and around the washing activity area and must meet all applicable building code requirements. Sizing of the paved area must adequately cover the activity area, including the placement of the vehicle or piece of equipment to be cleaned.

DRAINAGE

The paved area beneath the cover must be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away.

- Drainage from the hydraulically isolated area must be directed through an oil/water separator and must meet the oil/water separator design requirements in **Section 4.3.3.** The discharge from the oil/water separator must drain to an approved City sanitary sewer or authorized sanitary pretreatment facility.

- Wash water is not allowed to enter a storm drainage system. Surrounding runoff must be directed away from the hydraulically isolated washing pad to a stormwater discharge point that meets all applicable requirements of this manual.

On-site wash recycling systems must meet the above requirements, unless one of the exceptions below applies:

- Wash recycling systems may be used for oil control instead of using an oil/water separator as long as they can meet effluent discharge limits for the City's sanitary sewer system. A detail of the wash recycling system and vendor specifications identifying effluent efficiencies must be submitted as part of the building plans at the time of the building permit application.

- If an evaporation unit is installed as part of a wash recycling system, an exception to the sanitary sewer connection will be granted. Note: The cover requirement cannot be waived for evaporation units because of the sizing and capacity limitations of the individual units. A **Source Control Special Circumstances Form**, located in **Appendix D.9**, must be submitted as part of the building permit application to evaluate exception qualifications.

4.10 EXTERIOR STORAGE AND/OR PROCESSING OF BULK MATERIALS

4.10.1 Applicability

Applicable

The requirements of this section apply to developments that stockpile materials or store them in outdoor containers, or process the materials outdoors and those materials may erode and/or contribute pollutants to stormwater runoff.

The materials are separated into three categories, based on risk assessments for each material stored: high-risk, low-risk, and exempt. These include, but are not limited to, the general types of materials listed in the table below. Materials not on this list will be evaluated on a case-by-case basis.

Outdoor areas where materials are processed (rather than just stored) are generally considered to be high risk. Outdoor processing, shredding, grinding, and sorting exposes the materials to stormwater and contributes pollutants to stormwater, including, but not limited to, dissolved metals, total metals, total suspended solids, dissolved solids, oil and grease, biochemical oxygen demand (BOD), and bacteria (such as E. coli). Therefore, when any material is processed, shredded, ground, or sorted outdoors and will contribute pollutants to stormwater as described above, the area is considered high risk and must follow the high-risk requirements.

High-Risk Materials	Low-Risk Materials	Exempt Materials
• Materials to be recycled, with potential effluent or the potential to contribute pollutants to stormwater runoff • Corrosive materials (e.g., lead-acid batteries) • Scrap or salvage goods with potential effluent • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material byproducts with potential effluent • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human wastes	• Materials to be recycled, without potential effluent or the potential to contribute pollutants to stormwater runoff • Scrap or salvage goods • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material byproducts without potential effluent • Unwashed gravel/rock • Compost • Asphalt	• Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Clean concrete products (blocks, pipe, etc.) • Glass (new, clean, or free of residual product) • Inert products

Not Applicable

Storage and processing areas that are exempt from the requirements of this section have materials that meet any of the following criteria:

- Have no measurable solubility or mobility in water and no hazardous, toxic, or flammable properties.
- Exist in a gaseous form at ambient temperature.
- Contained in a manner that prevents contact with stormwater (excluding pesticides and fertilizers)—e.g., covered inside a building.
- Temporary storage areas associated with construction activities. These activities require implementation of the associated best management practices (BMPs) outlined in the City's *Erosion Control Manual* (in the section titled "Development Activity Control BMPs"). The *Erosion Control Manual* can be found online at http://www.portlandonline.com/shared/cfm/image.cfm?id=94539

4.10.2 Requirements

COVER

Low-risk materials must be covered and secured with a temporary plastic film or sheeting at a minimum.

High-risk materials must be permanently covered with a canopy or roof to prevent stormwater contact and minimize the quantity of rainfall entering the storage area. Runoff must be directed from the cover to a stormwater discharge point that meets all applicable code requirements.

- Covers **10 feet high or less** must have a minimum overhang of 3 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated activity area.

- Covers **higher than 10 feet** must have a minimum overhang of 5 feet on each side. The overhang must be measured relative to the perimeter of the hydraulically isolated activity area.

PAVEMENT

Low-risk material storage areas are not required to be paved.

High-risk material storage areas must be paved beneath the structural cover. Sizing of the paved area must adequately cover the activity area intended for storage.

DRAINAGE

Low-risk material storage areas are typically allowed in areas served by standard stormwater management systems. However, all stored erodible materials and stored materials that can contribute contaminants to stormwater runoff must be protected from rainfall.

For these materials, a structural containment barrier must be placed on at least three sides of every stockpile. The barrier must be tall enough to prevent run-on of uncontaminated stormwater into the storage area and migration of the stored materials as a result of being blown or washed away. If the area under the stockpile is paved, the barrier can be constructed of asphalt berms, concrete curbing, or retaining walls. If the area under the stockpile is unpaved, sunken retaining walls or ecology blocks can be used. The applicant must clearly identify the method of containment on the building plans.

For **high-risk** material storage areas, the paved area beneath the structural cover must be hydraulically isolated through grading, structural containment berms or walls, or perimeter drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away.

If materials are erodible or can contribute contaminants to stormwater runoff, the containment requirements described for low-risk areas, above, must be followed.

Low and high risk: Significant amounts of precipitation are not expected to accumulate in covered storage areas, and drainage facilities are not required for the contained area beneath the cover. If the applicant elects to install drainage facilities, the drainage from the hydraulically isolated area must be directed to an approved City sanitary sewer or authorized sanitary pretreatment facility. A shut-off valve must be installed if the materials have a potential effluent. BES will make this determination based on the type of material stored.

If the stored material will erode or has a potential effluent to the storm system, a sampling manhole or other suitable stormwater monitoring access point is required to monitor stormwater runoff. The monitoring location must be representative of the facility activities and located downstream of all treatment devices.

SIGNAGE

Signage must be provided at the storage area if hazardous materials or other materials of concern are stored. Signage must be located so it is plainly visible from all storage activity areas. More than one sign may be needed to accommodate large storage areas. More information is provided in **Section 4.3.5,** and signage examples are located in **Appendix G.5, SW-511**.

ADDITIONAL REQUIREMENTS

Storage of pesticides and fertilizers may need to comply with specific regulations outlined by DEQ. For answers to technical questions, call DEQ's Northwest Region main office at 503-229-5263.

Storage of hazardous materials in designated wellhead protection areas is subject to additional requirements, as identified in the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003). The manual can be found on the Water Bureau website at
http://www.portlandonline.com/water/index.cfm?c=29602

4.11 SOIL, STORMWATER, AND GROUNDWATER MANAGEMENT FOR DEVELOPMENT ON LAND WITH SUSPECTED OR KNOWN CONTAMINATION OR ADJACENT TO CONTAMINATED SITES

4.11.1 Overview

Special handling and management of soils, collected groundwater, and surface drainage may be necessary under federal, state, and local regulations. Sites with known or suspected contamination require a more detailed review process, and this may delay issuance of related building permits.

In addition, areas associated with construction activities are required to implement the best management practices (BMPs) outlined in the City's *Erosion Control Manual* (in the section titled "Development Activity Control BMPs"). The *Erosion Control Manual* can be found online at http://www.portlandonline.com/shared/cfm/image.cfm?id=94539

Applicants are advised to contact the BES Source Control Plan Review team early in the plan design process (before plan submittal) if they are aware or suspect that the site has contaminants or is adjacent to a contaminated site. It is also recommended the applicant contact the DEQ Land and Water Quality divisions before plan submittal and obtain DEQ approval before applying for City permits.

To research property-specific contaminant information, refer to DEQ's facility profiler database, which can be found at **http://deq12.deq.state.or.us/fp20/.** If records indicate that a No Further Action (NFA) or Record of Decision (ROD) exists for the site, the applicant must contact DEQ prior to pre- and post-construction activities to ensure conditions of record are not violated.

For technical questions related to site contamination and cleanup, contact DEQ's Land Quality Division. All DEQ regulatory divisions or departments referenced in this section can be reached by calling the DEQ's Northwest Region Office at 503-229-5263.

If a site is not included in the DEQ's tracking database, it does not mean that contamination may not be present.

To avoid confusion with the term "water quality pollutant" that is used throughout this manual, this section refers to pollutants as contaminants and/or contamination, unless otherwise specified.

4.11.2 Applicability

The requirements in this section apply to the following:

- Any development project that disturbs property known or suspected to contain contaminants in the soil, stormwater, or groundwater or that may exacerbate contamination by moving the contaminants onsite or offsite. This includes developments that are surrounded by or adjacent to properties suspected or found to have trace contaminants.

- Any project seeking to make a new connection to a public storm system (connections to City UIC facilities are prohibited) from a property that is known or suspected to contain contaminants in the soil or groundwater or performing work that may exacerbate contamination onsite or on an adjacent site. City Code, rules, and policy apply and must be met when a new connection is proposed.

- If contaminants have the potential to become entrained and transported through construction activities or through the post-construction design elements of the development, all requirements in this section and **Section 4.4** must be followed. Examples of the activities and design elements include, but are not limited to:

  - Development on land that is at risk, known, or suspected to contain contaminants in the soil or groundwater.

  - Excavation and/or stockpiling of contaminated soils (soil management).

  - Discharge or reuse facilities related to groundwater, foundation or footing drains, interior floor drains in basements or sub-grade structures, construction dewatering, long-term dewatering, and stormwater treatment and conveyance systems. The requirements for groundwater discharges and temporary stormwater discharges are in **Section 4.4**.

  - Activities in an area of concern, including, but not limited to: City property, Portland Harbor Superfund area, area adjacent to or surrounded by contaminated sites, wildlife habitat area, areas where new development and redevelopment must meet state, federal, or local source control requirements to prevent contamination or recontamination of that specific area of concern.

4.11.3 Review

Contaminants, media, and site conditions are unique to each parcel of land. Sites at risk for contamination must therefore be reviewed on a case-by-case basis.

Stormwater and groundwater discharges from sites suspected of contamination, whether proposed as a temporary construction connection or flow or as a permanent connection to any public system, will require discharge authorization from BES. After reviewing the proposal and a characterization of the contaminants from the site, the BES Source Control Division may make one or more of the following decisions. For groundwater discharges, also refer to **Section 4.4**.

- Deny the request to use the City conveyance system.
- Approve the discharge in accordance with City code, rules, and policy, with possible restrictions such as those described in this section or as necessary, given the nature of the discharge.
- Require the applicant to obtain an NPDES permit from DEQ for the anticipated discharge prior to connection and require a sample point that is representative of the discharge as it enters the City conveyance system.
- Require the applicant to obtain a City-issued permit or authorization and require a sample point that is representative of the discharge as it enters the City conveyance system.
- Require the applicant to become part of BES's Industrial Pretreatment Program.
- Allow an unrestricted connection to the City storm sewer and require a sample point that is representative of the discharge as it enters the City system.

4.11.4 Requirements

The following are the requirements for the different contaminated medias that exist on known or potentially contaminated properties. The City will review and assess all data as required below, and depending on the levels of contaminates and the type of the contaminated media, there maybe different requirements on how stormwater, groundwater or soil is managed. In some cases, development permits may be held up until the DEQ and/or City approves of the discharge or development.

If a site is not included in the DEQ's tracking database as described in the Applicability section above, it does not mean that contamination may not be present. If a site has a history of commercial or industrial use, a copy of the Phase I and/or Phase II Environmental Site Assessment for the site will be required for review by BES. If a Phase I or II Environmental Site Assessment was not completed, additional sampling is required, as outlined in City policies and this chapter.

SOIL MANAGEMENT

- Stockpiles of contaminated soils must be covered with temporary plastic film or sheeting to prevent stormwater from coming into contact with them. Site controls must be employed that protect drag-out into a City street from the development and, if a clean-up action site (contaminated), from the day-to-day operations.

- Stockpile perimeters must have a containment barrier on all four sides of every stockpile to prevent stormwater run-on and material runoff. Barriers can consist of concrete curbing, silt fencing, or other berming material, depending on the activity, size, and resources available.

- Areas under stockpiles of contaminated soils are not required to be paved. However, an impervious layer must be placed beneath the stockpile to protect uncontaminated areas from potential leachate. Examples of impervious layers include, but are not limited to, asphalt, concrete, or a geomembrane.

LABORATORY ANALYSIS REPORTS

Laboratory testing and associated analysis reports are required on sites that are suspected or have known contamination on site in order to identify the characteristics and levels of contamination in the soils, stormwater, and groundwater. The City in collaboration with the DEQ will coordinate the review of the data. The review will assess the different media pathways and determine the appropriate requirements for stormwater, groundwater, or soil management. The minimum testing requirements and information required is outlined in the beginning of **Chapter 4** in **Section 4.3.4**.

It is highly recommended that the analytical testing of the applicable media be performed prior to submitting building permit applications and the responsible party contact the DEQ very early in the design phase to provide them the chance to review the proposal. Based upon the review of the data with the DEQ, the determination may be made that the proposal can not move forward as submitted. Therefore, communication early in the process may help catch design flaws, or perhaps move the proposal along quicker and help meet the project's desired timeline.

STORMWATER AND GROUNDWATER DISCHARGE MANAGEMENT

Stormwater and groundwater management on contaminated sites require additional review by BES Source Control. The requirements are listed below for both media types.

Temporary and Long-Term Dewatering: All temporary and long-term dewatering discharges resulting from groundwater or temporary construction-related stormwater (as defined in **Section 4.4**, **Applicability**) discharges will be evaluated for contaminates before a discharge location can be approved. See **Section 4.4** for dewatering requirements. On contaminated sites, dewatering may require additional oversight by the DEQ and associated permits or authorizations by that agency. The City will coordinate with the DEQ on the review process.

Post Construction Stormwater Management: **Chapter 1** of this manual requires vegetated infiltration facilities as the first Category of stormwater discharge. For contaminated sites, stormwater management options may be limited because of contamination onsite or on an adjacent site.

If the site or adjacent site has groundwater or soil contamination, the City will coordinate with the assigned DEQ project clean-up manager and in the case there is no assigned project clean-up manger, the City will coordinate with the DEQ manager of the Clean-up Division, Water Quality Division, or their designees.

In some cases, the stormwater management facility may be required to be lined with an impervious liner creating a flow-through facility, unless the contaminants of concerns do not mobilize with stormwater or additional leachability testing and hydrology modeling has been completed to show that infiltration will not mobilize contaminants offsite or to surface waters. In the absence of good sound analytical data, the City will apply the most conservative decision, and require an imperviously lined facility.

Above-grade facilities are also an option, especially for tree landscaping requirements. Above-grade planters can be designed large enough for trees and other large plantings, or they can be designed small for portability. In some cases, additional contamination delineation must occur and; therefore, permanent facilities can not be constructed. Thus, portable above-ground planters are an option in those cases.

POST-CONSTRUCTION WATER RECLAIM OR REUSE SYSTEMS

Water reclamation or reuse systems provide innovative ways to use natural resources and save money. However, using groundwater as a resource from sites at risk of contamination may require additional source controls and trigger environmental compliance regulations, depending on the nature of the contaminants and the extent of the remediation that has been completed.

Irrigation systems may encourage transportation of contaminants, and require authorization from DEQ's Land Quality Division prior to installation.

Authorizations for all reuse systems are typically required from BDS, BES, the Oregon Water Resources Department, and DEQ. On contaminated sites, the City will coordinate with the DEQ prior to approving a groundwater reuse system.

See **Section 4.13** for water reclaim and reuse system requirements.

4.12 COVERED AND UNCOVERED VEHICLE PARKING AREAS

4.12.1 Applicability

The requirements in this section apply to all development with a covered or uncovered vehicle parking area.

Applicable

- New or redeveloped parking structures.

Not applicable

- Existing parking structures are not required to retrofit unless the structure is being redeveloped.
- Single-level covers (canopies, overhangs, and carports).
- Single-family and duplex residential sites.

4.12.2 Requirements

DRAINAGE

Below-Grade or Covered Parking Floor Areas
Drainage facilities on the floors of a covered vehicle parking area are not required. If the applicant elects to install drainage facilities, the drainage must be directed to an approved City sanitary sewer, per all applicable City code and policies.

Entrance trench drains located within the first few feet of the covered entrance to the parking area may discharge to the storm sewer. Trench drains located beyond the first few feet of the entrance or at the bottom of the entrance ramp must discharge to the sanitary sewer. This is evaluated on a case-by-case basis due to different ramp designs. In general, a trench drain located at 10 feet or less on a ramp that slopes and continues beyond 10 feet, can discharge to storm. On a ramp that levels out and no longer slopes beyond the 10 feet, the storm trench drain would need to be within the first 2 feet of the entrance to the ramp.

Parking Areas with Top Floor Open to Rainfall
Stormwater runoff from the top floor must be directed to a stormwater discharge point that meets all water quality requirements of this manual and any other applicable code requirements.

Adjacent, Uncovered Portions of the Site

The surrounding uncovered portions of the site must be designed so stormwater does not enter the covered parking areas. This can be accomplished through grading, berms, or drains.

4.13 WATER RECLAIM AND REUSE SYSTEMS

4.13.1 Applicability

This section applies to commercial and industrial properties only.

Water reclamation or reuse systems provide innovative ways to use natural resources and save money. Reclaim and reuse systems that will discharge to the City's sanitary sewer are subject to sanitary sewer user fees.

Utilizing groundwater or stormwater as a resource from sites at risk of contamination may require additional source controls and trigger environmental compliance regulations, depending on the nature of the contaminants and the extent of the remediation that has been completed. See **Section 4.11** for information on contaminated sites.

4.13.2 General Requirements

Reuse systems that use stormwater or groundwater for non-potable water use in plumbing fixtures and industrial equipment (e.g., toilets, cooling towers or boilers) are required to meet the following requirements:

- A discharge meter must be installed on the outlet of the reuse system for sewer billing purposes. Discharge meter specifications and requirements can be found in City Code Chapter 17.36 and City policy.

- Industrial equipment bleed-offs or drain valves must have discharges routed to the sanitary waste line of the facility. Discharges must meet local discharge limits, as stated in City Code, Chapter 17.34, and administrative rules.

- A permanent monitoring point is required to ensure compliance with local discharge regulations or permits. A sampling manhole, 6-inch clean-out, or flow-through vault must be installed on the discharge line of the subsurface drainage system prior to commingling with any other discharges.

- A permit or authorization for a reuse system is required from BDS and BES. The Water Resources Department (WRD) and DEQ may also require permits or authorizations for the reuse of groundwater; contact them directly for information.

Reusing Surface Drainage (Rainwater Harvesting)

Reuse systems that use only stormwater are not expected to discharge pollutants/contaminants and should not pose a threat to City infrastructure. However, non-potable uses for reclaimed/reuse water in plumbing fixtures and industrial equipment (e.g., toilets, cooling towers or boilers) must meet the requirements listed under Section 4.13.2, above.

Reusing Subsurface Drainage

Discharges may contain contaminants, and analytical data will be required and evaluated for the specific pollutants/contaminants of concern before discharge methods will be approved. Analytical submittal requirements are identified in **Section 4.3.4** and must be submitted as part of the permit review process.

Overflows from the reuse system, prior to use, may contain contaminants; therefore, the overflow discharge must also comply with the requirements of Section 4.13.2.

In addition to the Section 4.13.2 requirements, non-potable uses for reclaimed/reuse water in plumbing fixtures and industrial equipment (e.g., toilets, cooling towers or boilers) will require the following:

- If commercial or industrial facilities use groundwater for non-potable uses or irrigation, authorization or a permit is required from the Oregon Water Resources Department (WRD) prior to use. Minimum requirements that warrant a permit for industrial and commercial groundwater wells include, but are not limited to, irrigation of areas that are greater than ½ acre and use more than 5,000 gallons per day of water. Unique groundwater reuse systems (anything other than a standard supply well installation) will be reviewed by WRD on a case-by-case basis to determine permitting requirements (if applicable).

  For assistance in obtaining authorization for the use of groundwater, contact WRD's Multnomah County Water Master at 503-722-1410. For more information on water rights and groundwater regulations, see the WRD website at **www.wrd.state.or.us.**

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DEFINITIONS

Note: *All definitions are used in this manual and are intended to be consistent with City Code Chapters 17.34, 17.36, 17.38, and 17.39. Some references to specific chapters or sections of the manual are included to help the user navigate the manual.*

Above-Ground Storage of Liquid Materials (**Section 4.8**): Places with exterior storage (either permanent or temporary) of liquid chemicals, food products, waste oils, solvents, process wastewaters, or petroleum products in above-ground containers, in quantities of 50 gallons or more.

Applicant: Any person, company, or agency that applies for a permit through the City of Portland. Includes all parties represented by the applicant.

Approved Receiving System (Discharge Point): Any system approved by BES to receive stormwater runoff or other discharges. Receiving systems include, but are not limited to, groundwater; onsite, offsite, or public stormwater, sanitary, or combined sewers; and waters of the state.

Batch Discharge**:** The controlled discharge of a discrete, contained volume of water or wastewater. Batch discharges into the public sewer system must conform to the requirements of City Code Chapters 17.34: Industrial Wastewater Discharges and 17.39: Stormwater Discharge.

BDS: Bureau of Development Services, City of Portland.

BES: Bureau of Environmental Services, City of Portland.

Bioretention Facility: A facility that uses soils and both woody and herbaceous plants to remove pollutants from stormwater runoff. Examples of bioretention facilities in this manual include vegetated swales, flow-through and infiltration planters, vegetated filters, and vegetated infiltration basins.

Bulk Fuel Terminal**:** Any area with its primary function dedicated to the storage and distribution of fuel to distributors (such as gas stations).

Bulk Material Transportation Route**:** Any path routinely used to transport materials regulated in **Section 4.6 & 4.7** onto, off of, or within a site.

Bulk Materials**:** Non-containerized materials.

Capacity: The flow volume or rate that a facility (e.g., pipe, pond, vault, swale, ditch, drywell, etc.) is designed to safely contain, receive, convey, reduce pollutants from, or infiltrate to meet a specific performance standard. Performance standards for pollution reduction, flow control, conveyance, and infiltration/discharge vary by facility, depending on location.

Catch Basin: A structural facility located just below the ground surface, used to collect stormwater runoff for conveyance purposes. Generally located in streets and parking lots, catch basins have grated lids, allowing stormwater from the surface to pass through for collection. Catch basins also include a sumped bottom and submerged outlet pipe (downturned 90 degree elbow, hood, or baffle board) to trap coarse sediment and oils.

Combined (or Combination) Sewers: Pipes that convey both sanitary sewage and stormwater.

Connection: Connecting a private sanitary sewage or drainage facility to the public sanitary sewer or drainage system.

***Containerized*:** The storage of any product, byproduct, or waste that is completely held or included on all sides, within a discrete volume or area.

***Containment*:** The temporary storage of potentially contaminated stormwater or process wastewater when a City sanitary sewer is not available for appropriate discharge.

Contaminated Dewatering: The discharge at the point of connection to a conveyance system after some level of treatment (such as vegetated water quality facility or device, air sparging for VOCs, electrocoagulation for solids, flocculation with Chitosan media for solids, or pH adjustment with weak caustics), when the resulting treated flow still does not meet local standards. Local standards include Portland Harbor or Columbia Slough source control strategies, and/or OAR 340 Table 33A, and/or City Code Chapter 17.39. If the discharge meets the specified regulatory criteria either before or after treatment, it will be considered for storm sewer discharge for discharge purposes under this manual. For discharge to a City sanitary or combined sewer system, the temporary or permanent discharge is considered contaminated if it does not meet the City's sanitary local limits per City Code Chapter 17.34 and therefore requires sanitary pretreatment permitting.

Control Structure: A device used to hold back or direct a calculated amount of stormwater to or from a stormwater management facility. Typical control structures include vaults or manholes fitted with baffles, weirs, or orifices. See **Chapter 2** for information regarding the design of control structures.

Conveyance: The transport of stormwater or wastewater from one point to another.

Covered Vehicle Parking Areas (**Section 4.12**): Vehicle parking structures used to cover parked vehicles, other than single-level covers such as canopies, overhangs, and carports.

CSO (Combined Sewer Overflow): A discharge of a mixture of sanitary sewage and stormwater at a point in the combination sewer system designed to relieve surcharging flows.

DEQ: Oregon Department of Environmental Quality.

Design Storm: Design criteria used for sizing stormwater management facilities and their conveyance. Design storms are a combination of the design storm return period (which refers to the frequency) and the storm duration (which defines the rainfall depth or intensity). A prescribed hyetograph and total precipitation amount (for a specific duration recurrence frequency) are used to estimate runoff for a hypothetical storm 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. The minimum design storms are selected by the permit authority to reflect required levels of protection, the local climate, and catchment conditions.

Design Water Surface Elevation: The elevation at the upper limit of the maximum depth and the lower limit of the freeboard, which corresponds to the overflow elevation. It can be considered the initial outlet elevation or over-topping elevation of the facility where an outlet is not included. The design water surface elevation is the upper limit of the capacity of the stormwater facility. Each cell of the facility may have a different design water surface elevation. The design water surface elevation can be relative to the final discharge point, a known actual elevation onsite, or can be set to zero.

Detention Facility: A facility designed to receive and hold stormwater and release it at a slower rate, usually over a number of hours. The entire volume of stormwater that enters the facility is eventually released.

Detention Tank, Vault, or Oversized Pipe: A structural subsurface facility used to provide flow control for a particular drainage basin. See **Chapter 2** for information regarding the design of detention tanks, vaults, and oversized pipes.

Development: Any human-induced change to improved or unimproved real estate, whether public or private, for which a permit is required, including but not limited to construction, installation, or expansion of a building or other structure; land division; street construction; drilling; and site alteration such as dredging, grading, paving, parking or storage facilities, excavation, filling, or clearing. Development encompasses both new development and redevelopment.

Development Footprint: The new or redeveloped area covered by buildings or other roof structures and other impervious surface areas, such as roads, parking lots, and sidewalks.

Discharge Point: The ultimate destination for the stormwater leaving a particular site, also known as the stormwater disposal point. Discharge can be through:

1. onsite infiltration (surface infiltration facilities, drywells, sumps, and soakage trenches) or
2. offsite flow to ditches, drainageways, streams, public or private separate stormwater piped systems, or combination sewers. See **Sections 1.3 and 1.4** for information regarding discharge requirements.

Discharge Rate: The rate of flow expressed in cubic feet per second (cfs).

Disposal: See definition of *Discharge Point*.

Drainage Basin: A specific area that contributes stormwater runoff to a particular point of interest, such as a stormwater management facility, drainageway, wetland, river, or pipe.

Drainageway: An open linear depression, whether constructed or natural, that functions for the collection and drainage of surface water. It may be permanently or temporarily inundated.

Driveway**:** The area that provides vehicular access to a site. A driveway begins at the property line and extends into the site. In parking areas, the driveway does not include vehicular parking, maneuvering, or circulation areas.

Drywell: A structural subsurface cylinder or vault with perforated sides and/or bottom, used to infiltrate stormwater into the ground. See **Chapter 2** for information regarding the design and use of drywells.

Ecoroof: A lightweight low-maintenance vegetated roof system consisting of waterproofing material, growing medium, and vegetation; used in place of or over the top of a conventional roof. Ecoroofs provide stormwater management by capturing, filtering, and evaporating rainfall. Ecoroofs are also called extensive green roofs. See **Chapter 2** for information regarding the design of ecoroofs.

Equipment and/or Vehicle Washing Facilities (**Section 4.9**): Designated equipment and/or vehicle washing or steam cleaning areas. This includes smaller activity areas, such as wheel-washing stations.

Extended Wet Detention Pond: A surface vegetated basin with a permanent pool of water and additional storage volume, used to provide pollution reduction and flow control for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. During large storm events, stormwater temporarily fills the additional storage volume and is slowly released over a number of hours, reducing peak flow rates. See **Chapter 2** for information regarding the design of extended wet detention ponds.

Exterior Materials Storage Area**:** Any outdoor materials storage location that is not completely enclosed by a roof and sidewalls.

Exterior Storage of Bulk Materials (**Section 4.10**): Outdoor areas used to stockpile materials that may erode and/or contribute pollutants to stormwater runoff.

Filter Fabric: A woven or non-woven water-permeable material, generally made of synthetic products such as polypropylene, used in stormwater management and erosion and sediment control applications to trap sediment or to prevent fine soil particles from clogging the aggregates.

Flow Control: The practice of limiting the release of peak flow rates and volumes from a site. Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increased stormwater runoff peak flow rates and volumes resulting from development. See **Section 1.3**.

Flow Control Facility: Any structure or drainage device that is designed, constructed, and maintained to collect, retain, infiltrate, or detain surface water runoff during and after a storm event for the purpose of controlling post-development quantity leaving the site.

Flow-through Planter: A structural facility filled with topsoil and gravel and planted with vegetation. The planter is completely lined and sealed, with a perforated collection pipe placed under the soil and gravel. The planter has an overflow that must be directed to an acceptable discharge point. The stormwater planter receives runoff from impervious surfaces, which is filtered and retained for a period of time. See **Chapter 2** for information regarding the design of flow-through planters.

Freeboard: The vertical distance between the design water surface elevation (overflow elevation) and the elevation at which overtopping of the structure or facility that contains the water would occur.

Fuel Dispensing Facilities (**Section 4.7**): Areas where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above-ground fuel tanks, fuel pumps, and the surrounding pad). This definition applies to large-sized gas stations as well as single-pump fueling operations.

***Greenstreets*:** Public stormwater facilities that accept runoff from the right-of-way. See definition of *Street Swale*.

Groundwater: Subsurface water that occurs in soils and geological formations that are fully saturated. Groundwater fluctuates seasonally and includes perched groundwater. Groundwater related discharges include, but are not limited to, subsurface water from site remediation and investigations, well development, Brownfield redevelopment, discharges from footing and foundation drains, rainwater infiltration into excavations, and subsurface water associated with construction or property management dewatering activities.

Growing Medium: Non-native soil mixture made up of sand, loam, and compost; used on the surface of stormwater facilities, as described in **Appendix F.3.**

***Hazardous Material*:** Any material or combination of materials that, because of the quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or that may pose a present or potential hazard to human health, safety, or welfare, or to animal or aquatic life or the environment when improperly used, stored, transported or disposed of, or otherwise managed. For purposes of chemical regulation by this manual, moderate to high toxicity and confirmed human carcinogenicity are the criteria used to identify hazardous substances. (Note: This manual does not use the Resource Conservation and Recovery Act [RCRA] definition of hazardous. For the purpose of this manual, hazardous material is intended to include hazardous, toxic, and other harmful substances.)

Impervious Surface/Area: Any surface that has a runoff coefficient greater than 0.8 (as defined in the City's 2006 *Sewer and Drainage Facilities Design Manual*). Types of impervious surface include rooftops, traditional asphalt and concrete parking lots, driveways, roads, sidewalks, and pedestrian plazas. *Note:* Slatted decks are considered pervious. Gravel surfaces are considered pervious unless they cover impervious surfaces or are compacted to a degree that causes their runoff coefficient to exceed 0.8.

Infiltration: The percolation of water into the ground. Infiltration is often expressed as a rate (inches per hour), which is determined through an infiltration test.

Infiltration Planter: A structural facility filled with topsoil and gravel and planted with vegetation. The planter has on open bottom, allowing water to infiltrate into the ground. Stormwater runoff from impervious surfaces is directed into the planter, where it is filtered and infiltrated into the surrounding soil. See **Chapter 2** for information regarding the design of infiltration planters.

Infiltration Test: Infiltration tests are conducted to determine the feasibility of onsite stormwater percolation for every new development. Three methods are described in the manual: the falling head test, the double-ring infiltrometer test, and the pit test. See **Appendix F.2** for more information regarding requirements.

Inlet: 1) A structure located just below the ground surface, used to collect stormwater runoff. Generally located in streets and parking lots, inlets have grated lids, allowing stormwater from the surface to pass through for collection. 2) The initial entry into an overflow from a stormwater facility. 3) The point at which stormwater from impervious surfaces or conveyance piping enters a stormwater management facility.

Landscaping: See definition of *Stormwater Facility Landscaping*.

Long-term Dewatering: When groundwater is drained or pumped from a subsurface or surface system. For site development, long-term is defined as dewatering that occurs during the longevity of the constructed subsurface system. Other permanent dewatering activities are defined as greater than three (3) years. Long-term dewatering includes, but is not limited to, groundwater remediation systems and development/construction sites.

Manufactured Stormwater Treatment Technology: A proprietary structural facility or device used to remove pollutants from stormwater. Refer to **Chapter 2** and **Appendix B** for approval criteria related to manufactured stormwater treatment technologies.

Material Transfer Areas/Loading Docks (**Section 4.6**): Areas designed to accommodate a truck/trailer being backed up to or into them, and used specifically to receive or distribute materials to and/or from trucks/trailers. Includes loading/unloading facilities with docks, and large bay doors without docks.

Maximum Depth: The greatest vertical distance between the design water surface elevation (overflow elevation) and the top of the growing medium of a surface facility or the base of a subsurface facility, which creates a reservoir capable of providing safe storage capacity of stormwater. Also referred to as the storage depth.

Offsite Stormwater Facility: Any stormwater management facility located outside the property boundaries of a specific development but designed to provide stormwater management benefits for that development.

Onsite Stormwater Facility: Any stormwater management facility located within the property boundaries of a specific development and designed to provide stormwater management benefits for that development.

Open Channel: A fluid passageway that allows part of the fluid to be exposed to the atmosphere.

Operations and Maintenance (O&M): The continuing activities required to keep stormwater management facilities and their components functioning in accordance with design objectives. See **Chapter 3** regarding operations and maintenance requirements for stormwater management facilities.

Outfall: A location where collected and concentrated water is discharged. Outfalls can include discharge from stormwater management facilities, drainage pipe systems, and constructed open channels. See **Chapter 2** for information regarding the design of outfalls.

Overflow Elevation: See definition for ***Design Water Surface Elevation.***

Partial Infiltration: When the total infiltration design storm (or another specified design storm as required) is unable to be completely percolated into the ground, a portion of the storm must be percolated for fulfillment of partial infiltration.

Parking Area**:** The area of a site devoted to the temporary or permanent storage, maneuvering, or circulation of motor vehicles. Parking areas do not include driveways or areas devoted exclusively to non-passenger loading.

PDOT: Portland Department of Transportation

Perched Groundwater: As defined in the City's Water Pollution Control Facility (WPCF) permit: Groundwater held above the regional or main (permanent) water table by a less permeable underlying earth or rock material.

Permeable Pavement: See definition of *Pervious Pavement*.

Pervious: Any surface determined to have a runoff coefficient less than 0.8; a surface modified in a way to encourage infiltration of water (as defined in the City's 2006 *Sewer and Drainage Facilities Design Manual*).

Pervious Pavement: The numerous types of alternative pavement systems that allow stormwater to percolate through them and into subsurface drainage systems or the ground (e.g., permeable pavers, pervious asphalt, and pervious concrete). See **Chapter 2** for design requirements related to pervious pavement. Also referred to as porous or permeable pavement.

Pollutant: An elemental or physical material that can be mobilized or dissolved by water or air and creates a negative impact to human health and/or the environment. Pollutants include suspended solids (sediment), heavy metals (such as lead, copper, zinc, and cadmium), nutrients (such as nitrogen and phosphorus), bacteria and viruses, organics (such as oil, grease, hydrocarbons, pesticides, and fertilizers), floatable debris, and increased temperature.

Pollution Reduction: **The Pollution Reduction storm event is representative of 90% of the average annual rainfall and is used to size facilities for the pollution reduction stormwater management requirement (see Section 1.3.3). Refer to Appendix E for additional discussion of the pollution reduction storm precipitation. Also known as the water quality storm.**

Pollution Reduction Facility: A structure, landscape, or drainage device that is designed, constructed, and maintained to collect and filter, retain, or detain surface water runoff during and after a storm event for the purpose of maintaining or improving surface and/or groundwater quality.

Pollutants of Concern: Watershed-specific parameters identified by the Oregon Department of Environmental Quality (DEQ) as having a negative impact on the receiving water body. Pollutants of concern can include suspended solids, heavy metals, nutrients, bacteria and viruses, organics, volatiles, semi-volatiles, floatable debris, and increased temperature.

Porous Pavement: See definition of *Permeable Pavement*.

***Post-Construction Subsurface Drainage*:** Foundation, footing, or perimeter piping and drainage systems installed to collect subsurface water and convey it to a point of use or disposal. Subsurface water is defined as groundwater. See definition of G*roundwater*.

Post-Construction Surface Drainage: Piped storm drainage systems and stormwater facilities used to convey stormwater runoff to a point of use or disposal when construction is complete.

Post-Developed Condition: As related to new or redevelopment: A site's ground cover and grading after development.

Practicable: Available and capable of being done, as determined by the BES Director, after taking into consideration cost, resources, existing technology, and logistics in light of overall project purpose.

Pre-Developed Condition: As related to new development: A site's ground cover and grading prior to development. As related to redevelopment: A site's ground cover and grading prior to any development taking place (i.e., Lewis & Clark days).

Presumptive Approach Calculator (PAC): Calculation tool used to size vegetated stormwater facilities. The PAC assumes that the 2-year, 24-hour event must be met for water quality, and the 10-year, 24-hour event must be met for flow control. See **Appendix C** for the PAC and the User's Manual.

Public Facility: A street, right-of-way, sewer, drainage, stormwater management, or other facility that is either currently owned by the City or will be conveyed to the City for maintenance responsibility after construction. A new stormwater management facility that receives direct stormwater runoff from a public right-of-way becomes a public (City-maintained) facility unless the right-of-way is not part of the City's road maintenance system.

Public Works Project: Any development conducted or financed by a local, state, or federal governmental body, including local improvements and public improvements, as defined in City Code Title 17: Public Improvements.

Raingarden: See definition of *Vegetated Infiltration Basin.*

Rainwater Harvesting: The practice of collecting and using stormwater for purposes such as irrigation and toilet flushing. For the purpose of this manual, harvesting is a stormwater facility only if the system is used for water quality or flow control, as determined by BES. When harvesting is proposed as a stormwater facility, the Performance Approach must be used to show how Chapter 1 requirements of the manual are met. See **Chapter 2** for information regarding rainwater harvesting.

Rational Method: The method used to estimate the peak rate of runoff from a drainage basin, using the formula: Q=CiA. Q is the peak discharge, cubic feet per second; C is the runoff coefficient; i is the rainfall intensity, inches per hour; and A is the drainage area, acres (as defined in the City's 2006 *Sewer and Drainage Facilities Design Manual*).

Redevelopment: Any development that requires demolition or complete removal of existing structures or impervious surfaces at a site and replacement with new impervious surfaces. Maintenance activities such as top-layer grinding, repaving (where all pavement is not removed), and reroofing are not considered to be redevelopment. Interior remodeling projects and tenant improvements are also not considered to be redevelopment. Utility trenches in streets are not considered to be redevelopment unless more than 50 percent of the street width is removed and repaved.

Regrading: Applies to areas that are excavated to a depth at or below the top of the subgrade and replaced with new pavement. The subgrade is taken to be the crushed surfacing directly below the pavement layer (asphalt concrete pavement, Portland cement concrete pavement, bituminious surface treatment). If the removal and replacement of existing pavement goes below the pavement layer, the new surfacing is considered to be regrading.

Repaving: Applies to areas that are not excavated to a depth at or below the top of the subgrade (pavement repair work included) and are replaced in kind. The subgrade is taken to be the crushed surfacing directly below the pavement layer (asphalt concrete pavement, Portland cement concrete pavement, bituminious surface treatment). If the removal and replacement of existing pavement does not go below the pavement layer, as with typical PCCP grinding or ACP planing, the new surfacing is considered to be repaving.

Reservoir: The volume available for holding runoff prior to overflow. For vegetated surface facilities it is defined as the volume between the top of the growing medium, the design water surface elevation (overflow elevation), and the edges of the facility (whether sloped or vertical).

Retention Facility: A facility designed to receive and hold stormwater runoff. Rather than storing and releasing the entire runoff volume, retention facilities permanently retain a portion of the water onsite, where it infiltrates, evaporates, or is absorbed by surrounding vegetation. In this way, the full volume of stormwater that enters the facility is not released offsite.

Retrofit: Installation of a new stormwater facility to treat stormwater from existing impervious area, including, but not limited to, roofs, patios, walkways, and driving or parking surfaces.

Roadway**:** Any paved surface used to carry vehicular traffic (cars/trucks, forklifts, farm machinery, or any other large machinery).

Roof Garden: A heavyweight roof system of waterproofing material with a thick soil and vegetation cover. Roof gardens can provide stormwater management by capturing, filtering, and evaporating rainfall. See the ecoroof section of **Chapter 2** for information regarding the design of roof gardens as stormwater management facilities.

Runoff Coefficient: A unitless number between zero and one that relates the average rate of rainfall over a homogenous area to the maximum rate of runoff, as defined in Table 6.5 of the City's 2006 *Sewer and Drainage Facilities Design Manual*.

Safety Factor**:** A safety factor is based on a risk/value assessment that evaluates the specific conditions anticipated in an application, the failure mode of the construction material, unexpected construction deficiencies, and potential cost of system failure. The safety factor is applied to the maximum performance limit to calculate a lower value, which is then used as a design value. A safety factor must be used to provide reasonable assurance of acceptable long-term system performance.

Sand Filter: A structural facility with a layer of sand, used to filter pollutants from stormwater. See **Chapter 2** for information regarding the design of sand filters.

Santa Barbara Urban Hydrograph (SBUH): A hydrologic method used to calculate runoff hydrographs. See **Appendix C** for information regarding the use of the SBUH method.

Seasonally High Groundwater Level: As defined in the City's Water Pollution Control Facility (WPCF) permit: The highest level that the permanent groundwater table or perched groundwater may reach on a seasonal basis.

Soakage Trench: A linear excavation backfilled with drain rock, used to filter pollutants and infiltrate stormwater. See **Chapter 2** for information regarding the design of soakage trenches.

Solid Waste Containers: Compactors, dumpsters, compost bins, grease bins, and garbage cans.

Solid Waste Storage Area: An indoor or outdoor area where solid waste containers are collectively stored **(Section 4.5)**. Solid wastes include both food and non-food waste or recycling.

Stormwater: Water runoff that originates as precipitation on a particular site, basin, or watershed. Also referred to as runoff.

Stormwater Facility Landscaping: The vegetation (plantings), topsoil, rocks, and other surface elements associated with stormwater management facility design. See **Chapter 2 and Appendix F** for stormwater facility landscaping requirements.

Stormwater Management: The overall culmination of techniques used to reduce pollutants from, detain, retain, or provide a discharge point for stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows or basement sewer backups, or to fit within the capacity of existing infrastructure.

Stormwater Management Facility: A technique used to reduce pollutants from, detain and/or retain, or provide a discharge point for stormwater to best preserve or mimic the natural hydrologic cycle, to accomplish goals of reducing combined sewer overflows or basement sewer backups, and/or to fit within or improve the capacity of existing infrastructure.

Stormwater Reuse: See definition of *Rainwater Harvesting*.

Street Swale: A vegetated swale located next to a public or private street for the purpose of managing stormwater. See **Chapter 2** for information regarding the design of street swales. Also known as *GreenStreets*.

Sump: A large public drywell (see definition) used to infiltrate stormwater from public streets. Sumps are generally 48 inches in diameter and 30 feet deep. The term *sump* is also used in reference to any volume of a facility below the point of outlet, in which water can accumulate. See **Chapter 2** for information regarding the use and design of sumps.

Surcharge: A flow condition, i.e. pressure flow, resulting when the downstream hydraulic capacity is less than the upstream inflow causing water to accumulate and rise above the inside crown of a pipe or facility. It also refers to the greatest measured distance from the water surface above the pipe to the pipe crown.

Surface Conveyance: The transport of stormwater on the ground surface from one point to another.

Surface Infiltration Facility: A vegetated facility designed to receive and infiltrate stormwater runoff at the ground surface to meet stormwater infiltration/discharge requirements. Pollution reduction and flow control requirements can also be met with surface infiltration facilities.

***Temporary Dewatering*:** When groundwater or stormwater is temporarily drained or pumped from a subsurface or surface system. For site development, temporarily is defined as the duration of time during the preconstruction or construction site work. Other temporary dewatering activities are defined as less than three (3) years. Specific activities include, but are not limited to, construction dewatering, dewatering wells, trench systems or sediment control ponds. Remediation sites are covered under the temporary connections definition in Title 17.36.

Temporary Structure: A structure shall be deemed temporary if it is a separate and distinct entity from all other structures and it is created and removed in its entirety, including impervious area associated with the structure, within a continuous period of three years or less. Paved areas such as parking lots that are developed alongside structures are not considered temporary for the purpose of this manual.

Tenant Improvements: Structural upgrades made to the interior or exterior of buildings. Tenant improvements may trigger **Chapter 4** source controls if they take place on sites with specified activities.

Time of Concentration (T of C or TOC): The amount of time it takes stormwater runoff to travel from the most distant point (measured by travel time) on a particular site or drainage basin to a particular point of interest. See **Appendix C** for calculations related to time of concentration.

Topsoil: See *Growing Medium*. Also refer to the 2007 City of Portland *Standard Construction Specifications*.

Total Infiltration: When the entire designated design storm is able to be completely percolated into the ground.

Total Suspended Solids (TSS): Matter suspended in stormwater, excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter.

Underground Injection Control (UIC): A federal program under the Safe Drinking Water Act, delegated to the Oregon Department of Environmental Quality (DEQ), which regulates the injection of water below ground. The intent of the program is to protect groundwater aquifers, primarily those used as a source of drinking water, from contamination. See **Section 1.4** for information regarding the UIC program.

Vegetated Facilities: Stormwater management facilities that rely on plantings as an integral component of their functionality. Plantings can provide wildlife habitat and enhance many facility functions, including infiltration, pollutant removal, water cooling, flow calming, and erosion prevention.

Vegetated Filter: A gently sloping, densely vegetated area used to filter, slow, and infiltrate sheetflow stormwater. See **Chapter 2** for information regarding the design of vegetated filters.

Vegetated Infiltration Basin: A vegetated facility that temporarily holds and infiltrates stormwater into the ground. See **Chapter 2** for information regarding the design of vegetated infiltration basins.

Vegetated Swale: A long and narrow, trapezoidal or semicircular channel, planted with a variety of trees, shrubs, and grasses. Stormwater runoff from impervious surfaces is directed through the swale, where it is slowed and in some cases infiltrated, allowing pollutants to settle out. Check dams are used to create small ponded areas to facilitate infiltration. See **Chapter 2** for information regarding the design of vegetated swales.

Water Body: Water bodies include coastal waters, rivers, sloughs, continuous and intermittent streams and seeps, ponds, lakes, aquifers, and wetlands.

Water Quality: See definition of *Pollution Reduction*.

Water Quality Limited [303(d) listing]: Waters identified by DEQ that do not meet water quality standards. Total Maximum Daily Load (TMDL) must be developed for these waters to satisfy Clean Water Act (CWA) requirements. The most recent EPA-approved Section 303(d) list for Oregon can be found at **www.deq.state.or.us/wq/assessment/assessment.htm.**

Water Course: A channel in which a flow of water occurs, either continuously or intermittently, with some degree of regularity. Water courses may be either natural or artificial.

Water Table: As defined in the City's Water Pollution Control Facility (WPCF) permit: The upper surface of an unconfined water body, the surface of which is at atmospheric pressure and fluctuates seasonally. The water table is defined by the levels at which water stands in wells that penetrate the water body.

Wellhead Protection Area: An abbreviated term usually used to refer to the Columbia South Shore Well Field Wellhead Protection Area (see **Section 1.3.4 and Exhibit 1.7**).

The Water Bureau regulates the storage, use, and transportation of hazardous/toxic materials in this groundwater resource protection area.

Wet Pond: A vegetated basin with a permanent pool of water, used to provide pollution reduction for a particular drainage basin. The permanent pool of water provides a storage volume for pollutants to settle out. See **Chapter 2** for information regarding the design of wet ponds.

Wetland: An area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include swamps, marshes, bogs, and similar areas, except those constructed as pollution reduction or flow control facilities. Specific wetland designations are made by the U.S. Army Corps of Engineers and the Oregon Department of State Lands.

Stormwater Management Manual Contact Information

Stormwater Management Manual **website**:
http://www.portlandonline.com/bes/index.cfm?c=47952&

To purchase a **printed copy** of the Stormwater Management Manual visit the **Development Services Center** (see contact information below).

To request a **free CD** of the Stormwater Manual by mail call: 503-823-7103.

To request more information on **development standards** within the Stormwater Management Manual, write to: Stormwatermanual@bes.ci.portland.or.us

Useful City of Portland Addresses and Phone Numbers

Development Services Center (DSC)

1900 SW 4th Avenue, 1st Floor
Portland, OR 97201

Hours
Monday – Friday 7:30 am - 3:00 pm
Thursday Evenings 5:00 pm- 7:30 pm
(homeowners night)

Permitting Services (503) 823-7310
Planning and Zoning (Zoning questions) (503) 823-7526
Plumbing, Electrical, Mechanical, Sign Permits (503) 823-7363
Resource/Records (503) 823-7660
Permit Status via Voicemail (503) 823-7000 (4)

http://www.portlandonline.com/bds/index.cfm?c=34154

Other City Hotline or Reference Phone Numbers and Websites

Bureau of Environmental Services, System Development Division Hotline
(503) 823-7761

BDS Early Assistance Appointments
Questions: (503) 823-7526
Application form: (http://www.portlandonline.com/bds/index.cfm?c=36648)
Application Submittal: Submit EA Appointment request form in the DSC

Clean River Rewards (503) 823-1371
www.CleanRiverRewards.com

Columbia South Shore Well Field Wellhead Protection Program
http://www.portlandonline.com/water/index.cfm?c=29890

Combined Sewer Overflow (CSO) Program
http://www.portlandonline.com/bes/index.cfm?c=31030

Portland Department of Transportation
http://www.portlandonline.com/transportation/index.cfm?c=32360

Public Works Permitting Process
http://www.portlandonline.com/index.cfm?c=43826

Site Development Permits (503) 823-6892
http://www.portlandonline.com/bds/index.cfm?c=36670

Urban Forestry (503) 823-4489
http://www.portlandonline.com/parks/index.cfm?c=38294

City Codes

Title 10: Erosion and Sediment Control
http://www.portlandonline.com/auditor/index.cfm?c=28175

Title 17: Public Improvements
http://www.portlandonline.com/auditor/index.cfm?c=28181

Title 24: Building Regulations
http://www.portlandonline.com/auditor/index.cfm?c=28188

Title 33: Planning and Zoning
http://www.portlandonline.com/auditor/index.cfm?c=28197

2008 Oregon Specialty Plumbing Code
http://www.cbs.state.or.us/external/bcd/programs/plumbing/2008opsc.html

Site Evaluation Maps

http://www.Portlandonline.com/bes/swmaps

Portland Maps (including storm water, utility and drainage way maps)
http://www.portlandmaps.com

Soil Survey of Multnomah County (Soil Conservation Service, 1982)
http://soildatamart.nrcs.usda.gov/Manuscripts/OR051/0/or051_text.pdf

Multnomah County SAIL (Plat Maps)
http://gis.co.multnomah.or.us/sail/index.cfm?action=mox42_if_frameset

Standard Construction Specifications

Standard City of Portland Drawings, Details and Plans - Construction Specifications – Standard Drawings Environmental Services
http://www.portlandonline.com/transportation/index.cfm?c=40032&a=152861

Manuals/Documents

Sewer and Drainage Facilities Design Manual
http://www.portlandonline.com/bes/index.cfm?c=43271&

Erosion and Sediment Control Manual
http://www.portlandonline.com/bes/index.cfm?c=43428&a=195782

2006 Rules for Sewer Connection
http://.portlandonline.com/shared/cfm/image.cfm?id=131995

Stormwater Solutions Handbook
http://www.portlandonline.com/bes/index.cfm?&c=43110

Transportation Element, Comprehensive Plan
http://www.portlandonline.com/transportation/index.cfm?a=84748&c=35934

Other Agencies

City of Seattle, "Stormwater Treatment Technical Requirements Manual"
http://web1.seattle.gov/dpd/dirrulesviewer/Rule.aspx?id=27-2000

Clean Water Services, "Water Quality and Quantity Facility Design"
http://www.cleanwaterservices.org/

King County Surface Water Management, King County, Washington, "Surface Water Design Manual", Originally published in 1990 (effective January 24, 2005)
http://www.kingcounty.gov/environment/waterandland/stormwater/documents/surface-water-design-manual.aspx

Metro
http://www.metro-region.org/

Metro Code
http://www.metro-region.org/index.cfm/go/by.web/id/408

Multnomah County Drainage District
http://mcdd.org/

Oregon Administrative Rules
http://arcweb.sos.state.or.us/banners/rules.htm

Oregon DEQ
http://www.oregon.gov/DEQ

Oregon Department of Environmental Quality (DEQ), Underground Injection Control Program (UIC)
http://www.deq.state.or.us/wq/uic/uic.htm

Oregon Department of State Lands
http://statelands.dsl.state.or.us/

Washington State Department of Ecology, "Stormwater Management Manual for Western Washington"
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html

US Army Corps of Engineers
http://www.usace.army.mil/

Oregon Administrative Rules
http://arcweb.sos.state.or.us/banners/rules.htm

U.S. Green Building Council
http://www.usgbc.org/

Appendix A Table of Contents

Appendix A.1 City Code Chapter 17.38

At the time of this publication, Chapter 17.38 was under revision. Please refer to the Auditor's Office website for the most up to date information.

http://www.portlandonline.com/auditor/index.cfm?c=28865

Appendix A.2 Policy Framework and Revision Process

The Stormwater Policy Advisory Committee (SPAC) was established in April 1996 at the direction of the City Commissioner of Public Works. SPAC members included representatives of City bureaus, the Homebuilders Association, Metro, the Oregon Department of Environmental Quality, watershed advocates, and the development community. The SPAC was charged with recommending stormwater management policies to the Bureau of Environmental Services (BES). In addressing stormwater issues, the SPAC also considered other City goals and policies for environmental protection, density, transportation, and economic development.

In July 1997, the SPAC submitted and City Council accepted policy recommendations for new development (*Final Recommendations: Stormwater Management Requirements for New Development*). Council directed BES to develop this *Stormwater Management Manual* to implement policy recommendations for development. The *Stormwater Management Manual* was adopted on July 1, 1999. The *Stormwater Management Manual* is part of BES's Administrative Rules, authorized by Portland City Code Chapter 17.38, adopted by the Director of BES following a public review process, and filed with the City Auditor as required by Portland City Code Chapter 1.07.

In spring 1999, the City Council established the Stormwater Advisory Committee (SAC), whose members represent environmental, development, engineering, business, and community interests. One of the SAC's tasks was to review and make recommendations regarding changes to the manual. The SAC presented its recommendations to Council in April 2000 and again in August 2002. In addition, a public review process was conducted to obtain public comment on the manual. The SAC recommendations, public comments where appropriate, and BES staff changes are incorporated into this revised manual.

The policies that form the basis for this manual are codified in City Code Chapter 17.38, which is restated above.

Update and Amendment Process

This *Stormwater Management Manual* will be reviewed a minimum of every 3 years and updated as necessary. The review process will include:

- Consideration of changed and new technologies
- Review of appeals made during the preceding interval
- Review of requests for variances to standard design criteria for public and private facilities
- Review of all performance-based approaches approved since the last manual revision
- Review of recommendations from the Stormwater Advisory Committee
- Review of community comments and concerns
- Adjustment of internal review processes and submittal requirements
- Incorporation of new sections and issues

The amendment process will also include a mailing to interested persons to solicit suggestions for amendments or procedural changes; a public meeting to review amendments and solicit input; and documentation and explanation of any changes made.

Suggestions for changes and improvements can be made at any time and should be sent to:

City of Portland, BES
1120 SW 5th Ave., Room 1100
Portland, OR 97204
Attention: Stormwater Manual Project Manager

Or email: StormwaterManaul@bes.ci.portland.or.us

Any changes to the current stormwater management policies will require the approval of City Council. If changes to the manual are proposed, the Chief Engineer will distribute any proposed manual improvements to interested parties and internal staff no later than May 1 of the year the manual is to be revised. The amended manual will be approved by the Chief Engineer and Bureau Director no later than September 1 of the year the amendments will occur.

APPENDIX A.3

Private Drainage Reserve Administrative Rules

Contents Page

I. Program Goals and Objectives

The main goal of the drainage reserve code and associated administrative rules is to protect flow conveyance in both natural and manmade surface channels (drainageways), thereby minimizing scouring and erosion in local stream systems and protecting properties from impacts related to modifications of drainageways. Drainage reserves act as a no-build area, not an easement. Drainage reserves ensure that properties with drainage downstream and upstream of developing properties are not damaged or destabilized by ponding, flooding, or other impacts from excess flows. While reserves are implemented on a site-by site basis, the drainage reserve code and administrative rules strive to protect local waterways from cumulative impacts of development, especially in headwater areas. The code and administrative rules are intended to establish standards and appeal processes to meet the following objectives:

A. Responsibly manage stormwater and limit site impacts. Maintain the location of stormwater discharges and flows where they naturally occur within the development area and cause least detrimental environmental impact.

B. Limit off-site impacts. If any encroachments into the drainageway channel are proposed, identification of the upstream tributary drainage and a downstream analysis shall be required to ensure there are no substantive impacts to downstream properties. The kind of analysis required will depend on the cumulative impact of problems identified within the basin and the size of the planned project.

C. Control runoff. Proposed construction projects and system modifications or improvements shall provide runoff controls to limit the developed condition's peak rates of runoff to the pre-development peak rates for a specific design storm frequency, based on the proposed project site's existing runoff conditions.

D. Control erosion. All conveyance systems shall be designed and modified to prevent and reduce construction erosion and long-term, scour-related erosion within the drainageway. This includes the establishment of woody vegetation for scour protection and enhanced infiltration and water quality.

E. Provide operation and maintenance. The private property owner is responsible for retaining the drainageway as an open system and for maintaining all drainage facilities constructed or modified by a project, unless the City has specifically agreed to City operation and maintenance (O&M) before plan approval. Owners shall also be responsible for maintaining all enrichment elements approved by the City and covered by a drainage reserve O&M plan.

F. Maintain capacity. Because drainageways serve an important hydrologic function for small waterways, there may be a requirement to demonstrate that any encroachments into the drainageway will not affect storage or conveyance volumes of the drainageway. Mitigation may be required for any lost capacity in the drainageway resulting from encroachments.

While protection of flow conveyance is the purpose for establishing drainage reserves, the rules also include elements to meet secondary City goals such as plant diversity, water quality, habitat, and other watershed health issues such as restoring onsite hydrology, improving water quality, habitat, and biological communities.

II. Background

Throughout Portland are areas without constructed drainage facilities, where drainage flows over land through private properties and unimproved or substandard rights-of-way. Usually this overland flow of water collects into some kind of open conveyance that carries the water across the property. For the purposes of these rules, these open conveyances are collectively called drainageways. Drainageways may also fall into other City Code definitions concerning water movement, especially terms such as "streams" and "channels." Some drainageways may be formed or controlled by structures, such as culverts, that direct or pond water. Natural seeps, springs, and wetlands may generate water, but do not convey water across property and therefore are not specifically drainageways. These rules are not intended to cover these natural water features. Drainageways must be carefully considered when properties are developed, regardless of whether the drainageways are naturally occurring or have resulted after water has been moved, shifted, or modified as part of earlier developments or actions. It is critical for watershed health and public health and safety that these private flow conveyance systems be protected and improved if receiving any development impacts. Private property owners are responsible for maintaining flow conveyance and erosion prevention within any drainageway that runs through their property.

In the mid 1970s, the City of Portland implemented provisions within the City's land division code (known at the time as Title 34 and now known as the 600 series in Title 33) to ensure that open conveyance systems stayed open. The intent at that time was for subdivisions and planned unit developments to redesign around open conveyance channels when possible. Given the growing science of using open areas for managing drainage and for flood control, the City identified the need to establish drainage reserves over drainageways as a method of enhancing control of stormwater flows.

In 1994, the City began to rewrite its land division code. Drainage reserves were deemed a technical review item and moved into the public works code section 17.38, which is administered by the Bureau of Environmental Services (BES). Moving these regulations also reinforced that flow conveyance is a public infrastructure and public safety element, similar to other public works elements found in Title 17 of the City Code. This move also reinforced that such technical review items are distinct from more traditional subjective land use review items and that technical items are not open for appeal to the Oregon Land Use Board of Appeals (LUBA). By the time this code provision was moved in 2002, BES decided to expand the coverage of the drainageway regulations to apply to all types of development reviews (e.g., land use reviews, building permits, site development permits), not just land division reviews (one specific type of development review). This expansion to all types of development reviews enhanced City efforts to provide safe flow conveyance across the City, and the change provided equitable regulation across all forms of development.

During the 2002 code rewrite, new administrative rules were created to describe the technical review standards that were not described in the zoning code language. Those rules, which described how BES would administer drainage reserves across all forms of development review, were adopted in December 2002. (See Appendix A3-A.) The rules generally stated the technical standards and decision-making criteria that BES would use to determine whether a drainage reserve should be placed on a developing property. At that time, the City also defined drainage reserves as a condition of development approval, rather than as an easement that would be purchased or required by the City. That designation was made because no municipal facilities are involved on these private properties, and the City is not the party responsible for ongoing maintenance. Because of that decision, drainage reserves have not been shown on final plat surveys or on private property title searches. These new 2008 rules implement a procedure to record notice of conditions against a deed in order to provide some notice to property owners that a drainageway is present on their property. (See Appendix A.3-B.)These 2008 administrative rules supercede the 2002 rules.

III. Purpose of these Rules

These rules detail the criteria BES will use to establish drainage reserves and to review for drainage reserve encroachments related to development. Applicants are encouraged to either meet these rules outright or request an appeal to review site-specific conditions that could influence the establishment of a drainage reserve or the approval for encroachments. All appeals shall be prepared to address the intent of the standards and criteria outlined in this document. Appeals shall be processed as described in Section XII.

BES staff experience over the five years of implementing the 2002 drainageway rules has identified the need to have greater flexibility for encroachment. While the City code grants general authorities, it does not specifically describe how a development proposal will be reviewed and evaluated for the need to place a drainage reserve. These rules achieve the following:

- Clearly identify BES's obligations for ensuring appropriate protections of stormwater flows.
- Clarify BES's administrative review, submittal requirements, and evaluation standards for requiring drainage reserves.
- Detail the responsibilities for protecting drainage reserves from other site development.
- Explicitly describe the approval standards and process for modifications made within a designated reserve area.
- Reflect the differences between building permit review and land division review, especially the ability to redesign at a late stage of City review in the building permit process.
- Detail the issues of concern and the submittals required to approve encroachments into the reserve area versus into the drainageway channel.
- Identify the methods for an applicant to appeal and for site-specific consideration.
- Clarify the inspection and enforcement roles and responsibilities of all City parties.

- Identify the ongoing responsibilities of a property owner in protecting, using, and maintaining a drainageway and drainage reserve area.
- Create a new notice of condition recording process to ensure that property owners are aware that a drainage reserve is present on their property and that there are maintenance and encroachment review responsibilities.

In the last five years, the City has made substantial progress in identifying multiple watershed health objectives that should be met by all City activities. While **these rules are foremost for flow conveyance protection**, they also often result in improved vegetated facilities that meet multiple watershed health objectives. These other benefits are secondary; open flow conveyance is the primary objective of these rules. There may be site needs that result in a determination to pipe a drainageway for land stability or other safety issues. In these cases, public health and safety needs will be prioritized over other vegetative/habitat-related watershed benefits.

IV. Regulatory Authority

City Code Chapter 17.38.021 gives BES the authority to require drainage reserves as part of development review. The code states:

1. Authority. The Director may require drainage reserves or tracts over seeps, springs and drainageways as necessary to preserve the functioning of these areas and to limit flooding impacts from natural and man made channels, ditches, seeps, springs, intermittent flow channels and other open linear depressions. Standards and criteria for imposing drainage reserves or tract requirements shall be adopted by administrative rule. Placement and/or sizing of drainage reserves do not relieve property owners of their responsibility to manage stormwater in a manner that complies with the duties of property owners under applicable law. Drainage reserve or tract requirements may be imposed during land use reviews, building permit review or other development process that require Bureau of Environmental Services (BES) review.

2. Required management of the drainage reserve: Drainage reserves or tracts shall remain in natural topographic condition. No private structures, culverts, excavations or fills shall be constructed within drainage reserves or tracts unless authorized by the BES Chief Engineer. All changes must also comply with zoning regulations as described in Title 33, and grading and floodplain regulations as described in title 24.

While drainage reserves are routinely required at the building permit stage of development, BES staff will evaluate, identify, and propose conditions of approval at the land division stage of development to help enhance the ability of developers to design around reserve areas.

These rules do not specifically address existing development that has previously been built in areas that would meet the drainageway definitions found in this document. However, any new expansion of structures that encroach in the drainage reserve and trigger a building permit must comply with these rules.

V. Relationship of Drainage Reserve Code to Other Regulations

The City has multiple regulations that require management of open surface flow conveyance systems. Below are other regulations that may need to be addressed instead of or in addition to these drainage reserve regulations. The program descriptions identify differences among regulations and note any processes that coordinate review of drainage reserves with other reviews.

Land Division Tracts

BES participates in land division review processes to ensure the adequacy of sanitary services, onsite stormwater management, and drainageway protection. The main objective is to ensure that the property has sufficient space reserved for flow conveyances and post-development stormwater management facilities. Given the variety of regulatory mechanisms in the land division code (seep/spring tracts, stormwater management tracts, environmental tracts, and drainage reserves), Bureau of Development Services (BDS) and BES review staff coordinate closely to determine which regulatory mechanism is the most appropriate for protection of the drainageway. In many cases, drainageways are protected by the placement of a land division tract to ensure protection from future development.

Stormwater Management Manual (SWMM) Requirements

BES also administers regulations to control post-development stormwater flows for both water quality and quantity issues. The SWMM regulates new flows generated by new impervious surfaces in developments, while the drainageway regulations control the ***existing*** conveyance system for flows that cross an applicant's property. The onsite drainageway is often the ultimate approved disposal point for onsite structural facilities required by the SWMM.

Environmental Zones (E-zones)

Chapter 33.430 of the City's zoning code regulates impacts to the identified natural resources within the City's jurisdiction. These natural resources have been identified as providing benefits to the public, including fish and wildlife habitat, stream stability, and stormwater flow control. Development proposed within an environmental overlay zone (E-zone) must be sensitive to the site's protected resources and specifically provide protection to surface vegetation and land features, in addition to stream protection.

There are two kinds of environmental overlay zone: the Environmental Conservation overlay zone and the Environmental Protection overlay zone. BES's current practice is to establish drainage reserves in the Environmental Conservation overlay zone as necessary because development is allowed within that zone. Establishing drainage reserves in the Environmental Protection overlay zone is not necessary because allowed development is limited.

BES and BDS coordinate review when drainageways are identified within an E-zone. When an environmental review is required, BES provides drainage reserve comments on the development proposal along with its other environmental review comments related to the development proposal.

Drainageway-related regulations are BES's responsibility and are required as a separate review in any of the following situations:

- The development proposal requires an environmental plan check and there is a drainageway on the site that is not identified on the map of streams and waterbodies.
- The development proposal requires an environmental plan check.
- The development proposal is exempt from E-zone regulations.
- The drainageway is outside of the E-zone.

Geotechnical Issues

Section 24.70 of the City's building regulations specifies City regulations regarding clearing, grading, and erosion control (as does Title 10). BDS reviews all development proposals to determine whether any clearing, grading, or geologic condition on private property is or may become a hazard to life and limb; endanger property; cause erosion; adversely affect drainage; or adversely affect the safety, use, or stability of a public right-of-way or drainage channel. BES and BDS coordinate review of any development or mitigation proposed within a drainage reserve.

Floodplain Regulations

If the drainageway is located in a floodway mapped by the Federal Emergency Management Area (FEMA), a specific drainage reserve is not required, since the floodplain regulations of Title 24 and Title 33 are sufficient to protect flow conveyance. Drainageways may also be classified as unidentified watercourse flood zones, even if they are not identified in a federal insurance study, and may be subject to further regulations as provided for in the flood hazard chapter (Section 24.50.050.I) of the City Code.

VI. Definitions

Pursuant to City Code Title 17.38 and these administrative rules, the following definitions apply to these administrative rules. They are not necessarily the same as dictionary or zoning code definitions:

A. *Channel*. For the purposes of these rules, a channel is the portion of the drainageway that demonstrates evidence of the passage of water. It is the depression between the banks worn by the regular and usual flow of the water. The channel need not contain water year-round.

B. *Drainage*. Drainage is a general term for waters generated at or conveyed through a particular site. Drainage is predominantly surface runoff generated from rainfall. Surface groundwater shall be considered drainage.

C. *Drainageway*. A drainageway is an open linear depression, whether constructed or natural, that functions for the collection and drainage of surface water across a property. It may be permanently or temporarily inundated, act as a headwater or tributary to a larger drainage system, and may be present as a distinct channel tributary. Natural seeps, springs, or wetlands where subsurface waters come to the surface are not considered drainageways unless they are part of a conveyance carrying waters across a property.

D. *Drainage Reserve.* A drainage reserve is a portion of property set aside to protect the functional flow values of the drainageway. This reserve is placed during the development review process and is legally reserved as a no-build area on the building permit or application. Previous rules and City Code called this a drainageway easement.

E. *Headwaters***.** Headwaters are the source of a stream or river (e.g., a spring). [Department of State Lands definition OAR 141-085-0010 (93)]. They are an area where groundwater surfaces and forms an open drainage channel.

F. *Outfall*. An outfall (as specified in the BES *Sewer Design Manual*) is a location where collected and concentrated water is discharged. An outfall can occur at the end of a pipe system, from a structural facility, or from an open drainage channel.

VII. Identifying Drainageways on Properties

BES review staff will evaluate mapped stream layers, site development plans, aerials, and other information to ascertain whether a drainageway may be present on a property that is in for development or building permit review. City review or inspection staff (usually from BES or BDS) will usually make a site visit to collect information on site conditions. BES staff will make a final determination of the existence of a drainageway area, based on both topographic and infrastructure indicators on and near the site and on any evidence of concentrated flow and/or ponding. Factors may be present in wet or dry seasons or both. The determination of an onsite drainageway does not depend on water being present, only on factors that demonstrate the presence of water during a previous wet season. In making a determination, staff will evaluate the factors listed below. Placement of a drainage reserve may be based on any combination of these factors; not all of the factors must be present.

A. Year-round Factors

1. Topography.
2. Infrastructure type, size, and location (e.g., culverts, right-of-way ditches, outfalls).
3. Soil type.
4. Erosion/incision.
5. Channel substrate.
6. Evidence of drift lines, waterborne sediment deposits, or sorting.
7. Soil saturation within 18 inches of the surface.
8. Characteristic vegetation
9. Visual topographic or vegetative connection to nearby wetlands, streams, seeps/springs, and sensitive natural areas identified by other regulatory agencies.
10. Maps, photographs, and historical records.
11. Identification of any municipally owned stormwater control structures or management facilities along the drainageway or at its outlet.

B. Additional Wet Season Factors

1. Visible flowing or ponding water.
2. Volume and velocity of existing drainage on, upstream of, and downstream of the site (including groundwater flows). The amount of upland development will be coarsely evaluated to help identify the quantity of presumed flow.

VIII. Placing and Protecting Drainage Reserves

BES will place a drainage reserve over any portion of a property with flow conveyance features that meet the drainageway definitions and are not already protected by environmental stream mapping or land division tracts (described earlier). If the environmental overlay zones or land division tracts are insufficiently sized to cover the presumed 30-foot-wide reserve width, drainage reserves may be placed on top of these other protection methods to ensure full protection of the full desired width for flow conveyance. The drainage reserve shall be considered a no-disturbance area for the purposes of the proposed site development. Proposed developments that wish to encroach into the designated reserve area must meet the standards and submittals of Section IX (Drainage Reserve Encroachment Standards and Review). In essence, the drainage reserve can be thought of as a buffer, protecting the flowing water from development. The standard buffer is 15 feet from the centerline of the flowing water on both sides of the flowing water. Like a setback, these generally are areas that should stay clear of structures, but can be approved for use by specific types of development.

A. Sizing

Drainage reserves shall be sized to ensure that the current flow rate and pattern of the drainage continues to be adequately conveyed through the site. Current flow volumes and/or drainageway capacities may be determined through reviewing a number of sources, including but not limited to:

1. Drainage basin hydrology and hydrologic records.
2. Delineation of the drainage catchment, including any impacts of adjacent open and piped drainage systems on the catchment of concern.
3. Modeling information, including volume and velocity, using a continuous simulation model to be approved by BES.
4. Historical data.
5. High-water marks.
6. Soil inundation records.
7. Photographs of past flooding limits.
8. Placement. Drainage reserves are typically 30 feet in width and placed on a site in one of the following manners:
   a. 15 feet from the centerline of the identified channel on both sides, or
   b. Within the boundary of designated environmental zones (if the zone is less than a total 30-foot zone), or
   c. For full coverage of the channel, plus 15 feet from top of bank, if the 30-foot width will not fully protect the channel width on larger drainageways.

BES staff retains the authority to modify or remove drainage reserves if the drainageway poses or may pose a landslide, flooding, or other public health and safety concern. In those instances, BES may allow drainageways to be moved, modified, or piped to protect public health and safety, in compliance with Title 24 and 33 regulations.

B. Long-term Protection

Drainage reserves shall be protected during the course of any proposed or future development to ensure the continuation of flow conveyance and other benefits. Drainage reserves shall be protected and maintained to meet the following standards:

1. The limits of the drainage reserve shall remain in natural topographic condition to the maximum extent practicable, as determined by BES.

2. No new vegetation proposed within the drainage reserve limits shall be on Portland's lists of nuisance plants or prohibited plants. Preference shall be given to native vegetation, especially for erosion control and water quality purposes.

C. Recording Notice of Conditions against the Property Deed

T o help ensure long-term protection of drainage reserve areas, BES will require the applicant to record notice of condition against the property deed. This notice of condition is to notify future property owners of the presence of a drainage reserve onsite and the requirements to maintain it as an open, functional flow conveyance feature. (See Appendix A.3-B for a sample notice of condition form.)

D. Protection during Site Development

Development proposals shall meet all of the following minimum standards to ensure drainageway protection.

1. All proposed disturbances on the site, including but not limited to structures, pipes, culverts, excavations, and fills, shall be located away from the existing drainageway and drainage reserve limits to the maximum extent practicable, as determined by BES review staff. Small facility outfalls are exempted. (See Section 3-B, below).
2. Temporary and permanent erosion control measures shall meet the requirements in the City's *Erosion Control Manual* (City Code Title 10.30.020). Additional erosion control measures (e.g., reinforced silt fence, bio-filter bags, or erosion blankets) may be required to ensure adequate protection of the drainageway during construction and during the establishment of vegetation within the drainage reserve.
3. During site construction, water shall be safely conveyed around or through the drainageway. The channel shall not be obstructed, with the exception of properly employed erosion control measures (such as bio-filter bags) when necessary. Seasonal limitations on development in or near the reserve may be placed if there are special site conditions such as those defined in Title 10.
4. No heavy machinery that produces ground compaction shall be allowed within the drainage reserve limits during construction. Low ground-pressure vehicles (such as spider hoes) may be allowed if the applicant can show adequate soil and vegetation protection.

E. Development Plan Submittal Requirements

To assess proper protection of drainage reserves during development review, the following information must be included for BES review:

1. Land Use Reviews (other than land division and environmental overlay related reviews). In addition to standard plan sets that show topography, general development layout, and large trees, BES will review for the following information, which should be located on a separate plan sheet or on an existing erosion control plan sheet:

   a. Location of drainageways, both natural and manmade. The limits of the identified drainageway shall be clearly delineated.

b. Location of proposed drainage reserve. The standard 30-foot reserve shall be used, or alternatively a smaller reserve proposal shall be made. (See Section 3 below for supporting documentation requirements.) Describe the tools to be used to demarcate the drainageway on the development property for staff review during onsite visits (flags, tape, fencing, etc). Provide construction plan notes to ensure proper installation, inspection, and maintenance of construction protection devices (orange construction fence, sediment fence, etc.) for issues such as sediment removal, inspection for undercutting, and bank sloughing.

c. Location and type of proposed encroachment or modification into the required drainage reserve area or into the drainageway itself.

2. Building Permit Reviews. ***In addition to the information above***, development-type permits must also include:

   a. A **site plan** of the entire property, including all items below, shall be submitted as part of the building permit or site development permit submittals. Submittals shall ensure that all of the following elements are included:

      i. Property lines and dimensions.

      ii. Location of the proposed development activity, disturbance area, and staging and/or stockpiling areas.

      iii. Location of existing trees 6 inches or greater dbh (diameter at breast height) and all proposed vegetation.

      iv. Location and dimensions of existing and proposed roads, driveways, utilities, parking areas, and building footprints.

      v. Existing and proposed topographic contour lines for site grading.

   b. An **erosion control plan** shall be submitted to identify how drainageways on the site will be protected during construction (including exclusionary fencing to prevent encroachment and protect drainageways from soil stockpiles, backfill, construction debris, construction equipment, etc.) and how disturbed soil will be permanently stabilized. For proposals that include construction activity within or adjacent to the limits of a drainage reserve, the erosion control fencing that protects the drainage reserve shall be reinforced. Refer to Section IX-B below for reserve encroachment review submittal requirements.

   c. A **development schedule** shall be submitted that notes any seasonal development limitations for drainageway protection.

   BES reviewers will evaluate the development submittals to determine if the proposed development adequately meets the standards for protection of drainageways identified above.

3. Requests for Smaller Reserves. An applicant may make a request for a smaller reserve area to BES. Any such request shall be sent to the appeals recipient described in Section XII of these rules and shall include an engineer's design report, as detailed in Section X: Channel Encroachment Standards and Review. BES will review and determine whether a smaller reserve sufficiently meets the drainage reserve goals

outlined in this section. Smaller drainage reserve areas shall be noted on all deed notice of conditions.

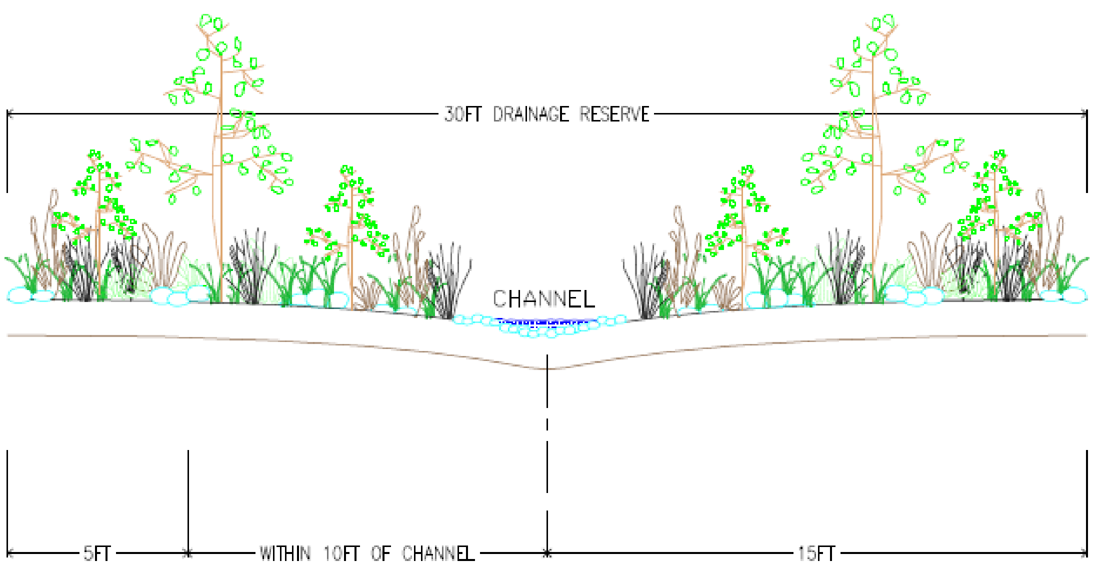
IX. Drainage Reserve Encroachment Standards and Review

Proposed encroachments into the drainage reserve will require additional review by City staff. Encroachments into a drainage reserve are evaluated based on the encroachment feature's proximity to an actual channel of the drainageway. In-channel structures can cause flow diversion, flow capacity, and bank stabilization issues. Encroachments into the reserve can cause floodplain impingements for high-flow conditions. The amount of encroachment can have negative impacts resulting from the cumulative loss of floodplain space. For ease of review, BES has separated encroachment into two types:

- Channel encroachment – within 10 feet of the channel centerline or for encroachments that remove more than 10 percent of the entire reserve area on the development-related side of the drainage channel.
- Reserve encroachment – usually within only the outside 5-foot edge of a reserve.

Exhibit A.3-1 shows this distinction. This section specifies the standards and submittal requirements for all reserve encroachments. Section X identifies additional standards and submittals required for channel encroachments. Appendix A.3-C summarizes development and submittal requirements for drainage reserve and channel encroachments.

Exhibit A.3-1: Cross-Section View of Drainage Reserve



A. Reserve Encroachment Standards. The proposal will be approved if the applicant has clearly demonstrated that ALL of the following standards can be met:

   1. The encroachment shall be minimized to the maximum extent possible.

2. The encroachment shall occur in the most environmentally sensitive manner, considering seasonality, slope, soil, geologic, and erosion control issues to limit disturbance impact to flow capacity and channel stability.
3. All mitigation for disturbances within the drainage reserve limits shall be located on the project site. Proposed mitigation shall equal or exceed any loss in conveyance volume, flow rate control, and vegetation density within the drainage reserve limits.
4. All structures, mitigation plantings, and drainageway improvements shall be maintained in accordance with the submitted O&M plan.
5. Proper temporary and permanent erosion control and exclusionary fencing measures, including but not limited to those found in the *Erosion Control Manual* (City Code Title 10.30.020), shall be employed to ensure adequate protection of the drainageway during construction and during the establishment of vegetation within the drainage reserve limits.
6. Flows shall be conveyed around the encroachment area during construction.

B. Reserve Encroachment Review Submittal Requirements. In addition to the general review submittals required in section VIII-B, the applicant shall provide information specific to encroachment, including but not limited to:

1. Type of encroachment/improvement structure.
2. Boundary of disturbance (both permanent and temporary) to the reserve caused by the encroachment. Type and size of any proposed encroachments. (Refer to Section IX-B for reserve encroachment review submittal requirements).
3. Estimate of flow impacts to the drainageway, including decreases in cross-sectional flow volume, flow path alteration, or any structure that could cause flow ponding.
4. Number or density and type of vegetation to be removed within the reserve boundaries.
5. A **mitigation plan** that clearly identifies existing and proposed conditions (included in the building plans). The mitigation plan shall include calculations and channel cross-sections to demonstrate where lost flow conveyance capacity will be restored within the project site. The plan shall include a revegetation plan that shows how proposed areas of disturbance within the drainage reserve limits will be protected from erosion by replanting with native plants that are similar types and sizes, or equivalent basal area, as those removed. Because plantings are used for long-term erosion control purposes, all plantings must be within the drainageway and drainage reserve area.
6. An **operations and maintenance plan** for the actual structure that is encroaching and for the mitigation plan elements, submitted in accordance with Section XII: Operations and Maintenance Requirements.

X. Channel Encroachment Standards and Review

The following additional requirements apply to encroachments within 10 feet of a drainage channel or for encroachments that remove more than 10 percent of the entire reserve area on the development-related side of the drainage channel. Modifications to channels shall be considered facilities and shall require ongoing maintenance by the property owner.

A. Channel Encroachment Exemptions. Single, small-gauge outfalls from stormwater management facilities, regardless of location, are allowed to encroach outright if they meet the standards that govern outfalls in the City's environmental zoning code (Chapter33.430). These standards address many environmental sensitivity issues and are being used as a guide for the approval of all small outfalls, both within and outside of environmental overlay zones, that reach a drainageway. Outfalls that meet these E-zone standards are exempt from channel encroachment review and submittal requirements. All other outfalls that do not meet these standards shall be processed by the review standards and submittals detailed below.

B. Channel Encroachment Standards. The proposal will be approved if the applicant has clearly demonstrated that ALL of the following standards can be met:
   1. The encroachment shall not worsen any existing drainageway conditions, such as channel erosion or water impoundment.
   2. Construction activities shall not occur during the wet-weather season (October 1 through April 30) or outside of designated work season windows for Oregon Department of Fish and Wildlife designated streams.
   3. The channel encroachment shall be mitigated by modifying the channel to retain its original capacity or by enhancing storage and conveyance volumes.
   4. Flows resulting from the encroaching facility shall leave the site in a location and manner that maximizes the watershed benefits of the drainageway. Flow rates and outlet locations may be altered to improve watershed function. Hydrologic modeling may be required, depending on site conditions and the extent of encroachment.
   5. Additional erosion control measures, independent of those required on the building permit, shall be used to ensure protection and functionality of the existing stormwater conveyance system during construction of the improved/modified drainageway.

C. Channel Encroachment Review Submittals Requirements. Modifications to existing drainageway channels shall be done under a BDS building permit, either for drainageway work specifically or combined with a property-wide building permit. The site drainageway protections and structures encroaching into a drainage reserve shall be inspected as part of overall site erosion control inspections. Reserve protections shall be in place by the time of the preconstruction erosion control inspections. Drainageway encroachments must meet all elements of area floodway and floodplain regulations, if applicable. The permit submittal shall include all of the submittals required in the reserve encroachment section, plus the following information:
   1. Engineering design report. This report, stamped by a licensed engineer, shall include technical evaluation of all site and drainageway concerns and all of the following information:
      a. A hydrologic modeling analysis of the upstream tributary drainage area and a downstream analysis shall be conducted. The analysis must extend downstream of the proposed project location to a point in the public drainage system where the proposed project site constitutes less than 15 percent of the total tributary drainage

area. This point shall not be less than 1,500 feet downstream of the site. The level of analysis required will depend on the problems identified within the basin by the deign engineer, in consultation with the City, and the size of the project being planned.

b. Cross-sectional data for the new and existing channel shall be incorporated into the hydrologic modeling analysis. The report shall include cross-sectional data at various points along the existing and proposed sections of open channel. These cross-sectional data shall be provided at:

   i. Locations several feet from the beginning and the end of the open channel.

   ii. Points of significant change in configuration (e.g., grade, size, or shape of channel). The following data shall be provided for each cross-section:

   - Width, depth, shape, and invert elevation.
   - Roughness coefficient/condition of the open channel (e.g., rocky, dense vegetation, large woody debris).

c. For proposed pipes, cross-sectional data shall include:

   i. Diameter, length, slope, and invert elevations at beginning and end of pipe.

   ii. Pipe material.

2. Construction management plan. This plan shall be submitted to show the limits of all disturbance areas for the entire site, including the area within the drainage reserve that will be disturbed during construction. It may be submitted as a separate sheet or combined with the erosion control plan, and shall describe:

   a. The nature of the disturbance, including construction access roads and areas where materials and equipment will be stored/stockpiled.

   b. Areas where equipment will be maneuvered, staging areas, and the limits of grading. The plan shall identify how undisturbed and tree protection areas will be protected.

   c. A schedule of activities. A narrative description of the type, sequence, and timing of all major construction activities shall be written on or attached to the construction management plan.

XI. Relationship to Public Drainage Improvements

Public improvements in drainageways are reviewed and administered through the City public works process, usually administered through a BES public works permit. Most of the guidelines for encroachment described above are implemented via BES public works permits, based on technical review by the BES Chief Engineer. It is the City's practice to avoid drainageway impacts where practicable. Appropriate road-crossing methodology shall be dictated by site-specific drainageway flow characteristics. All designs shall meet the evaluation criteria of the City Code Title 17.38 drainageway code and the following general standards:

A. The applicant has demonstrated that it is possible to construct street improvements within the right-of-way that will meet all of the following standards:
   1. The proposed street improvements shall not impede or restrict flows within the drainageway.
   2. The street improvements shall provide minimal impact to the slope, width, and depth of the stream channel, spring, or seep.
   3. The street improvements shall not impede fish passage in a drainageway that has been identified by the Oregon Department of Fish and Wildlife as fish bearing.
   4. Exposed soil shall be replanted with native seed mix and plants from the Portland Plant List, with preference give to native plants.

XII. Appeals

If the applicant does not agree with the BES staff determination of the location, size, or delineation of the existing drainageway or with the sizing of the drainage reserve, the applicant may appeal the BES determination. ***Appeals must be made through the BES administrative appeals process.*** Drainageway appeals are not allowed to be resolved through a building code appeals process. Drainage reserves that are either less than or greater than 30 feet may be placed over a drainageway, either at the discretion of BES staff based on evaluation of the criteria listed in Section VIII or at the request of the applicant through the appeals process. The applicant shall submit a written appeal and shall submit a land survey from a licensed land surveyor that includes, at minimum, the following information:

A. Property lines with dimensions.
B. Delineation and extent of the drainageway.
C. Distance from all points of intersection of the drainageway with the property lines, to the property corners.
D. Elevation of the drainageway at all points of intersection with property lines.
E. Modeling support information from Section X: Channel Encroachment Standards and Review.
F. A plan set showing the existing and proposed configurations.
G. A fee of $100.

Appeals will be reviewed by the Stormwater Early Assistance Team manager and routed to appropriate engineering staff for calculation and cross-section review. Reviews should take approximately 4 to 6 weeks. Appeals shall be sent to:

Stormwater Early Assistance Team Manager
City of Portland - Bureau of Environmental Services
1120 SW 5th Ave, RM 1000
Portland, OR 97204-1972

XIII. Inspections

In general, drainageways on private property will be inspected for protection and encroachment measures during the building permit process. All plan sets shall clearly demark the drainage reserve and appropriate protection measures (fencing, etc.). Any applicable maintenance measures, such as removal of collected sediment, shall also be noted on plan sets. BDS will verify that drainageway protections and encroachments shown on the site plan are in place. They will consult with BES staff on any concerns regarding adequacy of permitee efforts. Violations or failure to comply with drainage reserve protection requirements will be referred to BES staff for investigation and enforcement.

XIV. Operations and Maintenance Requirements

An Operations and Maintenance (O&M) plan is required if there is a permitted improvement or encroachment to the drainage reserve. For encroachments into the drainage reserve area, the O&M plan shall be kept on file with BES and attached to TRACS for public access. For encroachments into the active channel area, O&M plans shall be recorded with an O&M Form (Form 3) in the county of the subject property. See SWMM Appendix D for O&M Form instructions. The applicant may elect to use the O&M plan in A.3-D or may create a different one, which must be approved by BES. The drainage reserve and any mitigation must remain in their permitted condition.

A. Minimum Maintenance. The following minimum maintenance activities shall occur on all structures, channel enhancements, and mitigation sites approved for encroachment.
   1. Mitigation plants that die shall be replaced with the same species, same size, and in the same location. BES must approve proposals to relocate or substitute plants.
   2. Any structure that impedes flow (e.g., a fallen tree, illegally dumped garbage, sediment deposition) shall be removed, and the channel shall be restored to the natural or approved designed cross-section. Fallen trees, landslides, or other debris that blocks part of the channel conveyance shall be removed as quickly as practical. All repairs shall be made using handheld equipment, unless otherwise preapproved by BES staff.
      a. Structures or debris shall be removed within 30 days of their discovery.
      b. Any disturbance that has occurred to the drainageway or reserve shall be replanted or reinforced. If erosion occurs, the eroded area shall be reinforced with rocks, plantings, etc.
      c. Replanting/reinforcing shall occur within 15 days after the impediment is removed during the dry months or within 7 days during the wet months.

B. Log Sheets. The following information, at a minimum, shall be recorded on a log sheet on an annual basis for 5 years after mitigation is completed:
   1. Condition of mitigation plants and any replacement that has occurred.
   2. Soil erosion within the drainage reserve.
   3. Channel erosion or sedimentation.
   4. Condition and functionality of any flow control structures, such as culverts.

XV. Enforcement

Any unauthorized encroachment or other harm made within the drainage reserve or failure to obey the site-specific drainage reserve O&M plan shall be considered a violation of Title 17.38 and these rules. BES staff in the Spill Protection/Citizen Response (SP/CR) section shall respond to, investigate, and resolve all drainage reserve violation cases and shall respond to any complaints or referrals in a timely manner.

A. Staff may use education and technical assistance to remediate any discovered violations, especially with parties who are unlikely to have knowledge of regulatory requirements or knowledge of the reserve placement on their property. Timely remediation of any site issues such as vegetation removal that exposes bare ground, drainageway diversions, or blockages of the drainageway shall be priorities. Staff may work with property owners to establish an agreeable schedule for the remedy, but BES reserves the right to remediate any violations posing an imminent threat to public safety or water quality.

B. Enforcement to gain compliance with the standards of these rules and City Code shall generally follow the escalating steps of enforcement called out in the stormwater administrative rules (under separate cover). Measures such as stop work orders (especially for violations resulting from construction activities), administrative reviews, formal voluntary compliance agreements, financial penalties and/or criminal charges are available enforcement tools. Appeal to the City Code hearings officer is available, pursuant to City Code Section 22.10.

Appendix A.3-A: Previous Drainage Reserve Administrative Rules Adopted in December 2002*

V. Protection of Drainageway Areas

III.B.1. c Easements/ Drainage Reserves. *Are there easements or drainage reserves already present that would influence site design? Other than pipe easement described in (4) above, applications may be required to obtain a drainageway reserve*. (From *Sewer Design Manual* and Technical Review Standards above)

(1) Definition. Drainageway is an open linear depression, whether constructed or natural, which functions for the collection and drainage of surface water. It may be permanently or temporarily inundated.

(2) Drainageway Reserves. A drainageway reserve shall be placed to assure adequate and environmentally beneficial conveyance of stormwater across a developing site. Because of the unpredictable nature of storm events and great variation in potential flows, the sizing of drainageway reserves does not guarantee prevention of damages in all situations. Requirements imposed by the Bureau of Environmental Services are designed to address typical flows and do not relieve property owners of their responsibility to manage stormwater in a manner that complies with the duties of property owners under applicable law. Reserves shall be placed on a proposed development site in one of the following manners:

- **(a)** 15 feet from the centerline of the channel; or
- **(b)** 15 feet from the delineated edge of a designated water feature (i.e. seep, spring, wetland); or
- **(c)** Within the boundary of a designated environmental zone; or
- **(d)** Over a designated seep, spring and stream tract.

Exemptions: Drainage reserves shall not be required for drainageways located within a FEMA designated and mapped area.

(3) Sizing of Drainageway Reserves. Drainage reserves shall be sized to assure that the current flow rate and pattern of the drainageway continues to be adequately conveyed through the development site. Current flow volumes and/or drainageway capacities will be determined by:

- **(a)** Reviewing existing data, which may include available hydrologic records, drainage basin hydrology, historical data, high water marks, soil inundation records, photographs of past flooding, and other similar information.

(4) Improvements within Drainageway Reserves. Improvements within the drainageway reserve shall only be approved when all of the following conditions exist:

- **(a)** Where the modification will not impede or reduce flows within the drainageway; and
- **(b)** Where the improvement will enhance the surface flow capacity and habitat values of the drainageway; and
- **(c)** Where the improvement shall provide additional safety to public or privately held properties or facilities; and

* Adopted as part of the Title 17 Land Division Related Administrative Rules package

(d) Where the improvement is constructed with minimal hard surface armoring of the drainageway.

(5) Improvement Development Standards: All improvements shall meet one of the following development standards:

(a) All improvements shall comply with City codes and standards that apply to the improvement being proposed (i.e. erosion control manual, street design standards, and *Sewer Design Manual*); or

(b) Other design guidelines may be used, but only if approved by the BES Chief Engineer.

Appendix A.3-B: Notice of Condition Form for Recording Against Property Deed

After Recording Return Copy to:

LAND USE REVIEW DIVISION
BUREAU OF DEVELOPMENT SERVICES
1900 SW Fourth Avenue, Suite 4500
Portland, OR 97201

This Space Reserved For Recorder's Use:

PORTLAND BUREAU OF ENVIRONMENTAL SERVICES (BES)
1900 SW Fourth Avenue, Suite 5000
Portland, OR 97201

Notice of Condition of Development Permit Approval Conditions

________________________ is the declarant of lot or parcel with Legal Description # ______________ located at Site Address ______________________Multnomah County Records. Approval of the development permit for this parcel is based on the Portland City Code Title 17.38. Section 17.38.021 requires that drainage flows from above to below this property be conveyed in an open drainageway, which can appear as a channel or depression that conveys flows across a site. To assure continued operation and maintenance of this drainageway in an open, naturalized condition, the City's Bureau of Environmental Services (BES) has placed a drainage reserve on this property. The reserve is a 30 foot buffer, centered on the centerline of a drainageway, with 15 feet of reserve area on each side of the centerline. This buffer overlay where development encroachment, flow path alteration, or vegetation disturbance is prohibited without BES review and approval. Parcel or Lot owners and future parcel/lot owners should verify the constraints on their lots in the applicable land use and building permit decisions and conditions of approval, and with BES land use review staff.

Name and title of declaring

By:____________________________

The forgoing instrument was acknowledged before me on this ______ day of ________,_______ by declarant, the developer of the lot or parcel with R number __________________________.

Appendix A.3-C: Summary of Development and Submittal Requirements for Drainage Reserve and Channel Encroachments

Requirement	Location		
	In Drainage Reserve: • At least 10 feet away from channel AND • Less than (<)10% total of the reserve area on the development side of the channel	In Drainage Reserve: • Within 10 feet of the channel OR • More than (>)10% total of the reserve area on the development side of the channel	In Drainageway Channel
Site Plan	Required	Required	Required
Erosion Control Plan	Required	Required	Required
Mitigation Plan	Required	Required	Required
Construction Management Plan		Required	Required
Work Period	Any	Dry Weather Only	Dry Weather Only
Engineering Design Report			Required
Hydrologic Modeling		May be Required	Required
Cross-Sectional Data			Required
O&M Plan	Office Copy	Office Copy	Recorded with County
Notice of Condition Against Deed	Recorded with County	Recorded with County	Recorded with County

Private drainage channels, which have been modified through a City permit process, must be inspected and maintained in order to ensure proper function and prevent property damage. All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability, at a minimum, quarterly for the first 2 years from the date of installation, 2 times per year thereafter, and within 48 hours after each major storm event (defined as ½" in 24 hours). The facility owner must keep a log, recording all inspection dates, observations, and maintenance activities. This log must be available to City inspector upon request. The following items shall be inspected and maintained as stated:
Inlet **(culvert/outfall) shall maintain an unimpeded and controlled flow of water entering the drainageway**. • Source of erosion shall be identified and controlled when native soil is exposed or erosion channels are forming. • Sediment accumulation shall be hand-removed with minimum damage to vegetation using proper erosion control measures. Sediment shall be removed if it is more than 4" thick or so thick as to damage or kill vegetation. • Inlet shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected. • Rock splash pads shall be replenished to prevent erosion.
Banks/Side Slopes **shall be maintained to prevent erosion that introduces sediment into the drainageway.** • Slopes shall be stabilized and planted using appropriate erosion control measures when native soil is exposed or erosion channels are forming.
Drainageway Outlet **shall maintain sheet flow of water exiting drainageway unless a collection drain is used. Source of erosion damage shall be identified and controlled when native soil is exposed or erosion channels are forming.** • Outlets such as drains and overland flow paths shall be cleared when 50% of the conveyance capacity is plugged. • Sources of sediment and debris shall be identified and corrected.
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Mulch shall be replenished as needed to ensure survival of vegetation. • Vegetation, large shrubs or trees that impedes flow within the drainageway channel shall be pruned. • Fallen leaves and debris from deciduous plant foliage shall be removed. • Nuisance and prohibited vegetation from the Portland Plant List (such as Himalayan blackberries and English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced. • Dead vegetation and woody material shall be removed to maintain less than 10% of area coverage or when drainageway flow is impeded. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining modified drainage channels shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all property owners and tenants.
Access to the drainageway shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. • Obstacles preventing maintenance personnel and/or equipment access to the drainageway shall be removed. • Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
If used at this site, the following will be applicable:
Check Dams shall control and distribute flow. • Causes for altered water flow shall be identified, and obstructions cleared upon discovery. • Causes for channelization shall be identified and repaired.

Appendix A.4 Design Guidance for Culverts and Outfalls[1]

Open Bottom Culverts and Outfalls

The inclusion of the detailed information regarding the design and construction of stormwater outfalls in the SWMM, is a focused effort by the City of Portland to provide options for stormwater management that are functional and minimize impacts to watersheds. The guidance documents are intended to provide guidance to designing stormwater outfalls and culverts. The guidance documents are also intended to provide flexibility to the engineer for designing a system, and to the reviewer examining the designed system. Staff recognizes the uniqueness of each site and potential stormwater management system.

Natural, open channel systems are formed and maintained by key watershed processes including flood flows, base flows, the erosion, transport and accumulation of sediments and woody debris, and the interaction of surface water and groundwater. When these processes are in equilibrium, they support a broad range of biological and ecological functions, including: fish spawning, rearing and migration; wildlife passage; habitat connectivity; and other ecological attributes that contribute to high biological productivity. In addition to ecological benefits, natural, open channel streams provide additional beneficial functions such as flood attenuation and water quality treatment.

Open Bottom / Natural-Bed Box Culverts Description

Culverts and bridges at road crossings and other constructed obstructions along these channels can disrupt watershed processes by altering or interrupting the transport of woody debris and sediments, and changing groundwater/surface water interactions. Poorly designed or failing road crossings can also block fish passage, preventing fish from migrating to spawning and rearing habitats. Over time, this can result in degradation of the biological productivity of the stream system and a net reduction in the ecological benefits it produces. Culverts can also restrict or block wildlife passage. In worst case situations, poorly designed culverts and bridges can induce major channel and bank erosion that threatens to undermine the roadway, and/or impede flood flow conveyance that in turn causes flooding of the roadway.

[1] The information included in this section is from a guidance document compiled by Herrera Environmental Consultants for the City of Portland *Concept Designs and Technical Guidance –Stormwater Outfalls* (April 2007) has been edited by City staff to eliminate duplicative information that is already contained in the SWMM, the SDFDM, and other references.

Ideally, road crossings over open channels should be designed to minimize the negative effects on watershed processes and ecological functions while adequately conveying flood flows downstream. To the extent possible, culverts beneath roadways should be designed to provide the following functions of a natural, open channel stream:

- Stream bed material transport,
- Woody debris transport,
- Natural flood attenuation,
- Biological productivity,
- Water quality benefits,
- Fish migration.
- Wildlife passage (other than fish),
- Surface water/ground water hydraulic connectivity.

These functions can be largely maintained by simulating a natural channel bed through the bottom of a culvert. Stream simulation methodology (ODFW 2004, WDFW 2003) can be used to design an open-bottom or natural-bed box culvert. An open-bottom culvert typically consists of a pipe arch or bottomless concrete structure (typically called a three-sided box) supported on footings, spanning a streambed for the entire length of the roadway crossing. Alternatively, a box-shaped culvert structure can be placed in a deeper excavation and partially filled with substrate materials to simulate a natural streambed. Typical culvert configurations are shown in **Exhibit SW-530**. If properly designed, these types of culverts can mimic the substrate and flow conditions in the natural channel upstream and downstream of the culvert, thereby reducing the impacts of the road crossing structure on natural channel functions. While these culverts typically cannot reproduce all conditions of a natural streambed (e.g., floodplains, undercut banks, etc.) it can vastly reduce the impacts relative to traditional round, small diameter culvert installations.

Applicability

The selection factors for open-bottom and natural-bed box culverts are listed in **Exhibit A.4-1**. As indicated in in **Exhibit A.4-1**, open-bottom and natural-bed box culverts are recommended for a variety of scenarios.

When native migratory fish are currently present or were historically present in the system, the culvert must provide fish passage pursuant to Oregon Department of Fish and Wildlife (ODFW) requirements. Current state law and ODFW fish passage criteria require consideration of fish passage requirements prior to installation or replacement of culverts in waters where native migratory fish are currently or were historically present.

In most cases, fish passage should be accommodated with the culvert design. The process for satisfying fish passage requirements includes native migratory fish determination, defining the fish passage criteria, and obtaining plan approval from all of the required federal, state, and local agencies.

Wildlife passage is also an important consideration for culvert design. Culvert width can be increased to contain an artificial ledge inside the culvert on one or both sides to enable connectivity for terrestrial species.

For specific guidance on additional measures that can be incorporated into culvert or bridge design to maximize wildlife passage, the wildlife crossings toolkit has various resources: www.wildlifecrossings.info/beta2.htm. For project-specific information, contact Oregon Department of Fish and Wildlife: www.dfw.state.or.us.

Bridges

Many of the concerns related to culverts at road crossings can be alleviated by constructing a bridge rather than a culvert. Bridges are the most appropriate choice to maintain the integrity of many of Portland's urban stream systems, particularly those systems with wide active channels (greater than 20 feet).

Bridges do not have the dimensional limitations of culverts and can be large enough that the structure does not significantly affect the flood hydraulic profile. A bridge, rather than a culvert crossing, should be considered when:

- The active channel width is greater than 20 feet.
- The channel gradient is greater than 6 percent.
- Movement of large woody debris occurs frequently.
- There is a high risk associated with flooding.
- The channel is actively meandering.
- There are large animals such as coyote or deer present and there is limited local wildlife passage.
- It is difficult to achieve hydraulic objectives (i.e., flood flow capacity, stream power continuity, subcritical flow regime, debris flows, and fish passage depth and velocity criteria, if applicable).

Exhibit A.4-1: Selection considerations for open bottom and box culverts

Selection Factors	Open Bottom or Box Culvert		Consider Bridge	Additional or Alternate Measures	Natural Stream Function of Culvert
	Required by ODFW	Recommended			
Fish Passage					
Native migratory fish currently or historically present (Unless waiver or exemption obtained from ODFW)	X				Provide fish passage and habitat
Wildlife Passage (non migratory fish)					
Resident fish, amphibians, small animals present		X			Provide wildlife passage and habitat
Large animals (coyote, deer) present with limited upland passage			X		
Downstream Fish Presence					
Tributary to fish-bearing stream		X			Maintain biological productivity (invertebrate habitat) and water quality functions
Woody Debris Transport					
Woody debris in channel, high potential for recruitment (well vegetated riparian corridor)		X	X	Consider upstream trapping with engineered log jam or collection and relocation of large wood to prevent blockage	Provide woody debris transport, lowering likelihood of culvert blockage
Hydrologic Conditions					
High variability in flow, "flashy" flow regime (typical for highly developed, urban, snowmelt and rain on snow systems)		X		Sufficient embedded depth to allow for vertical fluctuations in bed elevation	Enable sediment transport through culvert during episodes of bed scour and deposition (typical of flashy systems)
Flooding Concerns					
Flooding could endanger human health and safety, result in extensive property damage, or impact the environment significantly		X	X		Reduce likelihood of inlet blockage with debris or aggraded sediment that could result in capacity reduction and flooding. Channel provides natural flood control.
Channel Gradient					
Gradient greater than 6% and vulnerable to debris flow (headwaters include channels >20%)		X	X		Provide some capacity for debris flow
Up- and down-stream gradients differ or culvert bed slope differs from channel gradient		X	X	Sufficient embedded depth to allow for vertical fluctuations in bed elevation/consider grade control structures	Allow for some vertical fluctuations in bed elevation due to grade change
Channel Width					
Channel width greater than 20 feet			X		

Selection Factors	Open Bottom or Box Culvert: Required by ODFW	Open Bottom or Box Culvert: Recommended	Consider Bridge	Additional or Alternate Measures	Natural Stream Function of Culvert
Channel Stability					
Vertically aggrading or incising-evidence of historical fluctuations in channel bed elevation (e.g., headcuts, near-vertical channel banks, channel avulsion, gravel-splay deposits in floodplain)		X		Grade control structures recommended	Provides sediment transport / Allows for some vertical fluctuations in bed elevation
Actively meandering		X	X	Large wing walls or upstream bank stabilization	Provides sediment transport / Allows for more horizontal fluctuations in channel alignment than traditional round culverts
Confined channel-if confined due to historical incision		X		Grade control structures recommended	Provides sediment transport / Allows for some vertical fluctuations in bed elevation
High sediment flux		X		Sufficient embedded depth to allow for vertical fluctuations in bed elevation	Provides sediment transport / Allows for some vertical fluctuations in bed elevation
Maintenance					
Maintenance required		X		Consider grates in road bed to provide access for sediment removal	Larger culvert easier to access to remove debris and accumulated sediment

Summary of Analysis and Design Methods

This section provides a brief description of hydrologic analysis and design methodologies for open-bottom and natural-bed box culverts. Detailed design requirements and procedures are not included here, but can be found in reference documents listed below and cited in this section.

- Hydrologic analysis requirements for culverts in the City of Portland public drainage system are provided in chapter six of the Portland Sewer and Drainage Facilities Design Manual (BES 2006).

- Culvert design requirements and procedures are detailed in Chapter 8, Appendix A and Appendix J of the Portland Sewer and Drainage Facilities Design Manual (BES 2006).

- Culvert design guidance for fish passage is provided in the Oregon Department of Fish and Wildlife Fish Passage Criteria (ODFW 2004) and related statutes, the Oregon Road/Stream Crossing Restoration Guide (ODFW 1999), and the Washington Department of Fish and Wildlife Design of Road Culverts for Fish Passage (WDFW 2003).

- Permits from the US Army Corps of Engineers and the Oregon Division of State Lands may be required.

Design Storm

Typically, culverts must be designed to convey the 25-year storm flow (SDFDM Appendix J page 13 says 100 year) through a roadway fill without surcharging the inlet (i.e., water depth shall not exceed the inside height of the culvert crown). If the risk associated with culvert failure is high, a more conservative standard may be required. In addition, if the culvert is not oversized to convey the 100-year peak flow, a route must be established to safely convey any flow exceeding the 25-year storm without damage to property, endangering human life or public health, or causing significant environmental impact.

Hydrologic Analysis

The peak flow values used for culvert design should be estimated using single-event hydrologic methods. The Rational Method is recommended for culverts conveying runoff from a drainage basin less than 50 acres in size. Modeling peak flows based using the HEC-HMS (U.S. Army Corps of Engineers Hydrologic Engineering Center - Hydrologic Modeling System) or EPA SWMM (U.S. Environmental Protection Agency Stormwater Management Model) program, or a comparable alternative, is recommended for culverts conveying runoff from a drainage basin equal to or greater than 50 acres in size. The selected hydrologic analysis method for culverts conveying flow from these larger drainage areas requires approval from the City of Portland. Drainage area characteristics (e.g., area, land use, ground surface cover characteristics, time of concentration, runoff coefficients, runoff curve numbers, and infiltration rates) must be estimated to represent the future build-out condition as defined in the Comprehensive Plan.

Rainfall depths and an Intensity-Duration-Frequency Curve have been developed for the City of Portland. These are provided in the Portland Sewer and Drainage Facilities Design Manual.

Design Procedures

The culvert shape, dimensions, slope and bed roughness must be designed to provide flood conveyance capacity. To maintain natural stream function, it is also recommended that stream power (described below) is preserved through the culvert and that a subcritical flow regime (described below) is maintained. These three goals (conveyance capacity, stream power continuity, and subcritical flow regime) can be achieved by performing iterations using the following equations. The conditions during a 100-year event should also be evaluated.

Conveyance Capacity for Design Storm

The culvert shape, dimensions, slope and bed roughness should be designed to convey the peak design flow at build-out land use conditions in the upstream drainage area. Manning's Equation can be used to evaluate open channel flow (when the pipe is not surcharged) through the culvert barrel. Using English measurement units, the equation is as follows:

$$Q=1.49/n\ (A*R^{2/3}*S^{1/2})$$

Where, Q = flow rate (cubic feet per second)
    n = roughness coefficient (dimensionless)
    A = flow cross section area (square feet)
    R = hydraulic radius = flow cross section area / wetted perimeter (feet)
    S = friction slope (feet/foot)
    note: for uniform flow, S equals the slope of the channel bed.

Chapter 8 of the Portland Sewer and Drainage Facilities Design Manual (BES 2006) provides a discussion about the application of this equation for calculating capacity and velocity for pipes and channels.

For calculations using Manning's Equation, a Manning's roughness value ("n") of 0.013 must be used for the culvert regardless of culvert material type. BES has selected this constant value, while recognizing that it can vary as a function of pipe material, flow depth and pipe size. Approval must be obtained to use an alternative roughness factor. A typical roughness value for streambed gravel is 0.03.

When assuming open-channel flow, it is important to confirm that the tailwater (water surface elevation at the downstream end of the culvert) is not significantly greater than the culvert invert due to downstream controls. If tailwater conditions prevail at the downstream end of the culvert, the analysis must address "outlet control." Methods of analysis for culverts flowing under outlet control can be found in the Federal Highway Administration publication entitled Hydraulic Design of Highway Culverts (FHWA 2001a) as well as in many other hydraulic engineering publications.

Sediment Transport Capacity

Sediment transport capacity is directly related to stream power (Simons and Sentürk 1992). Stream power is not a quantitative measure unto itself (i.e., there is not an optimal range of stream power values that can be applied between watersheds).

Rather, it can be used as a relative measure of sediment transport capacity between adjacent stream and culvert reaches. Thus, the power of adjacent reaches can be compared to identify areas which may exhibit sediment aggradation in the channel (a reach with a low stream power value relative to the adjacent upstream reach) or channel bed degradation (a reach with a high stream power relative to the adjacent upstream reach). Stream power (Ω) can be calculated according to Simons and Sentürk (1992) as follows:

$$\Omega = v^*\tau_o = v^*\gamma^*R^*S_b$$

Where, v = velocity (feet per second)

τ_o = shear stress (shear force per unit wetted area, in pounds per square foot)

γ = specific weight of water (62.4 pounds per cubic foot at a water temperature of 50^{o}F)

R = hydraulic radius = flow cross section area / wetted perimeter (feet)

S_b = channel bed slope (feet/foot).

The stream power for the upstream reach, within the culvert barrel, and for the downstream reach can be compared at low and high flows (e.g., 2- and 25-year events) to assess the ability of the culvert to move sediment through the system.

Flow Regime

It should be confirmed that a subcritical flow regime is maintained through the culvert (i.e., the Froude number (F) is less than unity).

$$F=v/(g^*y_h)^{1/2}$$

Where, v = velocity (feet per second)

g = acceleration due to gravity (32.2 ft/s^2)

y_h = hydraulic depth.

Fish Passage Criteria

When fish passage is required, additional criteria, such as maximum velocity and minimum depths during fish passage flows must be met. Fish passage criteria vary as a function of fish species, age, and the time of migration among other factors. These requirements are detailed in Oregon Department of Fish and Wildlife guidance.

Surcharged Flow

Headwater depth under higher flow conditions (100-year peak flow) should be evaluated. Nomographs for culvert conveyance under inlet and outlet control conditions are provided in the Washington State Department of Transportation Highway Runoff Manual (WSDOT 2006).

Culvert Design Considerations

Considerations for the design of open-bottom and natural-bed box culverts are discussed below. For detailed design discussions refer to Oregon and Washington Department of Fish and Wildlife guidance documents (ODFW 1999, 2004; WDFW 2003).

In general, stream simulation culverts are designed to mimic the substrate and flow conditions in the natural streambed above and below the culvert. To accomplish this, the culvert alignment, culvert bed grade, and channel bed material should generally be as similar as possible to the adjacent natural streambed.

Horizontal Alignment

Culvert alignment should be established to make the culvert as short as possible while minimizing the skew of the culvert relative to the existing stream channel alignment. Skew between the upstream channel orientation and the culvert inlet increases inlet contraction resulting in turbulence at high flows and a reduction of flood conveyance capacity and sediment transport. In-channel deposition and bank scour often occur upstream of culverts with excess skew. When the culvert is skewed relative to the downstream channel alignment, there is an increased risk of bank erosion near the culvert outlet. When conditions make the ideal alignment impractical, the designer should consider relocation of a portion of the channel or small angle bends with bank stabilization.

Culvert Length

The culvert length should be minimized to reduce channel disturbance. This consideration should be balanced with the need to minimize the skew of the culvert alignment relative to the stream channel as described above.

The maximum culvert length that can provide conveyance capacity, stream power continuity, subcritical flow regime, and fish passage (if required) for any given channel are is dependent on stream hydrology and geomorphology (e.g., slope, sediment transport conditions). Culvert length can be minimized by adding headwalls to each end of the culvert, by narrowing the road or by steepening the fill embankments.

Culvert Size

The culvert span, rise and slope will be determined iteratively to meet capacity, stream power and Froude number requirements. Additional considerations regarding culvert span and rise are provided below.

The culvert span should be no less than the active channel width. According to ODFW (2004), the width of the active stream channel is the stream width that occurs annually at ordinary high water. This width can be determined by measuring the stream's cross-sectional distance between the ordinary high water line (OHWL) on both banks of the stream.

To more closely simulate stream functions, it has been suggested that the minimum culvert bed width be calculated as 1.2 times the active stream channel plus two feet (WDFW 2003).

Usually a span of at least 6 feet is necessary to enable channel bed construction within a culvert. For construction and maintenance of the culvert, a minimum effective rise (from the culvert bed to the height of the culvert crown) of 4 feet is recommended.

Culvert Bed Slope

Culvert bed slope should be set as close as possible to the natural channel gradient extending upstream and downstream of the culvert. For new installations, this is the slope of the existing channel. For replacement culverts this is the slope of the channel upstream and downstream of the roadway crossing (beyond the extents of any channel scour or bed aggradation created by the culvert that is being replaced).

Installing the culvert bed at a slope significantly lower (flatter) than the natural gradient may result in a reduction of stream power and resultant sediment aggradation that reduces conveyance capacity and hinders other natural functions. Installing the culvert bed at a slope significantly higher (steeper) than the natural gradient may induce instability of the culvert bed material during higher flows. It has been suggested that the ratio of the culvert bed slope to the natural channel slope should not exceed 1.25 (WDFW 2003).

It is recommended that the culvert design process include a comparison of stream power in the culvert barrel to the up-and downstream reaches of the stream to confirm continuity in sediment transport capacity.

The culvert pipe/structure itself may be installed flat or on a slope, depending upon the culvert length and bed slope. For box culverts, the slope of the culvert should be minimized to decrease shear stress between the culvert bottom and the bed material. The depth of channel bed material can vary through the length of a bottomless/open-bottom culvert that is laid flat to create the desired bed slope through the culvert. This typically requires a taller culvert pipe/structure so that the hydraulic opening on the upstream side meets the design criteria. Longer culverts will require some slope in order to maintain embedded depths and inlet capacity.

Culvert Bed Material

For Stream Simulation culverts, ODFW recommends the following mix of fill/bed material to provide the best streambed function:

- 30 percent fines (dirt or silt; this allows the new bed to "seal" and water to remain in the channel rather than flow sub-surface).
- 30 percent small rock (½ to 6 inch diameter).
- 30 percent large rock (6 inch - D_{100} diameter).
- 10 percent "shadow" rock (D_{150} to D_{200}; these simulate undercut banks, large wood, and boulders and should remain in place during flood events).

D_{100} rock is the size (diameter) of the largest rock found naturally in the stream. D_{150} to D_{200} rock is 50 to 100 percent larger than the largest rock found naturally in the stream. Shadow rock should protrude 30 to 50 percent above the final streambed elevation. During construction, the small rock, large rock, and fines should be mixed before placing. The final bed surface should be washed gently with water to allow the fines to work into interstitial spaces and provide a good seal, and to demonstrate that this seal has occurred.

Another approach is to select the bed material size based on the adjacent natural stream channel (WDFW 2003). In the "reference reach approach" the maximum particle size and appropriate distribution can be determined by examining reaches directly upstream from the culvert. If the culvert is designed to maintain stream power and subcritical flow, this material will move as the bed material in the adjacent channel, (so it will be replenished if it degrades). If the sediment transport capacity in the culvert will be higher, the size of the native channel substrate materials should be increased by a factor of safety to ensure bed stability.

Embedded Depth

The minimum embedded depth (depth of the bed material in the bottom of the culvert) is 12 inches, or 20 percent of the culvert rise, whichever is greater. The bottom of a box culvert or round arch culvert must be buried at sufficient depth in the channel bed to prevent exposure by scour. Scour calculations are therefore an important component of the design analysis, particularly if the culvert will constrict the flow of the upstream channel cross-section. Methods of scour analysis applicable to culvert installations can be found in FHWA (2006, 2001b, 2001c).

Baseflow Channel

The recommended cross-sectional dimensions for the baseflow channel (1 foot wide x 6 inches deep) are based on confining the summer baseflow. The baseflow channel helps to maintain stream power on the bottom leg of the hydrograph, hence transporting the fine-grained materials through the culvert. In addition, the baseflow channel confines low flows and helps to maintain sufficient depths for fish passage during low flow periods.

Woody Debris Transport

Culverts can be designed to provide some transport of woody debris. The size of material to pass through a culvert can be selected based on woody material present in the system (considering root-wad diameter for larger pieces) and culvert size constraints. The water depth required to pass (i.e., float the material) can be calculated. The culvert rise can be designed so that sufficient water depth and freeboard occurs during a storm in which the material would be mobile.

If it is not feasible to design for wood passage, and frequent accumulations of wood can reasonably be expected in the channel system upstream, the culvert may be vulnerable to blockage with wood mobilized in higher flow events. In these situations, consideration should be given to installing wood trapping measures in the upstream channel. For example, one or more engineered logjams could be installed in the channel upstream of the culvert to trap wood at a targeted location. If the culvert is not sized to effectively convey woody debris, long-term maintenance may be required to periodically remove collected debris in the channel upstream of the culvert and place it downstream of the culvert.

When frequent transport of large woody debris must be provided, a bridge should be considered. While there is no easy way to quantitatively evaluate the frequency of wood transport, considerations should be made for the downstream transport of woody debris when woody debris accumulations are observed in the channel, there is history of culvert plugging in the system, and/or there is a potential for recruitment of wood from a well-vegetated riparian corridor.

Inlet/Outlet Treatment

If the culvert width is less than the upstream or downstream channel width or the skew of the culvert inlet or outlet relative to the stream alignment is significant (not recommended, but sometimes may be necessary), structural protection of the inlet and/or outlet will be necessary. Depending on the size of the channel and the peak flow rates that the culvert will convey, this protection can range from concrete wingwalls to rock armoring or woody debris embedded in a tapered section of the channel bank approaching the upstream culvert entrance.
If the channel is actively meandering, large wing walls and/or upstream bank stabilization is strongly recommended.

Grade Control

If the stream channel bed is aggrading (rising) or degrading (incising), grade control structures are recommended. Such instability is indicated by evidence of historical fluctuations in channel bed elevation (e.g., headcuts, channel avulsion, gravel-splay deposits in floodplain). If instability is observed downstream of the road crossing, grade control should be installed below the culvert to prevent the upstream migration of headcuts that could undermine the structure and damage the roadway. If instability is observed upstream of the road crossing, grade control can help to stabilize the reach. Grade control structures can also be used to re-grade an adjacent channel to a steeper gradient.

If fish passage requirements are applicable, the grade control structures must meet ODFW elevation drop criteria.

Materials

There are several options for open-bottom and natural-bed box culvert material. Selection of the optimal material for a particular site is typically based on cost, considerations for onsite assembly as relates to desired construction duration, and site accessibility for material delivery. Material options for most applications include the following:

- Pre-cast concrete,
- Cast-in-place concrete,

- Metal arch pipe.

Cast-in-place concrete is the most expensive of these options, and results in the most construction impacts. However, it allows for a structure that conforms to the exact project and site constraints. Metal arch pipe is least expensive and due to its lighter weight, typically less complex construction than concrete. However, in certain soil and moisture conditions, metal pipe can be subject to corrosion, limiting its design life. For a detailed discussion of corrosion, including soil pH and resistivity values that may warrant protective coatings, see Section 5.7 of the Oregon Department of Transportation Hydraulics Manual (ODOT 2006). The ODOT Hydraulics Manual also provides information on the design life of different pipe materials (design lives summarized in Table 5-3 are applicable, provided that the requirements from Section 5.4 are met for the pipe material).

Minimum Cover Requirements

Open bottom culverts made of metal require soil cover between the top of the culvert barrel and the overlying ground surface or roadway pavement section. The depth of cover over the culvert may vary depending upon the weight of traffic loads or other land use that can be expected atop the culvert. Typically a minimum 2 feet of soil or crushed rock cover is needed above the culvert barrel to protect the culvert from deformation under heavy traffic loading. If a three-sided concrete box is proposed for the open bottom culvert, the top slab of the structure may be specified with a thickness that can greatly reduce or eliminate soil cover requirements. A structural engineer should be consulted for site-specific recommendations for cover depth when an open bottom culvert is planned.

Natural-bed box culverts are usually made of reinforced concrete, including a thick top slab, or elliptical metal pipe arches. As with open bottom culverts made of reinforced concrete, the top slabs on reinforced concrete boxes can be specified to a thickness that is capable of supporting heavy traffic loads. In some light traffic areas the top of the concrete box culvert can serve as the roadway driving surface. Cover depth over a natural-bed box culvert can typically be minimal if desired by specifying a stronger culvert material. The designer should evaluate the tradeoff of a taller and stronger box structure (at greater material cost) that requires less cover versus a lesser structure height (at lower material cost) covered with onsite soil from the culvert excavation.

Construction Considerations

Construction of open bottom and natural-bed box culverts requires fairly intrusive excavation and local modification of channel conditions at each end of the culvert. As such, there are many considerations that must be addressed for timely completion of construction and prevention of adverse environmental impacts during construction.

Erosion Control

Temporary erosion control measures should be implemented during construction to minimize erosion and prevent sediment from impacting site runoff. Permanent stabilization measures should be implemented to protect stream water quality and rehabilitate vegetation in the stream corridor. Details on appropriate erosion and sediment control measures are provided in the Erosion Control Manual (City of Portland, 2008).

Replanting

ODFW recommends that all disturbed areas be protected from erosion within 7 calendar days of completion of the project using vegetation or other means, and that the stream banks should be re-vegetated within 1 year with native or other approved woody plant species.

Stream Dewatering/Diversions

Culvert and related channel improvements should be constructed "in the dry" whenever possible to prevent or minimize water quality impacts on streams and biological communities. Construction in relatively dry site conditions typically enables faster completion of the construction work, avoids potential conflicts with sensitive fish species that may be present in the stream at the time of construction, and minimizes potential for mobilization of soil and sediments into the stream.

Bed Material Placement

Culvert fill material can be loaded into the pipe from either end using hand equipment for smaller projects, and with a small Bobcat® style front-end loader, a small bulldozer, a gravel conveyor belt or a rail-mounted cart for larger projects where hand placement is not practical. Alternatively, the bed material can be pushed into the culvert with a log or stiff board manipulated by an excavator (WDFW 2004). For culverts that are assembled in the field (in the excavation) in sections, stream bed material can be placed from the top before installing the top section of the culvert.

Care should be taken in the method in which the bed material is placed. According to WDFW (2004):

> *In order to achieve stream simulation, fill materials must be arranged to mimic channel conditions. Avoid grid patterns or flat, paved beds made of the largest rocks. A low-flow channel and secondary high-flow bench on either side should be created in the culvert. A step-pool profile generally occurs in the 3 to 10 percent slope range. The spacing of steps is somewhat variable, but one to four channel widths with a maximum 0.8-foot drop between successive crests is recommended. This type of channel ensures that stream energy is dissipated in pool turbulence, creating better fish passage and more stable channels. Segregating a portion of the coarsest fraction into bands can encourage this pattern. Do not exceed 0.8 feet of drop between successive steps. The steepest channels (greater than 10 percent grade) are cascades with large roughness elements protruding into the channel. The same material comprises the whole depth of fill. Stratification, such as placing spawning gravel over a boulder fill in a steep channel, is not appropriate.*

If the culvert bed material will be laid on a relatively steep slope or subjected to high velocity flows that could mobilize the channel bed material, baffles or other sill materials will be needed at intervals through the culvert length to hold the smaller bed materials in place. Sometimes it is sufficient to place boulder clusters within the culvert to prevent significant mobilization of bed material while not compromising high flow conveyance capacity. The designer should refer to ODFW (1999) and WDFW (2003) for details on options and design guidance for bed material retention.

Schedule

The time and duration of culvert construction should be carefully considered to minimize stream sedimentation, flow interruption, and disturbance of fish during sensitive periods. Generally, construction should be performed during low flow conditions in mid to late summer. If fish are present, construction must not coincide with fish migrations, spawning, and egg incubation periods. If in-water excavation is anticipated, timing must conform to state guidelines.

Foundation

If a box culvert structure is used, the only foundation typically required is crushed rock bedding material beneath the structure to create a smooth, even surface upon which the structure is laid. However, a geotechnical engineer should always be consulted to determine the adequacy of the underlying soil to support the weight of the structure, adjacent backfill, and the overlying roadway or other overlying land use. Site-specific techniques may be needed in some instances to provide a stable foundation for a box culvert. The geotechnical engineer's recommendations should be followed to achieve sufficient structural support for long-term success. A civil engineer also needs to be consulted to look at proposed and future loadings on the culvert as well as the basin dynamics.

If an open bottom culvert structure is used, the culvert will need to be laid on a foundation to prevent differential settlement over time that could compromise culvert functions and/or cause damage to the overlying roadway. Parallel foundation support is needed for each side of the culvert through the length of the culvert. Again, a geotechnical engineer should be consulted to determine the most appropriate foundation design for site-specific conditions. The basic options for open bottom culvert foundations include the following:

- Footing pads
- Continuous spread footings
- Pilings.

Minimizing Disturbance of Streambed and Banks

Disturbance of the bed and banks should be limited to that necessary to place the structure, embankment protection, and any required channel modification associated with the installation. This will expedite completion of construction and minimize potential for adverse water quality impacts. All disturbed areas associated with culvert construction should be replanted with native vegetation to help stabilize soils and slopes.

Outfalls

Outfall Description

This section provides guidance for designing and constructing drainage system outfalls to open channels or upland areas in such a manner as to prevent and reduce erosive conditions to protect the stability of shorelines, channel grades, ravine slopes, and channel banks. Three types of outfalls are addressed below. These are described in a preferred sequence for use; the first priority is for an open channel outfall, the second priority is for upland dispersion, and the third priority is for a piped outfall.

- **Open channel outfalls** – The location where stormwater is discharged via an open channel (typically a ditch) to a stream, drainage way, or another open channel. The longitudinal slope (in the direction of flow) of the outfall channel must be less than 20 percent.

- **Upland Dispersion –** A method used to spread out concentrated discharge of stormwater over an area outside the riparian zone and higher in elevation than the receiving stream, drainageway, or open channel. Where soil conditions are appropriate, this method enables stormwater to be used to support habitat functions while also adding attenuation benefits through uptake by vegetation, decreased flow velocities, and allowing infiltration. Upland dispersion is recommended only for low flows (100-year flow less than 2 cfs) and where site conditions are appropriate. Level spreading is another term that may be used for upland dispersion.

- **Piped outfalls** – The location where stormwater is discharged from a piped conduit (typically made of concrete, metal, or plastic) to a stream, drainageway, or open channel, as indicated above. This is often the end or terminus of a storm sewer pipe network.

Applicability

This section can be used as guidance for outfalls that are smaller than 36 inches in diameter/width. Abiding by the guidelines listed does not preclude submittal of additional engineering information when required by the City of Portland or other jurisdictions. See the City of Portland 2006 Sewer and Drainage Facilities Design Manual (SDFDM), Chapters 6 and 8 and Appendices A and J, for more detailed design information.

This section is *not* intended to cover outfalls governed by the City's municipal NPDES permit (National Pollutant Discharge Elimination System permit for separate storm sewer systems) with the Oregon Department of Environmental Quality (i.e., the larger municipal storm drain outfalls discharging to receiving water bodies throughout the City).

Open Channel Outfalls

Open channel outfalls are good options for sites with existing concentrated surface discharge (ditches or channels). For use of an open channel outfall to be acceptable, the following conditions must be met:

- The soils through which the outfall channel is constructed must be stable.

- The longitudinal slope (in the direction of flow) of the outfall channel must be less than 20 percent.

- Adequate space must be available to meet the design criteria for an open channel, such as side slopes and freeboard, as described in Section 8.5.1 of the 2006 SDFDM.

- The open channel will not pose safety risks at design flow depth.

Upland Dispersion

Dispersion of stormwater flows is often a good choice for sites with limited development where stormwater currently infiltrates, particularly if there are steep slopes, ravines, riparian areas, and/or other natural areas downstream where erosion could readily occur if stormwater is concentrated in an open channel outfall. For upland dispersion to be feasible, the following conditions must be met:

- The slope(s) onto which the runoff will be dispersed must be stable.

- The slope(s) onto which runoff will be dispersed must have a gradient of 20 percent or less.

- There must be no existing concentrated surface discharge (channels or ditches) on the site.

- No drinking water wells, septic systems, or springs used for drinking water may lie within 100 feet of the proposed dispersion site.

- A vegetated flow path of at least 50 feet must be accommodated from the proposed dispersion location to the nearest property line, structure, environmental zone, or steep slope (greater than 40 percent).

- It is imperative to determine and document potential downstream effects and conflicts associated prior to permitting and construction.

Piped Outfalls
Piped outfalls should be used if the soil, slope, or space requirements of an open channel or upland dispersion outfall cannot be met.

- Hand trenching should be provided where runoff will pass over erodible soils in a slope area that is higher than 20 feet with a gradient of 15 percent or steeper.

- For slopes steeper than 40 percent, it is recommended that the pipe be installed on the ground surface to minimize disturbance to what could be an unstable slope.

Outfall Design
Before initiating the design process, it is imperative that an assessment of the site be made to determine its existing characteristics, such as the type and condition of soil, vegetation, and habitat. Many outfalls have failed or otherwise caused significant environmental damage, such as major erosion, because the outfall design did not fully consider potential adverse consequences.

In most settings, the impacts of outfall design should be considered with the design storm event in mind. Under design event conditions, discharge velocities are greatest and have the most potential to damage slopes and receiving waterways. However, in settings where fish passage is an issue, low flow periods may require special consideration.

All outfalls should be designed to accommodate the peak flow during the pertinent recurrence interval design storm specified in SWMM **Chapter 1** and Section 6.4 of the SDFDM. The design should also minimize flow velocities and dissipate energy at the outfall to the extent possible, thereby decreasing the potential for erosion and scour in the flow path to the adjacent stream, drainageway, or open channel. In general, stormwater conveyance systems should be designed to reduce flow velocity throughout the length of the network, not just at the outfall.

Open Channel Outfalls

Open channel outfalls may be appropriate for sites with concentrated surface discharge under undeveloped conditions, as long as the slope, soil stability and space requirements indicated in the *Applicability* section of this document can be met.

Hydrologic Analysis and Hydraulic Design

- Design Storm Recurrence Interval: 25 years (see Section 6.4.1 of the SDFDM)

- As set forth in Section 8.5.3 of the SDFDM, there are separate velocity limitations identified for specific channel lining materials and for the vegetation within the channel. See the SDFDM for listed values. Please note, rock outfalls with native tree stakes is another type of vegetative channel lining that can accommodate slope up to 10% and a maximum velocity of 4 fps.

Channel Depth and Width

The primary concerns where an open channel outfall merges with a wider and deeper channel is prevention of erosion at the confluence of the outfall channel and the receiving channel, and stabilization of the outfall channel. The bottom (invert) of the open channel outfall should be at the same elevation as the bottom of the receiving channel, to avoid spilling of water down the bank of the receiving channel that can cause erosion of the bank or bed of the receiving channel. As recommended in the SDFDM, there should be 6 to 12 inches of freeboard depth above the design storm water surface elevation in an open drainage channel.

Erosion and Scour Control

The outfall and receiving waterway must be protected against erosion and scour. Erosion and scour can result when the shear stress of the flowing water exceeds the shear stress at which the soil lining the outfall channel or receiving waterway is stable (the critical shear stress). The maximum shear stress in the channel at any particular flow depth should be used as a basis for design to ensure the design is conservative. Maximum shear stress can be calculated as follows:

$$\tau_d = \gamma d S$$

τ_d = maximum shear stress, lb/ft^2

γ = unit weight of water, 62.4 lb/ft^3

d = depth of flow, ft

S = average channel slope, ft/ft

For more information on shear stress refer to Section 8.5.5 of the SDFDM.
Protection from erosion can be provided by these techniques:

- rock lining (large riprap or smaller quarry spalls, or streambed boulders),
- geotextile fabric lining (PDOT 2007, Section 00350),
- low-rise check dams spanning the outfall channel,
- plantings on the channel banks, and/or
- woody structures installed in the drainageway channel bank.

Each technique has specific design requirements listed in Chapter 8 of the SDFDM. As a rule of thumb, if check dams are used to slow velocities in the open channel outfall, a minimum of three check dams should be used with dam heights and spacing as indicated in the check dams **Exhibit SW-520**. They should be made of wood or rock, and must be keyed into the open channel bed and banks to prevent the dam from being displaced during high flows. Where rock is used, the rock must be placed by hand or mechanically, rather than dumped from a truck. Check dams are a good choice for steep outfall channels if channel lining is impracticable. Check dams are not usually necessary in low-gradient (less than 1 percent channel slope) reaches.

Angle of Discharge at Confluence with Drainageway Channel
The open channel outfall should be oriented at no less than a 30 degree angle from a perpendicular alignment with the receiving channel, with the confluence of flow oriented in the downstream direction (**see Exhibit SW-521**).

Plantings
Whenever possible, native vegetation should be incorporated into the design of an open channel outfall. In most cases involving planting, the use of an erosion control blanket over the bare soil is recommended until the vegetation is fully established. For guidance on plantings, refer to Section 8.5.6 of the SDFDM and SWMM **Appendix F**.

Grade Control
To minimize erosion and scour, the outfall should be designed to minimize the elevation difference between the bottom of the open channel and the bottom of the receiving waterway. Where the outfall channel slope drops steeply to meet the receiving drainageway channel, one or more grade control structures (larger than typical check dams) are required to create a step-pool sequence within the open channel outfall. Short drops of less than a foot will not typically require grade control, unless the outfall channel bed material is highly erodible. But steep (greater than 20 percent slope) elevation drops of greater than 1 foot should be avoided through use of properly designed and installed grade controls, particularly if upstream fish passage is a consideration. Appropriate grade control measures depend upon the outfall channel, the receiving waterway, the site characteristics, and fish passage considerations.

If the receiving drainageway channel is deeply incised near the outfall, grade control structures may be needed within the drainageway channel for a reasonable distance downstream of the outfall point to prevent the outfall discharges from worsening the incision problem. If a project site appears to need grade control structures for channel stability, a stream restoration design professional should be consulted early in the project design. If fish passage considerations apply to the site, ODFW fish passage design criteria for the elevation drop across a grade control structure must be adhered to (WDFW 2004).

Options for grade control include log sills, plank sills, and boulder controls. Design guidelines may be obtained from Chapter 7 of the Washington Department of Fish and Wildlife document entitled Design of Road Culverts for Fish Passage (WDFW 2003).

Upland Dispersion

Dispersion of concentrated stormwater flows is often a good choice for discharges to long slopes, ravines, riparian areas, and other natural areas where erosion could readily occur otherwise. Effective dispersion occurs when concentrated flows are converted to sheet flow. The primary concerns for effective dispersion design are stable slopes, a suitably-sized vegetated flowpath downslope of the dispersal location, prevention of erosion caused by the dispersed flow, and selection of plantings that are suited to the hydrologic regime that will be created by the flow dispersion.

Vegetated Area Requirements

A vegetated flowpath of at least 50 feet, and preferably greater, should be maintained between the dispersal point and any property line, structure, steep slope (greater than 40 percent), or Environmental Zone.

Dispersion Model

One method used to disperse concentrated stormwater flow in hilly terrain is through a flow dispersal trench (see **Exhibit SW-524**), where direct discharge from a storm drain or culvert infiltrates or percolates through a wide gravel-filled trench before it spreads out and continues onto existing soil and vegetation. It is recommended that this method not be used where hill slopes are greater than 20 percent. The discharge point shall not be placed on or above slopes greater than 20 percent or above identified erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and approval by the City of Portland Bureau of Development Services. The guidance below pertains to sites that meet these slope considerations.

The following guidance for dispersion trench design is taken from the Washington State Department of Transportation Highway Runoff Manual (WSDOT 2006). Discharge points with up to 0.2 cfs discharge for the peak 100-year flow may use rock pads or dispersion trenches to disperse flows. Piped discharge points with between 0.2 and 0.5

cfs discharge for the 100-year peak flow must use only dispersion trenches to disperse flows. Dispersion trenches must be a minimum of 2 feet wide by 2 feet deep in section, 50 feet in length; filled with ¾ - 1½ inch washed drain rock; and provided with a level notched grade board (see **Exhibit SW-160**). Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between four trenches (maximum). Multiple dispersion trenches must have a minimum spacing of 50 feet. If the 100-year peak flow at the outfall is greater than 2 cfs, dispersion is not an option for the site.

Erosion Control
Both the areas where stormwater enters and is dispersed must be protected against erosion. Erosion can result when the dispersed flow passes over sparsely vegetated ground or bare soil. If the dispersion area must be planted to provide the desired vegetation cover, a natural-fiber erosion control blanket (such as jute, coir, or excelsior) is recommended to provide soil stabilization while the vegetation matures, see City of Portland 2008 Erosion Control Manual. Native vegetation should be incorporated into an upland dispersion area, if not already present. Thick vegetation cover is critical to effective dispersion and infiltration of stormwater.

Piped Outfalls
On very steep or sensitive slopes, it may be difficult or impossible to route stormwater through an open channel or disperse upland without causing severe erosion. In such situations, it may be appropriate to use a piped outfall system (see **Exhibit SW-522**). All outfalls shall be located above the downstream mean low water level. Where the outfall may impact the receiving stream, especially fish bearing streams, consultation and approval by an ODFW authority may be required. The angle of discharge at the confluence with a drainageway channel is discussed later in this section.

Energy Dissipation

High velocity flows have significant kinetic energy, which can cause extensive erosion and scour at an outfall and/or receiving waterway. Every attempt should be made to decrease this kinetic energy throughout the conveyance network. However, when flow velocity is high at an outfall, the energy must be dissipated and erosion protection must be in place to protect against scour. This applies to all outfall scenarios regardless of outfall type. The design of an energy dissipation device is unique to the site; both the engineer designing the system and the reviewer of the design should consider that the device may not match these specifications. However, as long as it can be proven to both dissipate energy and protect against erosion and scour, it can be considered acceptable.

Techniques available:
- Rock outfalls with vegetation incorporated;
- Pipe Tee diffusion structures (see **Exhibit A.4-2**);
- Non-rock dissipaters that are shaped with soils, vegetation, berms, and woody debris are encouraged;
- *Energy dissipation structures (stilling basins, drop pools, hydraulic jump basins, baffled aprons, bucket aprons should be engineered) are required where velocities are greater than 20 feet per second.

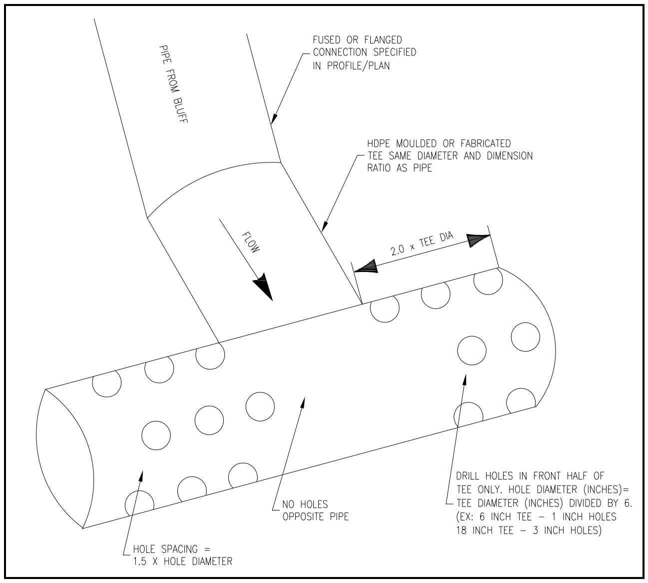


Exhibit A.4-2: Pipe Tee Diffuser

**These shall be designed by a professional engineer using published references such as Hydraulic Design of Energy Dissipaters for Culverts and Channels (U.S. Department of Transportation, Federal Highway Administration) and other references. The construction plan submittal shall identify the design reference.*

In general, rock protection of outfalls is most common. With the use of the proper size and gradation, rocks provide energy dissipation as well as protection against soil erosion. Depending on the flow velocity and existing site conditions, loose rocks such as riprap or quarry spalls can be used. **Exhibit A.4-3** has information on rock sizing based on outfall diameter and velocities. **Exhibit SW-523** and **Exhibit A.4-4** show two options for outfall energy dissipaters made of rock. All rock protection areas shall be inter-planted with willow stakes or other approved plantings, every two feet on center, to increase stability, reduce erosion, provide shading, and improve aesthetics.

The outfall should be oriented at no less than a 30 degree angle from a perpendicular alignment with the receiving channel; with the confluence of flow oriented in the downstream direction (same as described for open channel outfalls, see **Exhibit SW-521**).

Outfalls shall be located above the downstream mean low water level, except as approved by the City. Concrete endwalls will be required for all exposed outfall pipes greater than 12 inches in diameter (see **Exhibit SW-524**). Publicly accessible outfalls greater than 18 inches in diameter shall include grated protection in accordance with **Exhibit SW-525**.

Outfalls to drainageways and rivers are often located in Environmental Zones. Environmental Review may be required pursuant to City Code Title 33.

Drainageways and rivers may have steep slopes or banks and may have unstable landforms (i.e. slump). Geotechnical investigation to determine the stability of the stream or river bank, as reviewed and approved by BES or BDS, may be required for approval.

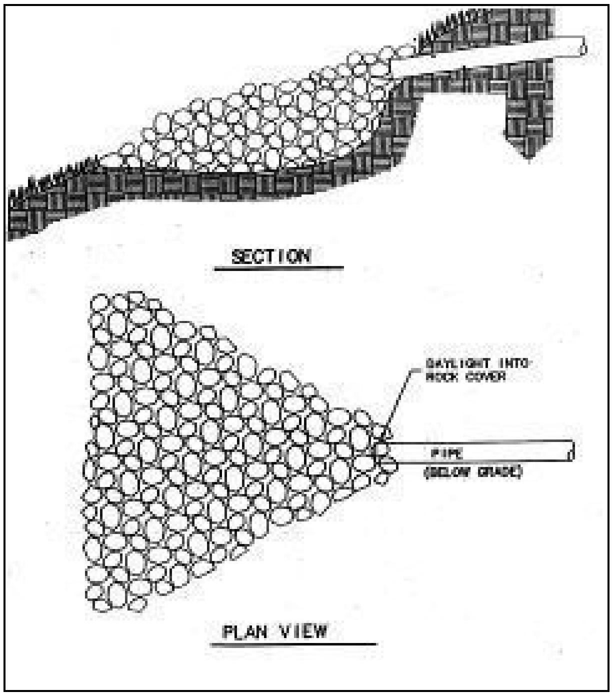


Exhibit A.4-3: On-Site Storm Outfall

Exhibit A.4.4: Rock Protection at Outfalls for Pipes

Outfall Diameter	Discharge Velocity at Design Flow	Type	Depth	Width	Length	Height
2 inch		Average stone size 1 inch	2 inch	12 inch	24 inch	
4 inch		Average stone size 2 inch	4 inch	24 inch	36 inch	
6 inch		Average stone size 4 inch	6 inch	36 inch	48 inch	
>6 inch	0 – 5 fps	Riprap [a]	2 x max. stone size	Diameter + 6 feet	As calculated [b]	Crown + 1 foot
	6 - 10 fps	Riprap [a]	2 x max. stone size	Greater of: (diameter + 6 feet) or (3 x diameter)	As calculated [b]	Crown + 1 foot
	11 - 20 fps	Gabion or riprap [a]	2 x max. stone size	Greater of: (diameter + 6 feet) or (4 x diameter)	As calculated [b]	Crown + 1 foot
	Over 20 fps		Engineered energy dissipater required			

[a] Riprap size shall be determined using the following formulae and the *City of Portland Standard Construction Specifications* (PDOT 2007), Section 00390.11 Riprap.
Riprap size ds=0.25*Do*Fo (6″ minimum).
Depth=2*ds (1 foot minimum).

[b]Apron length (ft) = Do(8+17*Log Fo).
V = Average velocity (ft/s).
Do = Pipe diameter (ft).
Fo = V/(g*Do)0.5 g = 32.2 ft/s^2.
ds = Riprap diameter (ft).
depth = Thickness (ft).

Construction Techniques for Both Open Channel and Piped Outfalls

To the extent possible, heavy equipment and machinery should be kept out of the receiving waterway and off the banks. Channel beds and banks are typically in a delicate state of equilibrium and can easily be damaged by the action and forces of large earth-moving machinery. Equipment operations within the waterway can cause the release of sediment and disrupt the natural layering and armoring of particles on the channel bed. Out of the waterway, excessive compaction of native soils can slow or limit the propagation of beneficial vegetation.

For open channel outfalls, it is required that the new channel excavation be completed and stabilized to the extent practicable before making the connection to the receiving drainageway. This will minimize the amount of time that disturbance occurs in the receiving drainageway while also enabling the downstream end of the excavated area to serve as a temporary sediment trap for downstream water quality protection. A plug of native soil should be retained between the outfall channel excavation and the receiving drainageway until the connection is ready to be made.

Construction in and adjacent to streams that provide habitat for fish must adhere to prescribed periods for in-water work, as defined in the Oregon Guidelines for Timing of In-Water Work to Protect Fish and Wildlife Resources (ODFW 2000). As defined currently, the preferred in-water work period for Willamette River tributaries within city limits is July 1 to October 15. Project applicants should check the in-water work dates prior to proceeding with in-water work.

If runoff or other discharge will occur in the area where a new energy dissipater or open channel outfall is to be constructed, flow bypass or other forms of dewatering must be accomplished to enable construction in relatively dry conditions.

APPENDIX A.5 STORMWATER RETROFITS

This appendix identifies the regulations in the City's Stormwater Management Manual (SWMM) that apply to stormwater retrofits on private property. A stormwater retrofit is the installation of a new stormwater facility to treat stormwater from existing impervious area, including, but not limited to, roofs, patios, walkways, and driving or parking surfaces.

Stormwater retrofits are installed for a variety of reasons, including:

- Land use, building, zoning, or other development proposals that may trigger compliance with SWMM requirements.

- Property owners motivated to increase their onsite stormwater management to provide multiple watershed health benefits, including reducing stormwater flow to combined sewer systems, reducing basement flooding, and providing groundwater recharge.

- Property owners wanting to install ecologically sensitive landscapes to reduce overall ecological footprint.

- Ratepayers wanting to reduce or eliminate onsite stormwater utility charges.

Each retrofit site is unique and has specific site conditions. These conditions include location of existing structures and other impervious areas, zoning considerations, soils, slopes, current and historic site use and source control concerns, required uses (e.g., number of parking spaces, accessibility), desired uses (e.g., play or other common areas, gardens, visual amenities), and the existing stormwater discharge point (onsite, offsite to public system, or offsite to natural feature or drainageway).

There are two types of stormwater management retrofits:

1. **Mandated retrofits,** which result from a land use or redevelopment requirement. Mandated retrofits help the City control stormwater discharges by requiring the site to comply with the applicable elements of the SWMM as a condition of development.

2. **Voluntary retrofits,** which help the City incrementally provide management of stormwater from existing impervious surfaces.

For information about required City permits for stormwater retrofits, see the Bureau of Development Services (BDS) brochure titled *Stormwater Retrofits, Permits and Inspections.* Permits are determined by site use and stormwater facility characteristics. If a site has multifamily, commercial, industrial or institutional uses, a permit will be needed for stormwater retrofits; a permit *may* be needed for specific stormwater facilities at residential sites.

Stormwater retrofits must meet SWMM requirements as follows:

- Retrofits required as part of land use, zoning, building permits, or other conditions of developments must meet the SWMM requirements in full.

- If new offsite connections are created as a part of a stormwater retrofit, the infiltration, discharge, flow control, and pollution prevention requirements of the SWMM apply in order to meet the requirements of the stormwater hierarchy.

- For installation of new Underground Injection Control (UIC) facilities to treat existing development, all SWMM requirements regarding water quality, source control, and depth to groundwater apply in full. The property owner, applicant, or site manager (as appropriate) is responsible for registering or rule authorizing new UICs with DEQ.

Voluntary retrofits must meet the following SWMM requirements when a City permit is necessary:

- Facility design and landscaping, as described in **Chapter 2**.

- Sizing methodology and permit submittals for appropriately selected stormwater facilities, as described in **Exhibit 2-5** in **Chapter 2**.

- Recorded operations and maintenance plans and activities, as described in **Chapter 3**.

- Source control requirements if the project site has characteristics or activities that would classify it as high risk, as described in **Chapter 4**.

For voluntary stormwater retrofits, there is flexibility in the facility sizing and site discharge location criteria. The City would rather encourage voluntary retrofits where the facilities are some portion of the required SWMM sizing than disallow facilities that do not meet full sizing criteria. These smaller facilities can still collectively add up to significant management of runoff from existing impervious surfaces. The following facility sizing and discharge criteria apply:

- Voluntary retrofits are encouraged to size facilities through the Simplified Approach for project areas of less than 10,000 square feet. If site characteristics make Simplified sizing difficult to achieve, voluntary retrofits are allowed to request the use of smaller facilities. Applicants must use the Presumptive Approach to get approval for smaller facilities. In general, the City will not approve facilities that are not sized to at least manage the water quality design storm. Applicants should clearly note on project submittals and any permit applications that the project is a voluntary retrofit and that water quality storm sizing is being used.

- Voluntary retrofits are encouraged to meet the stormwater hierarchy by fully infiltrating onsite whenever practicable. Infiltration testing (as described in Appendix F.2) is recommended in all situations and will be required for certain sizing approaches or stormwater facility options. If total onsite infiltration is not practicable, voluntary stormwater retrofits are allowed to use existing discharge systems and do not need to meet the stormwater hierarchy for discharge criteria. At sites where the Simplified sizing approach is appropriate and possible and total onsite infiltration is not expected to be practicable, infiltration testing is not required, and the site can use the existing discharge point. Examples of existing discharge points include, but are not limited to, onsite catch basins connected to offsite public systems or existing onsite infiltration facilities. Applicants should clearly note on project submittals and any permit applications that the project is a voluntary retrofit, that the existing discharge point will be used, and how and where the proposed stormwater management facility will connect to the existing discharge point.

Additional Resources

The Bureau of Environmental Services (BES) encourages retrofits by providing technical assistance, competitive funding opportunities, and partnerships. For choosing and designing stormwater facilities to manage runoff from existing impervious area, see BES's *Site Assessment Guide*, which is available on BES's website: http://www.portlandonline.com/bes.

The most common residential stormwater management retrofits are downspout disconnection, rain gardens, and soakage trenches. These can often be used in a comprehensive stormwater management system for a site and can most likely be constructed by property owners. Brochures about these residential retrofit stormwater management systems can be found on the BES website.

Maintenance guidance is available for a variety of stormwater management systems. Most residential stormwater systems include conveyance methods (such as downspouts, curb cuts, and piping), soil, and vegetation. A brochure titled *Maintaining Home Stormwater Systems* and other maintenance guidance is available on the BES website.

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Appendix B.1

CITY OF PORTLAND, OREGON
BUREAU OF ENVIRONMENTAL SERVICES

VENDOR SUBMISSION GUIDANCE

FOR

EVALUATING STORMWATER TREATMENT TECHNOLOGIES

February 2001, Updated September 1, 2004

INDEX

VENDOR SUBMISSION GUIDANCE FOR EVALUATING STORMWATER TREATMENT TECHNOLOGIES

February 20, 2001, Updated September 1, 2004

I. Introduction

The City of Portland's Stormwater Management Manual provides stormwater pollution reduction requirements and guidance. BES specifies design criteria, such as pollution reduction storm intensity and volume, and facility performance goals. Facilities need to be designed to satisfy those criteria as stand-alone systems or as part of a treatment train approach.

Chapter 2.0 presents stormwater pollution reduction facility designs and includes a section on manufactured stormwater treatment technologies. Stormwater treatment technologies and the knowledge base around them are rapidly evolving, and as such no proprietary facility names are included in the Stormwater Management Manual. Rather, BES will keep an updated list of technologies that have been approved for stand-alone and pretreatment uses.

This guidance is designed to provide a process of designating approval levels for manufactured treatment technologies. To be approved for use as a stand-alone stormwater pollution reduction facility, the protocols of this document must be followed. Results must indicate that the facility performs to Portland's design standards (see Performance Criteria section below, and Data Evaluation section, Page B-14).

This guidance will also define "TSS (Total Suspended Solids) removal", and provide the equations necessary to calculate it. Portland's method for evaluating test results, which includes provisions for influent concentration, is also included (See Data Evaluation section, Page B-14).

II. Performance Criteria

DESIGN STORM

Flow rate-based pollution reduction facilities shall be sized to treat 90% of the average annual Portland runoff. When used with the Rational Method, the following rainfall intensities will result in flow rates that achieve this goal (see Appendix E of the Stormwater Management Manual).

Site's Time of Concentration (Minutes)	Rainfall Intensity (Inches per Hour)
5	0.19
10	0.16
20	0.13

REQUIRED POLLUTION REDUCITON PERFORMANCE GOALS

Basic Pollution Reduction Performance Goal

The basic pollution reduction performance goal for the entire city is 70% TSS (Total Suspended Solids) removal from 90% of the average annual runoff. TSS is defined as "matter suspended in stormwater excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter (larger than coarse sand, also see Distribution of Sediment Sizes Table, Page B-9).

Influent concentration of TSS is known to greatly impact the ability of a facility to remove 70% TSS, so it is important to specify limits to be used in performance tests. BES will use the "Line of Comparative

Performance©" method, developed by Dr. Gary Minton of Resource Planning Associates (See Charts 1 through 3 in the Data Evaluation section, Pages B-14 and 14) to determine whether or not a facility meets this requirement. These lines were generated from test data on the TSS removal efficiencies of grassy swales and sand filters and modified to account for Portland's 70% TSS removal standard. The premise behind using these lines of performance is that grassy swales and sand filters have been widely accepted as adequate-performing treatment facilities. These, as well as other treatment BMPs, remove a higher percentage of TSS with higher TSS influent concentrations. It is not fair or practical to require 70% TSS removal from clean stormwater. This method of evaluation, however, accounts for this dilemma. Manufactured technologies will not be expected to outperform grassy swales and sand filters, but data points must be comparable, with a certain percentage falling above the "Line of Comparative Performance©" for the facility to be accepted as a "Presumptive Approach" in the Stormwater Manual. As a low-level baseline, a facility must also achieve an effluent goal of no more than 20 mg/l TSS for low influent concentrations (< 70 mg/l).

TMDL Enhanced Performance Goal

Certain watersheds within the City of Portland have established TMDLs (Total Maximum Daily Loads). The TMDLs apply specific pollution control requirements to designated pollutants of concern. To ensure that new development does not contribute pollutants of concern to a TMDL watershed, pollution reduction facilities are required to demonstrate specific removal rates for those specific pollutants.

To be considered for use as a stand-alone facility in a TMDL watershed, a manufactured technology must demonstrate removal efficiencies for specific pollutants of concern, as well as TSS. See Section 1.5.2 of the Stormwater Management Manual for a current list of TMDL watersheds with corresponding pollutant parameters.

Oil and Grease Performance Goal

Certain site uses within the City of Portland, such as high-use or high-risk parking lots, require additional treatment for oil and grease. The Stormwater Manual currently only recognizes oil/water separators for the pretreatment of oil and grease. To be considered for use as an oil/water separator, a manufactured technology must demonstrate adequate performance. Adequate performance needs to include: the removal of oil droplets from 50 to 60 microns in size, and the ability to achieve effluent efficiencies of 10 ppm or mg/L for influent concentrations exceeding 50 ppm or mg/L.

Pretreatment Performance Goal

A facility may be approved for pretreatment use only. In this case, the facility would be constructed in conjunction with another pollution reduction facility as a "treatment train" to accomplish the basic or enhanced performance goal. To be approved as a pretreatment facility only, data pertaining to the assessment protocol should be submitted. However, the level of performance will not need to meet basic pollution reduction performance goals. The facility will need to demonstrate the ability to remove large debris and the larger range of TSS particle sizes (see Distribution of Sediment Sizes Chart on page B-9), as approved by BES.

REQUIRED PERFORMANCE

Manufactured technologies claiming effectiveness for the listed pollutants must demonstrate (based on data provided per the Technology Assessment Protocol described below) that the above treatment performance goals will be generally achieved. Facilities shall be designed to perform without maintenance for one full year. In addition, factors other than treatment performance are important and will be evaluated to determine appropriate use of the emerging technology. Technologies may be approved as "Presumptive Approaches", which are then presumed to comply with the City's basic pollution reduction performance goal, or as pre-treatment facilities, only accepted in combination with other facilities. Facilities demonstrating compliance with enhanced or oil and grease performance goals may be added to applicable

Stormwater Manual sections in future revisions. Facilities that don't demonstrate adequate maintainability (See Section E, Page B-11) will not be included in the Stormwater Management Manual and will not be accepted for use within the City.

III. Technology Assessment Protocol

This testing protocol is based on protocols developed by other jurisdictions in the northwest. The Washington Chapter of the American Public Works Association (APWA), the Washington Department of Ecology, the City of Olympia, and the City of Sacramento/ Sacramento County have all developed very similar protocols, and were all instrumental in the development of this one. In this document, BES has tailored various sections of these protocols to fit Portland's design standards. BES reserves the right to change or update this document at any time. As design standards change, compliance with this protocol does not "grandfather" any manufactured facilities into the Stormwater Manual. BES reserves the right to request additional information at any time, and may remove technologies from accepted status after gaining further experience with them, or as new data becomes available. If a vendor wishes to use a different protocol, it is highly recommended to submit protocol details to BES for review prior to initiating tests.

REQUIRED NUMBER AND TYPES OF STUDIES

For BES to adequately evaluate the performance of a facility, a sufficient number of data points, or tests, must be submitted by the manufacturer. The submission of at least 30 tests will be deemed adequate for review. A "test" is defined as a controlled study that meets the requirements set forth in this protocol and results in a single data point which can be plotted on an Influent TSS (mg/L) vs. Removal Efficiency (%) curve (see Chart 3, Page B-15). Removal efficiency shall be calculated using methods specified on page B-10 of this report. At least half of the tests must come from field installations; either field performance studies with real storms or field performance studies with artificial storms.

Testing by "Independent Entities"

Testing of technologies may be conducted by qualified "independent entities" such as consultants, universities, local, state, or federal agencies. Testing may also be sponsored by the manufacturers themselves, but actual sampling, testing, and laboratory reporting must come from a qualified laboratory.

A. FIELD PERFORMANCE STUDIES WITH REAL STORMS

For inclusion in the Stormwater Manual as a stand-alone "Presumptive Approach", at least 15 data points must be obtained from actual field installations. These can come from field studies with real or artificial storms. At least two different land-uses must be represented, including medium density residential, retail commercial, non-retail commercial, or industrial. Testing within transportation corridors, including public or private streets within these land-uses, is encouraged. The purpose of this is to obtain a range of influent concentrations representative of typical storm water runoff. While it is acknowledged to be more difficult and expensive than laboratory testing, field testing will ensure that situations existing in "real-life" will be mimicked to the maximum extent practicable.

The following storm characteristic requirements must be met for field tests with real storm events, and must be documented and submitted to BES for acceptance.

NUMBER AND CHARACTERISTICS OF SAMPLED STORMS

Minimum Number of Sampled Storms

For acceptance as a stand-alone "Presumptive Approach", 5 storm events from three different sites must be submitted for a total of 15 storms. Real or artificial storm events can be used. At least two different land-uses must be represented, from either medium density residential, retail commercial, non-retail commercial, or industrial. Testing within transportation corridors, including public or private streets within these land-uses, is encouraged. The purpose of this is to obtain a range of influent concentrations representative of typical storm water runoff. For possible acceptance as a pretreatment device, at least 5 storm events must be submitted. To represent seasonal differences if only real storms are used, the tests shall occur throughout the calendar year. No more than 70% of the real storms may be sampled during the dry season (May through September) or during the wet season (October through April).

Minimum Storm Depth

The minimum total storm depth shall be 0.12 inches. As a guideline, at least 50% of the sampled storms should exceed 0.42 inches, and at least 10% of the sampled storms should exceed 0.83 inches.

Minimum Facility Flow Rate

Obtain data for a range of flows, from 10 to 100% of the design flow for off-line facilities, and from 10 to 125% for facilities designed to be flow-through, on-line facilities. Exceeding the design flow will demonstrate the facility's ability to retain previously trapped pollutants during high-flow periods. This requirement will most likely be accomplished through field testing with artificial storms.

Start/ End of Storm Event: A storm event is preceded and followed by at least six hours of dry weather.

Minimum Runoff Duration: 6 Hours.

Minimum Average Rainfall Intensity

Minimum average rainfall intensity shall be 0.02 inches/ hour. As a guideline, at least 50% of the storms should exceed 0.03 inches/ hour, and at least 10% should exceed 0.05 inches/ hour.

Maximum Average Rainfall Intensity: Maximum average rainfall intensity shall be 0.1 inches/ hour.

SAMPLING SPECIFICATIONS

Type of Samples

Flow-weighted composite samples (Event Mean Concentration or EMC), except pollutants or technologies for which grab sampling is mandated by sampling protocols. Document all sample types for BES review.

Sampling Procedure

To the maximum extent practicable, sample the entire runoff period. As a guideline, sample at least 75% of the total volume of each storm. The final composite sample shall comprise at least 10 influent and 10 effluent sub-samples collected throughout the storm. Plot sampling times on a copy of the runoff hydrograph.

Sampling Locations

If Method #1, 2, or 3 (Page B-10) is used to calculate Removal Efficiency: Collect influent samples and measurements of flow rates and volumes at a point upstream of the treatment system, before any flow bypasses. Collect effluent samples and measurements of flow rates and volumes at a point downstream of the treatment system after bypassed and treated flows are rejoined.

If Method #4 (Page 10) is used to calculate Removal Efficiency: Ensure that the unit has been thoroughly cleaned and all sediment removed prior to start of test. Collect influent samples and measurements of flow rates and volumes at a point upstream of the treatment system. Immediately after test, block incoming flows and remove collected pollution for analysis.

Document all sampling locations for BES review.

Parameters of Interest

Parameters of interest include: total suspended solids (TSS), total dissolved solids, BOD, temperature, pH, hardness, total recoverable and dissolved metals including zinc, copper, lead, and cadmium, total and ortho-phosphate, total nitrogen, total petroleum hydrocarbons (NWTPH-Dx and –Gx, silica gel), visible sheen, bacteria (E. coli), nitrate-N, and ammonia-N. The vendor may submit any additional parameters that are deemed to be relevant to facility performance.

The vendor should tailor its sampling procedure to support the treatment goal. To be included in the Stormwater Manual as a general "Presumptive Approach", TSS needs to be sampled. To be considered as an oil/ water separator, Total petroleum hydrocarbons (NWTPH-Dx and –Gx, silica gel) and visible sheen needs to be tested. To be considered for use in TMDL watersheds, other pollutants of concern must be addressed. Because pollution removal parameter requirements tend to change over time, it is in the vendor's best interest to evaluate as many pollutants as possible. Testing methods and procedures are not included in this document for all pollutants of interest, and therefore must be submitted to BES with any testing data.

Sample Handling and Reporting

The methods of sample preservation and analysis are to be documented and submitted with test results. A qualified laboratory shall analyze samples. Results shall be analyzed and reported by entities independent of the vendor. The report shall discuss any discarded samples, QA/QC, duplicates, and ignored data. Analyzation techniques should not employ very minute samples, such as the "10 ml technique".

ACCUMULATED SEDIMENT TESTING

At the end of the test period, remove, weigh, and analyze accumulated sediment. Evaluate the sediment for the following: total dry weight, moisture content, particle size distribution, organic content, TPH, total phosphorus, and total zinc, copper, cadmium, and lead. Analyze particle size distribution using both wet and dry sieve test procedures following ASTM methods. Analyzing particle size distribution is very important in determining a facility's ability to remove the full range of sediment sizes (see table on page B-9). Quantify or otherwise document gross solids (debris, litter, and other particles exceeding 1 mm in diameter) and oil accumulations.

GROSS SOLIDS TESTING

At the end of the test period, remove, weigh, and describe accumulated gross solids. Compare gross solids collected in the facility with gross solids bypassed downstream, measured through collection in mesh bags with one-millimeter openings.

RAINFALL MONITORING

Rainfall shall be measured at a representative site. Document site location and distance from facility.

GEOGRAPHIC SETTING

Sites in the Pacific Northwest (SCS Type 1A Rainfall Distribution) are preferred, but not required, as long as rainfall and runoff measurements are within tolerances specified on page B-7.

B. FIELD PERFORMANCE STUDIES WITH ARTIFICIAL STORMS

Field performance studies with artificial storms may be submitted by vendors. The procedures described above for "real" storms must be followed, and additional data on the methods used to calculate and field-distribute the artificial storms must be documented and submitted. An artificial hydrograph or series of constant flow rates must be formulated and followed during the field test. It is highly recommended that the vendor submit this artificial hydrograph to BES for review prior to field testing.

C. LABORATORY PERFORMANCE STUDIES

BES recognizes that laboratory testing provides useful information under controlled conditions. Vendors may submit laboratory performance studies for consideration. Up to one-half (15) of the performance studies may be performed in the laboratory.

Removal rates for tests using potable water, spiked with pollutants, have generally been shown to be higher than tests using “real” storm water. Real storm water is therefore preferred when laboratory testing is employed, and should be used for at least half of the tests. When real storm water is used, one performance study shall be comprised of at least 10 influent and 10 effluent samples collected throughout the testing period (treatment efficiency calculation method #1, Page B-10), or 10 influent samples collected throughout the testing period and one final captured load mass (treatment efficiency calculation method #4, Page B-10). Documentation of the method of acquisition of test water must be submitted to BES for approval.

Spiked test water may be used for up to seven studies. When spiked test water is used, one study shall consist of either; 1) a test performed on water loaded with the full range of particle sizes, or 2) a series of tests on each separate particle size. Treatment efficiency calculation method #4 on page B-10 shall be used in either case. TSS added to laboratory water shall conform to the particle size distribution shown in the table below. Documentation of the composition of test water must be submitted to BES for approval.

TABLE: DISTRIBUTION OF SEDIMENT SIZES (STANDARD SIEVE)

PARTICLE DIAMETER	% LESS THAN (WEIGHT)
< 1,000 micron	100%
< 707 micron (coarse sand)	95 to 100%
< 595 micron	90 to 95%
< 420 micron (medium sand)	85 to 90%
< 297 micron	80 to 85%
< 177 micron (fine sand)	75 to 80%
< 88 micron (very fine sand)	50 to 75%
< 44 micron (coarse silt)	25 to 50%
< 16 micron (medium silt)	0 to 25%
<8 micron (fine silt)	0%

D. TREATMENT EFFICIENCY

There are many different methods used to calculate treatment efficiency, four of which are shown below. Method #1 and #4 calculate efficiencies for individual storms, while method #2 and #3 calculate average efficiencies over a number of storms. While any of these described methods are acceptable for use, methods 1 and 4 require fewer storm events to be sampled and are therefore easier to perform. Describe which treatment efficiency methods below were used and include calculations. All are expressed as percentages. Any samples analyzed below detection limits may either be included at the detection limit, or be excluded (with a notation to that effect).

Method #1: Removal in each storm calculated as:

100(flow-weighted influent concentration – flow-weighted effluent concentration) / flow-weighted influent concentration

Where: All concentrations are averages of the 10 flow-weighted sub-samples.

Method #2: Aggregate removal of the storms sampled as:

100(A-B) / A

Where: A = (influent concentration Storm 1)(flow of Storm 1) + (influent concentration of Storm 2)(flow of Storm 2) +…(influent concentration of Storm N)(flow of Storm N)

B = (effluent concentration of Storm 1)(flow of Storm 1) + (effluent concentration of Storm 2)(flow of Storm 2) +…(effluent concentration of Storm N)(flow of Storm N)

Where concentrations are flow-weighted, and flow = average storm flow or total storm volume (vendor's choice).

Method #3: Efficiency based on geometric mean:

100(A-B) / A

Where: A = Geometric mean of all products of flow-weighted influent concentration times average storm flow or total storm volume.

B = Geometric mean of all products of flow-weighted effluent concentration times average storm flow or total storm volume.

Method #4: Removal in each storm calculated as:

Efficiency = 100(Captured load mass) / (Influent load mass over entire storm)

Where: Captured load mass = Mass of accumulated TSS in the treatment facility during testing period

Influent load mass over entire storm = Flow-weighted influent concentration times total storm volume through facility, or for laboratory tests with spiked water, total mass of added TSS. Note: TSS gradation must comply with table on page B-9.

E. FACTORS OTHER THAN TREATMENT PERFORMANCE

BES staff must make reasoned decisions about storm water treatment technologies. To do so, all relevant factors need to be evaluated, while recognizing the critical importance of the technology's verified treatment performance for a target group of pollutants. Given the limited experience with emerging technologies, this is an arena where "best professional judgement" based on the weight of evidence is appropriate. To be accepted as a publicly owned and maintained facility, the vendor must present the following data to BES's *Standards and Practices Committee*, and receive their official consent. To be accepted for use as private facilities, the vendor must submit the following data to the BES address on page B-13.

Applications

1) How does the facility work? How does it remove pollutants?
2) For which applications (e.g. land uses, pollutants) does the vendor recommend this technology? Why?
3) How many systems are installed in the United States? Provide at least three references with names and telephone numbers. Provide specific model numbers.
4) Provide information on at least three units owned and maintained by public municipalities and information on the oldest units installed to date. Provide specific model numbers.

Site Characteristics

5) Do any of these site characteristics or safety considerations favor or limit the technology's use: steep slopes, high groundwater, baseflows, soils, proximity to wells, septic systems and buildings, facility depth limits for access and safety, risk of hazardous materials spills, and driving head requirements? How?

Design Criteria

6) Pollutant removal at design flow and for representative storm water characteristics (e.g. TSS particle size distribution)
7) Stormwater constituent limitations, pollutants and other constituents, including fouling factors
8) Design hydraulics (treatment and hydraulic design flows, by-pass flow, hydraulic grade line, scour velocities, etc.)
9) Design residence time, vertical/ horizontal velocities, etc.
10) Specific flow rate for media
11) Head loss curves for media
12) Minimum contact time and minimum thickness for media
13) Design life of system or components of the system before major overhaul is projected; describe fully
14) Media specifications to ensure that adequate quality of each medium is supplied to the user at all times. A list of all the physical/ chemical and impurity specifications should be provided
15) Structural, water tightness, buoyancy, and constructability
16) Design sizing and cost information for units designed to perform without maintenance for one full-year, and over-designed to last three years before the first cleaning.
17) Pretreatment requirements if any
18) Materials used to construct facility

Construction

19) What role does the vendor take in design and construction? Will a vendor representative be available to the contractor in the field? A letter from the vendor is required with every facility accepted to be publicly owned and maintained. This letter must confirm that the facility is being designed per manufacturer specifications to meet City of Portland requirements.
20) List the steps taken to install the technology. How long does it take?
21) How are factors such as structural integrity, water tightness, and buoyancy addressed?
22) What types of problems can occur in designing and installing the technology?

23) How are potential problems diagnosed and corrected, and by whom?
24) If problems go uncorrected, how does this affect the technology's effectiveness? What will cause complete facility failure?
25) How available is the technology (e.g. where do the major components come from and how much lead-time is needed?)

Costs

26) Provide materials (capital) and installation costs for complete system(s), indicating total costs and costs per cfs treated (not per cfs hydraulic capacity)
27) What is estimated useful facility life before replacement is needed?

Operation and Maintenance: For a typical installation with typical stormwater, discuss each of the following:

28) How are inspections performed and how often?
29) How do you tell or forecast when maintenance will be needed, i.e., what is the "trigger" for determining when maintenance is needed and why?
30) How is maintenance performed? Specify equipment, materials, and man-hours necessary
31) Are all maintenance areas accessible by people and equipment? Are special equipment or methods needed for access? Any confined space entry areas?
32) What is the estimated maintenance frequency and on what information/ tests do you base this estimate?
33) What role does the vendor take in maintenance/ How much does the vendor charge for maintenance service?
34) Can the technology be damaged due to delayed maintenance, and if so, how is it restored?
35) How many years have you been in business? If vendor goes out of business or product model changes, how/ where will facility owner find needed parts, materials, and service?
36) Provide information on how other public jurisdictions clean and maintain their units.
37) Is there a standardized Operations and Maintenance plan available? If so, please provide a copy.

Reliability

38) Assuming the technology is designed and installed correctly, what factors can cause it not to perform as designed?
39) Can the technology add, transform, or release accumulated pollutants?
40) Does the filter medium decompose or is it subject to slime/ bacteria growth/
41) Is the technology sensitive to heavy or fine sediment loadings- is pretreatment required?
42) How is under-performance diagnosed and treated?
43) What is the warranty?
44) What initial/ ongoing user support is provided? Does the vendor charge for support?

Other Factors

45) Does the technology provide benefits or present challenges in other potentially relevant areas, such as groundwater recharge, thermal effects on surface waters, habitat creation, aesthetics, vectors, safety, community acceptance, and recreational use?

IV. REPORTING

Vendors seeking BES approval of manufactured stormwater treatment facilities must submit the specified test data in report format, and must include answers to the "Factors Other than Treatment Performance" section above. While treatment performance is the most obvious factor in determining facility acceptance, others such as maintainability and reliability are equally important.

All relevant data should be included in the report, including but not limited to: test site locations with maps, dates and times of sampling, topography maps outlining drainage basins, system plans showing all relevant stormwater piping and pollution reduction facilities, expected flow calculations for various storm events, beginning and end times of all storm events and samplings, rainfall data from specified rain gage, measured flows through the system at various times (submit calculated hydrographs), and history of the facility (when constructed, when last maintenance/ cleaning occurred, etc.). All data pertaining to characteristics of storms and sampling procedures must be submitted to show conformance with previous specifications.

All reports should be submitted to ATTN: Engineering Services Support Manager
Bureau of Environmental Services, C.O.P.
1120 SW 5th Ave. Room 1000
Portland, OR 97204-1972

BES will evaluate the data and report findings to the vendor within 60 days of the submittal.

V. DATA EVALUATION

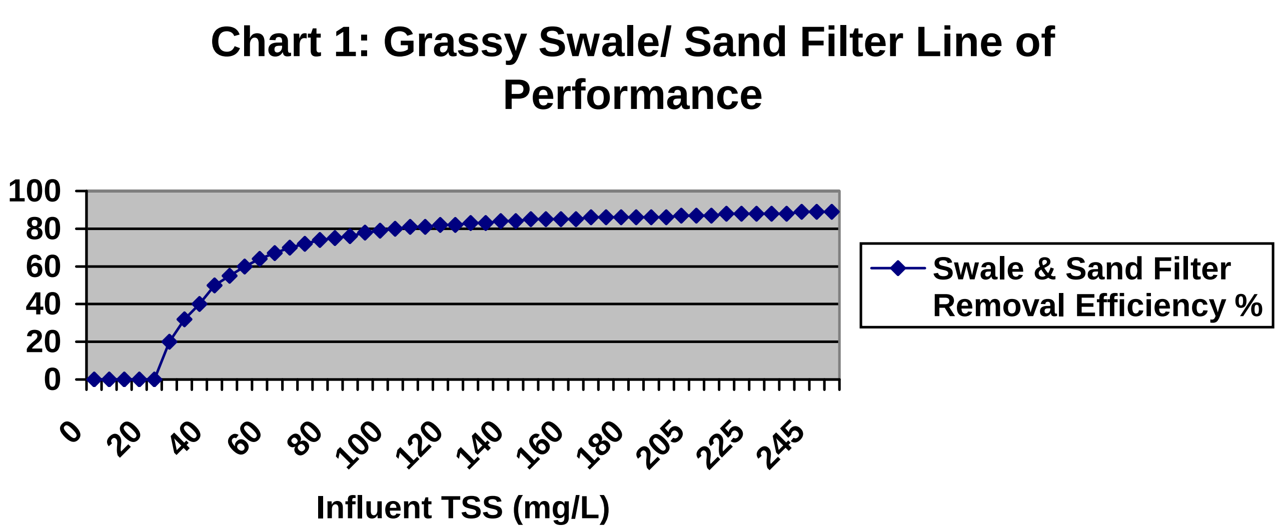
BES will evaluate the data submitted by the vendors, and group each technology into one or more of the following classifications:

- Presumptive Approach (TSS)
- Pretreatment Only
- Oil/ Water Separation
- Specific Pollutants of Concern (TMDL pollutants)
- Acceptable as Public Facility
- Private Facility Only
- Not Approved for Any Application
- Insufficient Information, Provide Additional Data

LINES OF COMPARABLE PERFORMANCE

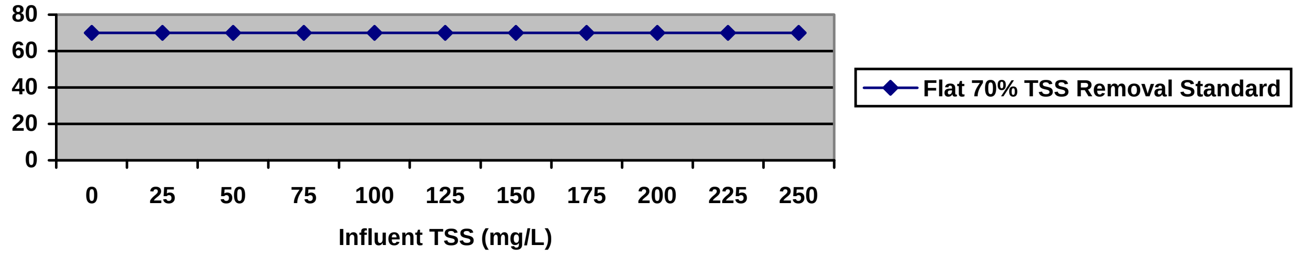
As mentioned earlier, BES will use the "Line of Comparative Performance©" method to evaluate a treatment technology's ability to remove TSS. The following table describes the data points that form the approximate grassy swale/ sand filter comparison line:

INFLUENT TSS (mg/L)	REMOVAL EFFICIENCY
20	0 %
25	20 %
50	60 %
75	74 %
100	80 %
125	83 %
150	85 %
175	87 %
200	88 %
250	89 %



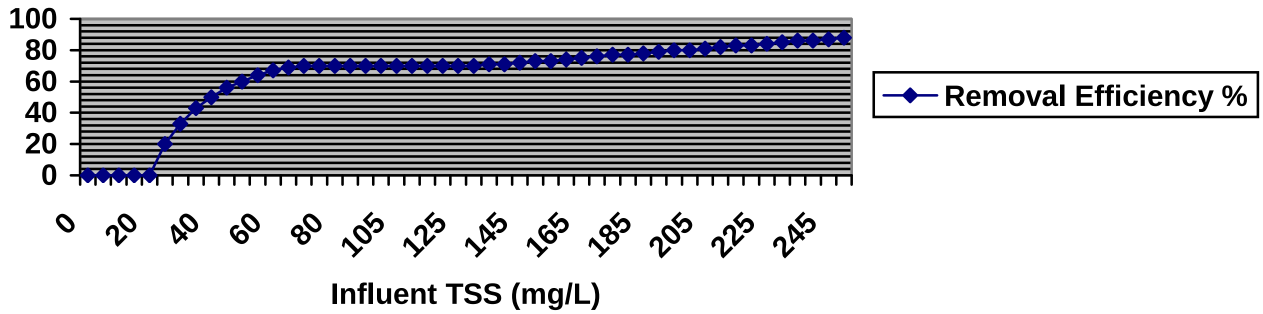
The following chart represents a flat "70% TSS Removal" standard:

Chart 2: Flat 70% TSS Removal Line



The following performance line is consistent with the City of Portland's 70% TSS removal standard and takes into account influent TSS concentrations:

Chart 3: Portland's Modified Performance Standard Line



According to Section 403 Report to Congress, U.S. EPA, 1995, "Typical" stormwater contains about 100 mg/L TSS. This line specifies 70% TSS removal for a range 30% below and 30% above 100 mg/L. For every point with less than 70 mg/L influent TSS, it is assumed that the effluent will be the minimum allowed 20 mg/L. For influent concentrations greater than 130 mg/L, the points rise linearly to 88% removal at 250 mg/L, which is a point shared with the swale/ sand filter comparison line.

To meet the City of Portland's basic pollution reduction standard, at least 50% of a technology's data points should fall above this line of performance, as approved by BES. Efficiency calculation methods on page B-9 and 10 shall be used to plot points on the chart. Facilities will be required to remove more than 70% for high (<130 mg/L) influent concentrations, while being allowed to remove less than 70% for low (<70 mg/L) influent concentrations. This will result in facilities being evaluated as they actually perform in the field, with those that average 70% TSS removal during the design storm of 0.83 inches over 24 hours receiving acceptable performance evaluations.

SAMPLE DATA COLLECTION SHEET

FIELD SITE #1

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

FIELD SITE #2

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

FIELD SITE #3

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

LABORATORY STUDIES WITH "REAL" STORMWATER

TEST 1= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 2= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 3= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 4= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 5= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 6= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 7= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____
TEST 8= 10 sub-samples: ave. influent conc.=_____; ave. effluent conc.=_____; efficiency=_____

LABORATORY STUDIES WITH SPIKED WATER

TEST 1: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 2: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 3: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 4: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 5: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 6: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____
TEST 7: influent load mass over entire storm=_____; captured load mass=_____; efficiency=_____

VI. REFERENCES

Washington Department of Ecology, “Draft 4: Vendor Submission Guidance for Evaluating Emerging Stormwater Treatment Technologies”, October 2000

Puget Sound Watershed, “Final Draft: Protocol for the Acceptance of Unapproved Stormwater Treatment Technologies for Use in the Puget Sound Watershed”, APWA Task Committee, November 1999

The County of Sacramento and Cities of Citrus Heights, Folsom, Galt, and Sacramento, “Investigation of Structural Control Measures for New Development”, November 1999

Boyd, Gail, URS Corporation, personal communication

Technical Update #1

Subject: **Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies: Clarification Regarding "TSS" versus "SSC" Testing Methods**

Date: **July 5, 2001**

The recently released USGS policy regarding the collection and use of total suspended solids data in determining the suspended sediment load in stormwater runoff was recently brought to our attention. We have been reviewing the USGS "Comparability of Suspended-Sediment Concentration and Total Suspended Solids Data" document dated August of 2000, and would like to clarify our sampling specifications, as listed in the above mentioned "Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies".

By using "Total Suspended Solids" or "TSS" terminology, we may have implied that the *Total Suspended Solids Analytical Method*, as described by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation should be used to analyze test samples. According to the USGS study (Water-Resources Investigations Report 00-4191 by John R. Gray, G. Douglas Glysson, Lisa M. Turcios, and Gregory E. Schwarz) this method, which uses predetermined sub-sample volumes from an original water sample obtained while the sample is being mixed, is fundamentally unreliable for the analysis of natural-water samples. Methods used in the withdrawal of an aliquot of the original sample are inconsistent and often non-representative of the sample.

The *Suspended-Sediment Concentration Analytical Method*, however, measures all sediment and the mass of the entire water-sediment mixture. ASTM Standard Test Method D 3977-97 lists three methods that result in a determination of SSC values in water and wastewater samples: Test Method A- Evaporation, Test Method B- Filtration, and Test Method C- Wet-sieving filtration. The percentage of sand-size and finer material can be determined as part of the SSC method, but not as part of the TSS method. Overall, the SSC method "produces relatively reliable results for samples of natural water, regardless of the amount or percentage of sand-size material in the samples".

We would like to see the *Suspended-Sediment Concentration Analytical Method* used, as described in ASTM D 3977-97 for analysis of suspended sediment load in stormwater runoff.

Appendix C Table of Contents

Go to BES Stormwater Management Manual Website for the most up to date version of the Calculator:

http://www.portlandonline.com/bes/index.cfm?c=47952&

Appendix C.1: Santa Barbara Urban Hydrograph Method

INTRODUCTION

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District to determine a runoff hydrograph for an urbanized area. It is a simpler method than some other approaches, as it computes a hydrograph directly without going through intermediate steps (i.e., a unit hydrograph) to determine the runoff hydrograph.

The SBUH method is a popular method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the method approved by the Bureau of Environmental Services (BES) for determining runoff when doing flow control calculations.

ELEMENTS OF THE SBUH METHOD

The SBUH method depends on several variables:

- Pervious (A_p) and impervious (A_{imp}) land areas
- Time of concentration (T_c) calculations
- Runoff curve numbers (CN) applicable to the site
- Design storm

These elements shall all be presented as part of the submittal process for review by BES staff. In addition, maps showing the pre-development and post-development conditions shall be presented to BES to help in the review.

Land Area

The total area, including the pervious and impervious areas within a drainage basin, shall be quantified in order to evaluate critical contributing areas and the resulting site runoff. Each area within a basin shall be analyzed separately and their hydrographs combined to determine the total basin hydrograph. Areas shall be selected to represent homogenous land use/development units.

Time of Concentration

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed. (In this case, T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration.) T_c depends on several factors, including ground slope, ground roughness, and distance of flow. The following formula for determining T_c is found in BES's *Sewer Design Manual*.

Formulas

$T_c = T_{t1} + T_{c2} + T_{c3} + \ldots + T_{cn}$

$T_t = L/60V$ (Conversion of velocity to travel time)

$$T_t = \frac{0.42\,(nL)^{0.8}}{1.58(s)^{0.4}}$$ (Manning's kinematic solution for sheet flow less than 300 feet)

(Shallow concentrated flow for slopes less than 0.005 ft/ft. For steeper slopes, consult BES's Sewer Design Manual):

$V = 16.1345(s)^{0.5}$ (Unpaved surfaces)

$V = 20.3282(s)^{0.5}$ (Paved surfaces)

Where,

T_t = travel time, minutes
T_c = total time of concentration, minutes (minimum T_c = 5 minutes)
L = flow length, feet
V = average velocity of flow, feet per second
n = Manning's roughness coefficient for various surfaces (see Chart 10 of the 1991 Sewer Design Manual)
s = slope of the hydraulic grade line (land or watercourse slope), feet per foot

When calculating $T_{c,}$ the following limitations apply:

- Overland sheet flow (flow across flat areas that does not form into channels or rivulets) shall not extend for more than 300 feet.
- For flow paths through closed conveyance facilities such as pipes and culverts, standard hydraulic formulas shall be used for establishing velocity and travel time. (See the *Sewer Design Manual* for more data on pipe flow rates and velocities.)
- Flow paths through lakes or wetlands may be assumed to be zero (i.e. $T_c = 0$).

Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to reduce diverse characteristics such as soil type, land usage, and vegetation into a single variable for doing runoff calculations. The runoff curve numbers approved by BES for water quantity/quality calculations are included as Table C-2 of this appendix.

The curve numbers presented in Table C-2 are for *wet* antecedent moisture conditions. Wet conditions assume previous rainstorms have reduced the capacity of soil to absorb water. Given the frequency of rainstorms in the Portland area, wet conditions are most likely, and give conservative hydrographic values.

Design Storm

The SBUH method also requires a design storm to perform the runoff calculations. For flow control calculations, BES uses a NRCS Type 1A 24-hour storm distribution. This storm is shown in Figure C-1 and Table C-4. The depth of rainfall for the 2 through 100-year storm events is shown below in Table C-1.

Table C-1
24-HOUR RAINFALL DEPTHS AT PORTLAND AIRPORT

Recurrence Interval, Years	2	5	10	25	100
24-Hour Depths, Inches	2.4	2.9	3.4	3.9	4.4

Table C-2
RUNOFF CURVE NUMBERS

<u>Runoff curve numbers for urban areas</u>*

Cover description		**Curve numbers for hydrologic soil group**			
Cover type and hydrologic condition	Average percent impervious area	A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor condition (grass cover <50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

<u>Runoff curve numbers for other agricultural lands*</u>

Cover description		**Curve numbers for hydrologic soil group**			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range-continuous forage for grazing					
<50% ground cover or heavily grazed with no mulch	Poor	68	79	86	89
50 to 75% ground cover and not heavily grazed	Fair	49	69	79	84
>75% ground cover and lightly or only occasionally grazed	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay	-	30	58	71	78
Brush--weed-grass mixture with brush as the major element					
<50% ground cover	Poor	48	67	77	83
50 to 75% ground cover	Fair	35	56	70	77
>75% ground cover	Good	30	48	65	73
Woods-grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79

Runoff curve numbers for other agricultural lands*

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Woods					
Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.	Poor	45	66	77	83
Woods are grazed but not burned, and some forest litter covers the soil.	Fair	36	60	73	79
Woods are protected from grazing, and litter and brush adequately cover the soil.	Good	30	55	70	77

Runoff curve numbers for Simplified Approaches**

Cover description		Curve numbers for hydrologic soil group			
Simplified Approaches	Hydrologic condition	A	B	C	D
Eco-roof	Good	n/a	61	n/a	n/a
Roof Garden	Good	n/a	48	n/a	n/a
Contained Planter Box	Good	n/a	48	n/a	n/a
Infiltration & Flow-Through Planter Box	Good	n/a	48	n/a	n/a
Pervious Pavement	-	76	85	89	n/a
Trees					
New and/or Existing Evergreen	-	36	60	73	79
New and/or Existing Deciduous	-	36	60	73	79

n/a - Does not apply, as design criteria for the relevant mitigation measures do not include the use of this soil type.
*Soil Conservation Service, *Urban Hydrology for Small Watersheds*, Technical Release 55, pp. 2.5-2.8, June 1986.
**CNs of various cover types were assigned to the Proposed Simplified Approaches with similar cover types as follows:

Eco-roof – assumed grass in good condition with soil type B.
Roof Garden – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Contained Planter Box – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Infiltration & Flow-Through Planter Box – assumed brush-weed-grass mixture with >75% ground cover and soil type B.
Pervious Pavement – assumed gravel.
Trees – assumed woods with fair hydrologic conditions.

Note: To determine hydrologic soil type, consult local USDA Soil Conservation Service Soil Survey.

TABLE C-3
NRCS HYDROLOGIC SOIL GROUP DESCRIPTIONS

NRCS Hydrologic Soil Group	Description
Group A	Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.
Group B	Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
Group C	Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.
Group D	Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a fragipan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Figure C-1 - NRCS 24-Hour Type 1A Hyetograph

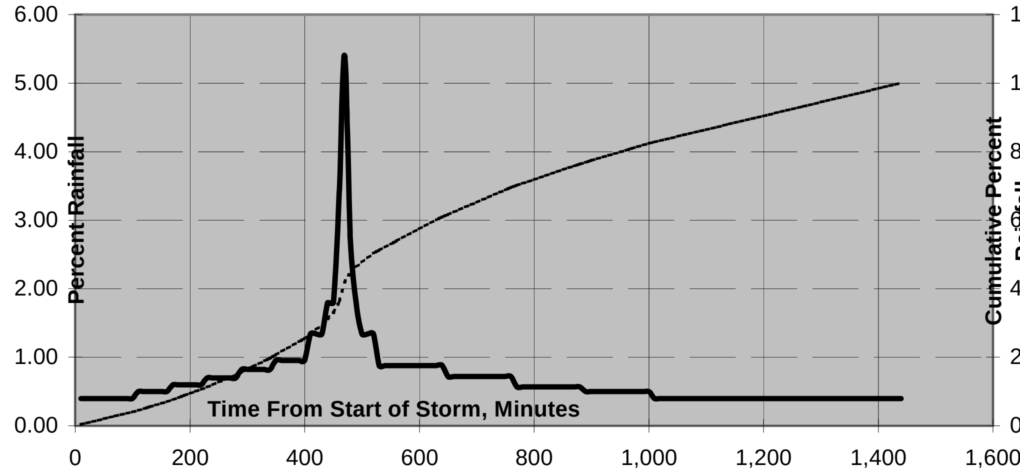


Table C-3 - NRCS Type 1A Hyetographic Distrubution - For Use In Water Quality/Quantity Design

Time From Start of Storm, Minutes	% Rainfall	Cumulative % Rainfall
0 - 10	0.40	0.40
10 - 20	0.40	0.80
20 - 30	0.40	1.20
30 - 40	0.40	1.60
40 - 50	0.40	2.00
50 - 60	0.40	2.40
60 - 70	0.40	2.80
70 - 80	0.40	3.20
80 - 90	0.40	3.60
90 - 100	0.40	4.00
100 - 110	0.50	4.50
110 - 120	0.50	5.00
120 - 130	0.50	5.50
130 - 140	0.50	6.00
140 - 150	0.50	6.50
150 - 160	0.50	7.00
160 - 170	0.60	7.60
170 - 180	0.60	8.20
180 - 190	0.60	8.80
190 - 200	0.60	9.40
200 - 210	0.60	10.00
210 - 220	0.60	10.60
220 - 230	0.70	11.30
230 - 240	0.70	12.00
240 - 250	0.70	12.70
250 - 260	0.70	13.40
260 - 270	0.70	14.10
270 - 280	0.70	14.80
280 - 290	0.82	15.62
290 - 300	0.82	16.44
300 - 310	0.82	17.26
310 - 320	0.82	18.08
320 - 330	0.82	18.90
330 - 340	0.82	19.72
340 - 350	0.95	20.67
350 - 360	0.95	21.62
360 - 370	0.95	22.57
370 - 380	0.95	23.52
380 - 390	0.95	24.47
390 - 400	0.95	25.42
400 - 410	1.34	26.76
410 - 420	1.34	28.10
420 - 430	1.34	29.44
430 - 440	1.80	31.24
440 - 450	1.80	33.04
450 - 460	3.40	36.44
460 - 470	5.40	41.84
470 - 480	2.70	44.54
480 - 490	1.80	46.34
490 - 500	1.34	47.68
500 - 510	1.34	49.02
510 - 520	1.34	50.36
520 - 530	0.88	51.24
530 - 540	0.88	52.12
540 - 550	0.88	53.00
550 - 560	0.88	53.88
560 - 570	0.88	54.76
570 - 580	0.88	55.64
580 - 590	0.88	56.52
590 - 600	0.88	57.40
600 - 610	0.88	58.28
610 - 620	0.88	59.16
620 - 630	0.88	60.04
630 - 640	0.88	60.92
640 - 650	0.72	61.64
650 - 660	0.72	62.36
660 - 670	0.72	63.08
670 - 680	0.72	63.80
680 - 690	0.72	64.52
690 - 700	0.72	65.24
700 - 710	0.72	65.96
710 - 720	0.72	66.68
720 - 730	0.72	67.40
730 - 740	0.72	68.12
740 - 750	0.72	68.84
750 - 760	0.72	69.56
760 - 770	0.57	70.13
770 - 780	0.57	70.70
780 - 790	0.57	71.27
790 - 800	0.57	71.84
800 - 810	0.57	72.41
810 - 820	0.57	72.98
820 - 830	0.57	73.55
830 - 840	0.57	74.12
840 - 850	0.57	74.69
850 - 860	0.57	75.26
860 - 870	0.57	75.83
870 - 880	0.57	76.40
880 - 890	0.50	76.90
890 - 900	0.50	77.40
900 - 910	0.50	77.90
910 - 920	0.50	78.40
920 - 930	0.50	78.90
930 - 940	0.50	79.40
940 - 950	0.50	79.90
950 - 960	0.50	80.40
960 - 970	0.50	80.90
970 - 980	0.50	81.40
980 - 990	0.50	81.90
990 - 1000	0.50	82.40
1000 - 1010	0.40	82.80
1010 - 1020	0.40	83.20
1020 - 1030	0.40	83.60
1030 - 1040	0.40	84.00
1040 - 1050	0.40	84.40
1050 - 1060	0.40	84.80
1060 - 1070	0.40	85.20
1070 - 1080	0.40	85.60
1080 - 1090	0.40	86.00
1090 - 1100	0.40	86.40
1100 - 1110	0.40	86.80
1110 - 1120	0.40	87.20
1120 - 1130	0.40	87.60
1130 - 1140	0.40	88.00
1140 - 1150	0.40	88.40
1150 - 1160	0.40	88.80
1160 - 1170	0.40	89.20
1170 - 1180	0.40	89.60
1180 - 1190	0.40	90.00
1190 - 1200	0.40	90.40
1200 - 1210	0.40	90.80
1210 - 1220	0.40	91.20
1220 - 1230	0.40	91.60
1230 - 1240	0.40	92.00
1240 - 1250	0.40	92.40
1250 - 1260	0.40	92.80
1260 - 1270	0.40	93.20
1270 - 1280	0.40	93.60
1280 - 1290	0.40	94.00
1290 - 1300	0.40	94.40
1300 - 1310	0.40	94.80
1310 - 1320	0.40	95.20
1320 - 1330	0.40	95.60
1330 - 1340	0.40	96.00
1340 - 1350	0.40	96.40
1350 - 1360	0.40	96.80
1360 - 1370	0.40	97.20
1370 - 1380	0.40	97.60
1380 - 1390	0.40	98.00
1390 - 1400	0.40	98.40
1400 - 1410	0.40	98.80
1410 - 1420	0.40	99.20
1420 - 1430	0.40	99.60
1430 - 1440	0.40	100.00

Appendix C.2: Simplified Approach Sizing Calculations

BES staff conducted a technical process to determine facility designs and sizes that would be appropriate for small development sites. The process included a review of technical literature, review of BES monitoring data, calculations, and theoretical analysis. The sizing factors on the **Simplified Form** were developed as a simple site planning tool for small projects and to accelerate permit review and approval. Generalized assumptions were used and are documented in the Simplified Sizing requirements in **Section 2.3**. Facilities sized through this approach assume that there is an overflow to an approved discharge point. Facilities built to the standards of Simplified Sizing are assumed to meet pollution reduction and flow control requirements but not infiltration and discharge requirements. Applicants have the option to use the sizing factors provided on the Simplified Approach Form or to follow the Presumptive or Performance Approach and submit an alternative facility size, along with supporting engineering or PAC calculations for BES review and consideration.

The spreadsheet columns are described below:

Column (1)	Time in Minutes
Column (2)	Inflow (cfs) **Note: Contributing Impervious Area = 1 acre** **Note: 10-Year Storm Event (3.4"/24 hours)**
Column (3)	Inflow Volume (cf) = Inflow (cfs) x 60 (sec/min) x 10 (min)
Column (4)	Cumulative Volume (cf) = Inflow Volume(cf) + Cumulative Inflow (cf) of previous step
Column (5)	Infiltration (cfs) = If(Inflow < Max Infiltration, Inflow, Maximum Infiltration)
Column (6)	Maximum Infiltration (cfs) = Infiltration Area (sf) x Infiltration Rate (ft/s) **Note: Infiltration rate is assumed to be 2.0"/hr in this case.**
Column (7)	Incremental Storage (cf) = [Inflow (cfs) – Infiltration (cfs)] x 60 (sec/min) x 10 (min)
Column (8)	Cumulative Storage (cf)
Column (9)	Percent Storage Capacity = Cumulative Storage / Facility Storage x 100 Planter Facility Storage = Facility Bottom Area (sf) x Storage Depth (ft) For this example: Bottom Area = 2,825 sf Storage Depth = 1 ft **Note that the storage capacity does not exceed 100% which would result in an overflow condition. The maximum depth of 12 inches is not exceeded.** **Resulting planter square-footage is 2,825 sf, which when divided by the 43,560 square-foot impervious surface equals a 0.065 sizing factor.**

(1) Time (minutes)	(2) Inflow (cfs)	(3) Inflow Volume (cf)	(4) Cummulative Volume (cf)	(5) Infiltration (cfs)	(6) Max. Infiltration (cfs)	(7) Incremental Storage (cf)	(8) Cummulative Storage Volume (cf)	(9) % Storage Capacity (%)
0	0.0000	0.00	0.00	0.0000	0.1308	-78.47	0.00	0%
10	0.0000	0.00	0.00	0.0000	0.1308	-78.47	0.00	0%
20	0.0000	0.00	0.00	0.0000	0.1308	-78.47	0.00	0%
30	0.0000	0.00	0.00	0.0000	0.1308	-78.47	0.00	0%
40	0.0026	1.54	1.54	0.0026	0.1308	-76.93	0.00	0%
50	0.0097	5.80	7.34	0.0097	0.1308	-72.67	0.00	0%
60	0.0180	10.79	18.13	0.0180	0.1308	-67.68	0.00	0%
70	0.0249	14.97	33.10	0.0249	0.1308	-63.50	0.00	0%
80	0.0308	18.50	51.60	0.0308	0.1308	-59.97	0.00	0%
90	0.0359	21.52	73.12	0.0359	0.1308	-56.95	0.00	0%
100	0.0402	24.11	97.24	0.0402	0.1308	-54.36	0.00	0%
110	0.0499	29.94	127.17	0.0499	0.1308	-48.54	0.00	0%
120	0.0599	35.94	163.11	0.0599	0.1308	-42.53	0.00	0%
130	0.0642	38.51	201.62	0.0642	0.1308	-39.96	0.00	0%
140	0.0679	40.71	242.33	0.0679	0.1308	-37.76	0.00	0%
150	0.0710	42.61	284.95	0.0710	0.1308	-35.86	0.00	0%
160	0.0738	44.27	329.22	0.0738	0.1308	-34.20	0.00	0%
170	0.0841	50.43	379.65	0.0841	0.1308	-28.04	0.00	0%
180	0.0944	56.66	436.31	0.0944	0.1308	-21.81	0.00	0%
190	0.0971	58.24	494.55	0.0971	0.1308	-20.24	0.00	0%
200	0.0993	59.60	554.15	0.0993	0.1308	-18.87	0.00	0%
210	0.1013	60.80	614.95	0.1013	0.1308	-17.67	0.00	0%
220	0.1031	61.85	676.81	0.1031	0.1308	-16.62	0.00	0%
230	0.1135	68.10	744.90	0.1135	0.1308	-10.38	0.00	0%
240	0.1239	74.37	819.27	0.1239	0.1308	-4.11	0.00	0%
250	0.1256	75.35	894.62	0.1256	0.1308	-3.12	0.00	0%
260	0.1270	76.22	970.83	0.1270	0.1308	-2.26	0.00	0%
270	0.1283	76.99	1047.82	0.1283	0.1308	-1.49	0.00	0%
280	0.1294	77.67	1125.49	0.1294	0.1308	-0.80	0.00	0%
290	0.1417	85.04	1210.53	0.1308	0.1308	6.57	6.57	0%
300	0.1541	92.45	1302.98	0.1308	0.1308	13.98	20.55	1%
310	0.1552	93.11	1396.09	0.1308	0.1308	14.64	35.19	1%
320	0.1562	93.70	1489.79	0.1308	0.1308	15.23	50.42	2%
330	0.1571	94.23	1584.03	0.1308	0.1308	15.76	66.18	2%
340	0.1578	94.71	1678.73	0.1308	0.1308	16.23	82.41	3%
350	0.1712	102.71	1781.44	0.1308	0.1308	24.24	106.65	4%
360	0.1845	110.73	1892.17	0.1308	0.1308	32.26	138.90	5%
370	0.1853	111.19	2003.36	0.1308	0.1308	32.72	171.62	6%
380	0.1860	111.60	2114.96	0.1308	0.1308	33.13	204.75	7%
390	0.1866	111.98	2226.94	0.1308	0.1308	33.50	238.26	8%
400	0.1872	112.31	2339.25	0.1308	0.1308	33.84	272.10	10%
410	0.2263	135.80	2475.06	0.1308	0.1308	57.33	329.43	12%
420	0.2657	159.39	2634.45	0.1308	0.1308	80.92	410.35	15%
430	0.2664	159.87	2794.32	0.1308	0.1308	81.40	491.75	17%
440	0.3131	187.88	2982.20	0.1308	0.1308	109.41	601.16	21%
450	0.3600	215.98	3198.18	0.1308	0.1308	137.51	738.66	26%
460	0.5219	313.11	3511.29	0.1308	0.1308	234.64	973.31	34%
470	0.8866	531.96	4043.26	0.1308	0.1308	453.49	1426.80	51%
480	0.8183	491.00	4534.26	0.1308	0.1308	412.53	1839.32	65%

(1) Time (minutes)	(2) Inflow (cfs)	(3) Inflow Volume (cf)	(4) Cummulative Volume (cf)	(5) Infiltration (cfs)	(6) Max. Infiltration (cfs)	(7) Incremental Storage (cf)	(8) Cummulative Storage Volume (cf)	(9) % Storage Capacity (%)
490	0.4558	273.50	4807.76	0.1308	0.1308	195.03	2034.35	72%
500	0.3185	191.07	4998.83	0.1308	0.1308	112.60	2146.95	76%
510	0.2720	163.22	5162.05	0.1308	0.1308	84.75	2231.70	79%
520	0.2722	163.32	5325.38	0.1308	0.1308	84.85	2316.55	82%
530	0.2256	135.36	5460.73	0.1308	0.1308	56.89	2373.44	84%
540	0.1789	107.36	5568.10	0.1308	0.1308	28.89	2402.33	85%
550	0.1790	107.40	5675.50	0.1308	0.1308	28.93	2431.26	86%
560	0.1791	107.44	5782.94	0.1308	0.1308	28.97	2460.23	87%
570	0.1791	107.47	5890.41	0.1308	0.1308	29.00	2489.23	88%
580	0.1792	107.51	5997.92	0.1308	0.1308	29.03	2518.26	89%
590	0.1792	107.54	6105.46	0.1308	0.1308	29.07	2547.33	90%
600	0.1793	107.57	6213.02	0.1308	0.1308	29.10	2576.42	91%
610	0.1793	107.60	6320.62	0.1308	0.1308	29.13	2605.55	92%
620	0.1794	107.63	6428.25	0.1308	0.1308	29.15	2634.70	93%
630	0.1794	107.65	6535.90	0.1308	0.1308	29.18	2663.88	94%
640	0.1795	107.68	6643.58	0.1308	0.1308	29.21	2693.09	95%
650	0.1632	97.91	6741.49	0.1308	0.1308	19.44	2712.53	96%
660	0.1469	88.14	6829.63	0.1308	0.1308	9.66	2722.19	96%
670	0.1469	88.15	6917.78	0.1308	0.1308	9.68	2731.87	97%
680	0.1469	88.17	7005.95	0.1308	0.1308	9.70	2741.57	97%
690	0.1470	88.18	7094.13	0.1308	0.1308	9.71	2751.28	97%
700	0.1470	88.20	7182.33	0.1308	0.1308	9.72	2761.00	98%
710	0.1470	88.21	7270.54	0.1308	0.1308	9.74	2770.74	98%
720	0.1470	88.22	7358.76	0.1308	0.1308	9.75	2780.49	98%
730	0.1471	88.24	7446.99	0.1308	0.1308	9.76	2790.26	99%
740	0.1471	88.25	7535.24	0.1308	0.1308	9.78	2800.03	99%
750	0.1471	88.26	7623.50	0.1308	0.1308	9.79	2809.82	99%
760	0.1471	88.27	7711.77	0.1308	0.1308	9.80	2819.62	100%
770	0.1318	79.09	7790.86	0.1308	0.1308	0.61	2820.23	100%
780	0.1165	69.90	7860.76	0.1165	0.1308	-8.57	2811.66	100%
790	0.1165	69.90	7930.66	0.1165	0.1308	-8.57	2803.09	99%
800	0.1165	69.91	8000.57	0.1165	0.1308	-8.56	2794.53	99%
810	0.1165	69.92	8070.49	0.1165	0.1308	-8.55	2785.98	99%
820	0.1165	69.92	8140.42	0.1165	0.1308	-8.55	2777.43	98%
830	0.1166	69.93	8210.35	0.1166	0.1308	-8.54	2768.89	98%
840	0.1166	69.94	8280.28	0.1166	0.1308	-8.54	2760.35	98%
850	0.1166	69.94	8350.23	0.1166	0.1308	-8.53	2751.82	97%
860	0.1166	69.95	8420.17	0.1166	0.1308	-8.52	2743.30	97%
870	0.1166	69.95	8490.13	0.1166	0.1308	-8.52	2734.78	97%
880	0.1166	69.96	8560.09	0.1166	0.1308	-8.51	2726.27	97%
890	0.1094	65.67	8625.76	0.1094	0.1308	-12.80	2713.46	96%
900	0.1023	61.38	8687.13	0.1023	0.1308	-17.10	2696.37	95%
910	0.1023	61.38	8748.51	0.1023	0.1308	-17.09	2679.28	95%
920	0.1023	61.38	8809.90	0.1023	0.1308	-17.09	2662.19	94%
930	0.1023	61.39	8871.29	0.1023	0.1308	-17.08	2645.10	94%
940	0.1023	61.39	8932.68	0.1023	0.1308	-17.08	2628.03	93%
950	0.1023	61.40	8994.08	0.1023	0.1308	-17.08	2610.95	92%
960	0.1023	61.40	9055.48	0.1023	0.1308	-17.07	2593.88	92%
970	0.1023	61.40	9116.88	0.1023	0.1308	-17.07	2576.81	91%

(1) Time (minutes)	(2) Inflow (cfs)	(3) Inflow Volume (cf)	(4) Cummulative Volume (cf)	(5) Infiltration (cfs)	(6) Max. Infiltration (cfs)	(7) Incremental Storage (cf)	(8) Cummulative Storage Volume (cf)	(9) % Storage Capacity (%)
980	0.1023	61.41	9178.29	0.1023	0.1308	-17.06	2559.74	91%
990	0.1024	61.41	9239.70	0.1024	0.1308	-17.06	2542.68	90%
1000	0.1024	61.41	9301.11	0.1024	0.1308	-17.06	2525.62	89%
1010	0.0921	55.28	9356.39	0.0921	0.1308	-23.20	2502.43	89%
1020	0.0819	49.14	9405.53	0.0819	0.1308	-29.34	2473.09	88%
1030	0.0819	49.14	9454.66	0.0819	0.1308	-29.33	2443.76	87%
1040	0.0819	49.14	9503.80	0.0819	0.1308	-29.33	2414.43	85%
1050	0.0819	49.14	9552.95	0.0819	0.1308	-29.33	2385.10	84%
1060	0.0819	49.14	9602.09	0.0819	0.1308	-29.33	2355.77	83%
1070	0.0819	49.15	9651.24	0.0819	0.1308	-29.33	2326.44	82%
1080	0.0819	49.15	9700.39	0.0819	0.1308	-29.32	2297.12	81%
1090	0.0819	49.15	9749.54	0.0819	0.1308	-29.32	2267.80	80%
1100	0.0819	49.15	9798.69	0.0819	0.1308	-29.32	2238.48	79%
1110	0.0819	49.15	9847.84	0.0819	0.1308	-29.32	2209.16	78%
1120	0.0819	49.16	9897.00	0.0819	0.1308	-29.32	2179.84	77%
1130	0.0819	49.16	9946.16	0.0819	0.1308	-29.31	2150.53	76%
1140	0.0819	49.16	9995.32	0.0819	0.1308	-29.31	2121.22	75%
1150	0.0819	49.16	10044.48	0.0819	0.1308	-29.31	2091.91	74%
1160	0.0819	49.16	10093.64	0.0819	0.1308	-29.31	2062.60	73%
1170	0.0819	49.16	10142.81	0.0819	0.1308	-29.31	2033.29	72%
1180	0.0819	49.17	10191.97	0.0819	0.1308	-29.31	2003.98	71%
1190	0.0819	49.17	10241.14	0.0819	0.1308	-29.30	1974.68	70%
1200	0.0820	49.17	10290.31	0.0820	0.1308	-29.30	1945.38	69%
1210	0.0820	49.17	10339.48	0.0820	0.1308	-29.30	1916.08	68%
1220	0.0820	49.17	10388.66	0.0820	0.1308	-29.30	1886.78	67%
1230	0.0820	49.18	10437.83	0.0820	0.1308	-29.30	1857.48	66%
1240	0.0820	49.18	10487.01	0.0820	0.1308	-29.30	1828.19	65%
1250	0.0820	49.18	10536.19	0.0820	0.1308	-29.29	1798.89	64%
1260	0.0820	49.18	10585.37	0.0820	0.1308	-29.29	1769.60	63%
1270	0.0820	49.18	10634.55	0.0820	0.1308	-29.29	1740.31	62%
1280	0.0820	49.18	10683.73	0.0820	0.1308	-29.29	1711.02	61%
1290	0.0820	49.18	10732.91	0.0820	0.1308	-29.29	1681.73	60%
1300	0.0820	49.19	10782.10	0.0820	0.1308	-29.29	1652.44	58%
1310	0.0820	49.19	10831.29	0.0820	0.1308	-29.28	1623.16	57%
1320	0.0820	49.19	10880.48	0.0820	0.1308	-29.28	1593.88	56%
1330	0.0820	49.19	10929.67	0.0820	0.1308	-29.28	1564.59	55%
1340	0.0820	49.19	10978.86	0.0820	0.1308	-29.28	1535.31	54%
1350	0.0820	49.19	11028.05	0.0820	0.1308	-29.28	1506.03	53%
1360	0.0820	49.19	11077.24	0.0820	0.1308	-29.28	1476.76	52%
1370	0.0820	49.20	11126.44	0.0820	0.1308	-29.28	1447.48	51%
1380	0.0820	49.20	11175.64	0.0820	0.1308	-29.28	1418.20	50%
1390	0.0820	49.20	11224.84	0.0820	0.1308	-29.27	1388.93	49%
1400	0.0820	49.20	11274.04	0.0820	0.1308	-29.27	1359.66	48%
1410	0.0820	49.20	11323.24	0.0820	0.1308	-29.27	1330.39	47%
1420	0.0820	49.20	11372.44	0.0820	0.1308	-29.27	1301.12	46%
1430	0.0820	49.20	11421.64	0.0820	0.1308	-29.27	1271.85	45%
1440	0.0820	49.20	11470.85	0.0820	0.1308	-29.27	1242.58	44%
1450	0.0410	24.60	11495.45	0.0410	0.1308	-53.87	1188.71	42%

Appendix C.3 Presumptive Approach Calculator

C.3 Presumptive Approach Calculator – Not Included in this Document

Presumptive Approach Calculator (PAC)

PAC User's Manual

PAC Stormwater Narrative

Go to BES Stormwater Management Manual Website for the most up to date version of the Calculator:

http://www.portlandonline.com/bes/index.cfm?c=47952&

Appendix D Submittal Guides and Forms

This appendix identifies the minimum submittal requirements for projects proposed under the 2008 *Stormwater Management Manual*. The City may require additional information prior to project approval.

APPENDIX D.1 LANDSCAPE SUBMITTAL GUIDE

Landscape specifications and plans are required (as described in **Section 2.3.2**) with all permits that include at least one vegetated stormwater facility. The only exception is where a contract with the Bureau of Environmental Services (BES) Watershed Revegetation Program is confirmed.

Landscape specifications and plans must address all elements that ensure plant survival and overall stormwater facility functional success. At a minimum, landscape specifications and plans must include:

- A planting plan that indicates existing vegetation to be preserved, the location of all landscape elements, and the size, species and location of all proposed plantings. The plant species should be selected and placed in accordance with proper delineation of Zone A (wet zone) and Zone B (moderate to dry zone), where appropriate.

- A plant list or table, including botanic and common names, size at time of planting, quantity, spacing, type of container, evergreen or deciduous, and other information related to the facility-specific planting, in accordance with landscape industry standards.

- A soil analysis for the stormwater facility growing medium (required for all public facilities and may be required for private facilities). A soil analysis is not required for single-family residential sites. The source of the growing medium must be provided. The location of all stockpiles must be indicated on plans, including erosion protection measures per the City's *Erosion Control Manual*.

- The method of irrigation to be used for the establishment period and for the permanent long term. Public stormwater management facilities must be designed so permanent long-term irrigation systems are not needed.

See facility specifications in **Section 2.3.3** for plant density and size requirements. See **Appendix G.2** for example planting templates appropriate for public and private streets.

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APPENDIX D.2 LAND USE REVIEW SUBMITTAL GUIDE

Land use review applications must include a conceptual Stormwater Management Plan that indicates stormwater pollution reduction, flow control, and discharge methods in accordance with the stormwater hierarchy (See **Section 1.3.1**). To meet zoning code requirements (Title 33 of the City Code) and use the available land most efficiently, the applicant must determine the proposed stormwater management facilities and illustrate them on a site plan. The size and location of the proposed facilities will be assessed during the review process to ensure that adequate space is available with required setbacks. The facilities must also be located for proper overflow or access to an approved discharge point.

BES and the Bureau of Development Services (BDS) work cooperatively to review proposed stormwater management plans during land use review. BDS Site Development determines infiltration feasibility on private property. BES determines infiltration feasibility in the public right-of-way and approves offsite discharge locations. BES also assesses the Stormwater Management Plan to determine if it meets the *Stormwater Management Manual* and *Sewer and Drainage Facilities Design Manual* requirements. BES provides the technical assessment information to BDS to determine if the land use review application meets zoning code approval criteria.

It is the applicant's responsibility to demonstrate that the stormwater hierarchy requirements are met. Some land use applications require more detailed information and more thorough planning and coordination with BES and BDS Site Development than others prior to land use approval. The determining factors are related to the type of land use review, the complexity of the proposed project, and the existing site conditions.

Land use applications that must address stormwater management can *generally* be divided into the following two categories:

1. Those that verify adequacy of services, such as land divisions, planned developments, zone changes, and conditional uses.
2. Those that verify the available area for stormwater management and in some cases the impact of the stormwater management system, such as environmental reviews, greenway reviews, design reviews, and adjustments to regulations such as setbacks, building coverage, and paved area.

Completing and documenting the first six steps presented in **Section 2.1.2** will meet most, if not all, of the submittal requirements for the Stormwater Management Report (see **Appendix D.4**) and the BES and BDS Site Development land use review process.

The applicant must determine the anticipated stormwater management design approach (Simplified, Presumptive, or Performance) that will be used. When the Presumptive or Performance Approach is used, the applicant must complete and submit the project overview and description, methodology, analysis, and engineering conclusions (described in and the Stormwater Management Report Outline in **Appendix D.4**) with submittal of the application.

To determine which category of the stormwater hierarchy (see **Section 1.3.1**) the project will meet, the applicant must establish if, and to what degree, onsite infiltration is feasible (see **Appendix F.2** for infiltration testing requirements). In addition to providing the justification necessary to select a category of the stormwater hierarchy, the results of the infiltration testing will contribute to decisions regarding type, size, and location of stormwater facilities.

Other Design Considerations:

- Perimeter landscaping requirements, limited available area meeting setback requirements, and the need for impermeable liners or watertight planter boxes may make stormwater facilities impractical along property lines.
- Elevation and topographic constraints must be evaluated to ensure that gravity flow is possible and plumbing code depth of cover requirements for pipes can be met.
- Coordination between the project engineer, architect, and landscape designer may be necessary to ensure that potential conflicts with construction methods and materials(geogrids, drains, footings, foundations, limitations on rooting depth imposed by planter box dimensions, impervious liners, etc.) are considered during the selection of trees and landscaping plantings.
- The landscape design should minimize potential impacts of plan and tree roots on stormwater facilities and utilities, including under drains, storm sewer, and rain drains.
- Tree preservation and tree planting must account for not only initial construction, but also the need for future maintenance of stormwater facilities and utilities.
- Arborist reports should address all stormwater facilities and utilities proposed to encroach in the root protection zones of trees required to be preserved.

When stormwater management is required, the applicant must provide adequate information to show that the proposed development can meet the stormwater requirements at the time of development. In general, this includes:

- ➢ A plant list or table, including botanic and common names, size at time of planting, quantity, spacing, type of container, evergreen or deciduous, and other information related to the facility-specific planting, in accordance with landscape industry standards.

- A site utility plan that includes stormwater management facilities and a proposed discharge point.

- If public street improvements will be required as a condition of land use approval, a plan for managing stormwater from the street and identification of required right-of-way dedications (that include space for stormwater management facilities).

- A Stormwater Management Report (see **Appendix D.4**) that describes how the proposal complies with the stormwater hierarchy, including supporting documentation such as infiltration testing (see **Appendix F.2**) and calculations, per the requirements of the appropriate design approach (see detailed requirements of the Simplified, Presumptive, and Performance Approaches in Appendices D.3, D.4, and D.5).

- Other requirements, depending on the site and complexity of the project. Examples include a grading plan, geotechnical report, and groundwater level testing (see **Appendix F.1**).

The use of the Presumptive and Performance Approach (required for larger and/or complex projects) require the stormwater submittal to be prepared by a qualified professional, as outlined in **Section 2.2**. The submittal must include Presumptive Approach Calculator (PAC) printouts that demonstrate the stormwater facility engineering.

Issues that Frequently Delay Land Use Review Applications

Land use applications that cannot be fully processed or approved often have the following deficiencies related to stormwater management:

- It is not clear whether infiltration is feasible on the site.
- It is not clear which category of the stormwater hierarchy is being met.
- A category of the stormwater hierarchy is chosen without proper justification.
- Access to an offsite stormwater discharge point (drainageway, storm sewer, or combined sewer) is not clearly shown.
- Site plan information is inaccurate or inadequate.

- The amount of land required to accommodate stormwater facilities is not accurately shown.
- Conflicts between stormwater facilities and property line or foundation setbacks are shown.
- Disturbance areas are undefined or inaccurate.
- Proposed and existing impervious areas are undefined or inaccurate.

To ensure a timely review, the land use review applicant is strongly encouraged to address these issues before submitting the land use application by following steps 1 through 5 in **Section 2.1.2**. This information should be included in the Stormwater Report and submitted with the land use application.

APPENDIX D.3 SIMPLIFIED APPROACH SUBMITTAL GUIDE

When the Simplified Approach is used to design stormwater facilities (see **Section 2.2)**, the minimum submittal requirements are as follows.

1. **Scaled Site Plans** must include the following information (at a minimum):

   - Minimum scale of 1 inch to 10 feet
   - North arrow
   - Elevations and topography
   - Property lines
   - Lot area and setbacks
   - Footprints of structures
   - Easements and driveways
   - Wells and septic systems
   - Utility lines
   - Width of right-of-way and curb height
   - Impervious areas
   - Type, location and size of stormwater facility
   - Existing and proposed surface drainage
   - Proposed discharge point

   See Bureau of Development Services site plan checklist www.portlandonline.com/bds

2. **Cross Section and Details** of the proposed facility must be included with the plan set. Where sites are topographically varied, it may be imperative to show elevations of inlets, outlets, and discharge points on the cross-section to show how gravity drainage will be met.

3. The **Simplified Approach Form** (see next page) must be completely filled out. The form includes tables for the required infiltration testing and instructions on how to perform an open pit test. See **Appendix F.2** for further details about infiltration testing and options. The form also provides the simplified sizing for the facilities.

4. The **O&M Form** (see **Appendix D.6**) must be recorded with the appropriate county and submitted to BES Document Services at 1900 SW 4th Ave. Portland, OR 97201.

5. The **O&M Specification** (see **Section 3.3**) must be recorded with the O&M Form and submitted to BES.

6. **Landscape plans** are required (see **Section 2.3.2 and Appendix D.1**).

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FORM
1 SIMPLIFIED APPROACH

Date: ______________________________

Permit Number: ____________________

If total impervious area for submitted development proposal is less than 10,000 square feet, the Simplified Approach form may be used for sizing stormwater facilities.

If total impervious area for submitted development proposal is equal to or greater than 10,000 square feet or includes public or private street improvements, the Presumptive or Performance Approach must be used and a Stormwater Management Report will be required. For more information, refer to the 2008 Stormwater Management Manual (SWMM) Sections 2.2.2 and 2.2.3, respectively.

1 Site Address: ____

____

2 State Property ID (R number): ______________________________

3 Brief Description of Proposed Development ______________________________

____

____

____

____

4 Total Amount of Proposed Impervious Area: ______________________________

Site Evaluation

Please refer to Stormwater Management Manual (SWMM) References and Resources section for site evaluation maps (including soil drainage class, slopes and groundwater).

S1 NRCS Soil Drainage Class: ______________________________

S2 Is the slope anywhere on the project area greater than 20%? ☐ yes ☐ no

S3 Are there known seeps, springs, or a high groundwater table in the project area? ☐ yes ☐ no

If answered yes to questions S2 or S3, then a flow-through or partial infiltration facility is required with overflow to an approved discharge point. If no, see S4.

S4 Required Infiltration Testing: Applicant may conduct a simple open pit test or any of the infiltration testing methods prescribed for the Presumptive Approach. (See Appendix F.2 for specifications.)

Please Note: Each individual tax lot is required to manage the stormwater it generates on the same lot to the maximum extent feasible. If the proposal is unable to meet this requirement, the applicant must submit a Special Circumstances request.

Form 1 - SIMPLIFIED APPROACH

Simplified Approach Infiltration Testing Instructions (Open Pit Test):

1. A simple open pit infiltration test should be conducted where the facility is proposed, or within the direct vicinity.
2. Excavate a test hole to the depth of the bottom of the proposed facility (up to 4 feet). The test hole can be excavated with small excavation equipment or by hand using a shovel, auger, or post-hole digger.
3. If you encounter a layer that is hard enough to prevent further excavation, or if you come across noticeable moisture/water in the soil, stop and measure this depth from the surface and record S5 below. Proceed with the test at this depth.
4. Fill the hole with water to a height of about 12 inches from the bottom of the hole (or to one half the maximum depth of the proposed facility), and record the exact time. Check the water level at regular intervals (every 1 minute for fast-draining soils to every 10 minutes for slower-draining soils) for a minimum of one hour or until all of the water has infiltrated. Record the distance the water has dropped from the top edge of the hole.
5. Repeat this process two more times, for a total of three rounds of testing. These tests should be performed as close together as possible to accurately portray the soil's ability to infiltrate at different levels of saturation. The third test should provide the best measure of the saturated infiltration rate.

For each test pit required, submit all three testing results.

S5 Infiltration Test Results: *For each test include date, time, initial and final water height, duration of test, and infiltration rate in inches per hour.*

Depth of Evacuation: ______________________________

Test 1: ____________	Test 2 : ____________	Test 3 : ____________
Date: ____________	Date: ____________	Date: ____________
Time: ____________	Time: ____________	Time: ____________
Initial water depth: ______	Initial water depth: ______	Initial water depth: ______
Final water depth: ______	Final water depth: ______	Final water depth: ______
Duration of test: ______	Duration of test: ______	Duration of test: ______
Infiltration rate: ______	Infiltration rate: ______	*Infiltration rate: ______

* The pit infiltration rate is the result of the third test.

$$\text{Pit Infiltration Rate} = \frac{\text{Initial Water Depth - Final Water Depth (inches)}}{\text{Duration of test (hours)}}$$

If the pit infiltration rate is greater than or equal to 2 inches per hour then onsite infiltration is required. Applicants may choose either a surface infiltration facility with overflow to a drywell or soakage trench or a surface infiltration facility with an overflow to an approved discharge point. If the tested infiltration rate is below 2 inches per hour, then a flow-through or partial infiltration facility is required with overflow to an approved discharge point.

Projects that infiltrate roof runoff with private soakage trenches or drywells are not required to provide pollution reduction prior to infiltration. This exemption does not apply to projects that discharge stormwater offsite. Single-family residential (up to three units) roofs and footing drains are excluded from UIC registration. Refer to Section 1.4 for specific pollution reduction requirements for UICs.

Form 1 - SIMPLIFIED APPROACH

Facility Sizing Worksheet

(The worksheet is on reverse side)

All facilities sized with this form are presumed to comply with the City's pollution and flow control requirements. Infiltration and discharge requirements are site specific and approved with the use of this form.

Instructions

1 Enter square footage (sf) of total impervious area being developed into BOX 1.

2 Enter square footage (sf) for impervious area reduction techniques.

3 Enter sum of the impervious area reduction techniques into BOX 2.

4 Subtract BOX 2 from BOX 1 to find BOX 3, the amount of impervious area that requires stormwater management.

5 Select appropriate stormwater management facilities based on infiltration rate (page 2).

6 Enter the square footage of impervious area managed that will flow into each facility type.

7 Check whether the planter, swale, basins, and filter strips are flow-through facilities.

8 Multiply each impervious area managed by the corresponding sizing factor. Enter this area as the facility surface area, which is the required size to manage the runoff.

9 Where selecting facilities that will overflow, select the final discharge location.

10 Enter the sum of the total of all the impervious area managed into BOX 4. Box 4 must be $\geq$ Box 3.

Form 1 - SIMPLIFIED APPROACH

Total impervious area being developed or redeveloped: .... ☐ **BOX 1**

1 Impervious Area Reduction

Ecoroof ________ sf
Pervious asphalt or concrete ________ sf
Permeable pavers ________ sf

Total Impervious Area Reduction: .... ☐ **BOX 2**

Total impervious area requiring stormwater management: .... ☐ **BOX 3**

2 Surface Facilities	**Impervious Area Managed**		**Sizing Factor**		**Facility Surface Area**
Planter	________ sf	x	0.06	=	________ sf
Swale	________ sf	x	0.09	=	________ sf
Basin	________ sf	x	0.09	=	________ sf
Vegetated Filter Strip for walks and driveways	________ sf	x	0.20	=	________ sf

Overflow will be directed to *(check all that apply)*:

☐ **Subsurface facility** ☐ **Surface water**
☐ **Stormwater sewer** ☐ **Combined Sewer**

3 Subsurface Facilities

The following subsurface facilities can receive overflow from the facilities listed above or can be used independently to manage stormwater from residential roofs. If stormwater is generated from anything other than residential roofs, the facilities are subject to the UIC (Underground Injection Control) requirements.

		(See Section 2.3.3 for sizing information)	**Facility Size**
Drywell	________ sf	________ Diameter	________ Depth
Soakage Trench	________ sf	________ Length	________ Width

Sum of Total Impervious Area Managed .... ☐ **BOX 4**

(BOX 4 should be greater than or equal to BOX 3)

4 Escape Route

In the event the stormwater facility temporarily fails or rainfall exceeds the facility design capacity, describe where flows will drain to in order to maintain public safety and avoid property damage. Depending on site conditions, this may include storage in an overflow structure, parking lot, street, or landscaped area. ____

____

APPENDIX D.4 PRESUMPTIVE APPROACH SUBMITTAL GUIDE

When the Presumptive Approach is used to design stormwater facilities, the minimum submittal requirements are as follows.

1. **Scaled Site Plans** including (at a minimum):

   - Minimum scale of 1 inch to 10 feet
   - North arrow
   - Elevations and topography
   - Property lines
   - Lot area and setbacks
   - Footprints of structures
   - Easements and driveways
   - Wells and septic systems
   - Utility lines
   - Width of right-of-way and curb height
   - Impervious areas
   - Type, location and size of stormwater facility
   - Existing and proposed surface drainage
   - Proposed discharge point

   See Bureau of Development Services site plan checklist www.portlandonline.com/bds

2. **Cross Section and Details** of the proposed facility must be included with the plan set. Where sites are topographically varied, it may be imperative to show elevations of inlets, outlets, and discharge points on the cross-section to show how gravity drainage will be met.

3. A **Stormwater Management Report** must be submitted. An outline is provided on the next page to identify report requirements.

4. The **O&M Form** (see **Appendix D.6**) must be recorded with the appropriate county and submitted to BES Document Services at 1900 SW 4th Ave. Portland, OR 97201.

5. An **O&M Plan** (see **Appendix D.6**) must be developed and submitted to BES Document Services at 1900 SW 4th Ave. Portland, OR 97201.

6. **Landscaping plans** are required (see **Section 2.3.2 and Appendix D.1**).

Stormwater Management Report Outline

The Stormwater Management Report is required for every site improvement where the Presumptive or Performance Approach is used. All reports shall be paginated and securely fastened (including maps and exhibits).

1) Cover Sheet
   - Project name and owner
   - Site address
   - Associated permit numbers
   - Submittal date
   - Engineer
   - Firm
   - Address
   - Contact information

2) Designer's Certification and Statement

   "I hereby certify that this Stormwater Management Report for _____________________ (name of project) has been prepared by me or under my supervision and meets minimum standards of the City of Portland and normal standards of engineering practice. I hereby acknowledge and agree that the jurisdiction does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities designed by me."

   Design Professional's Oregon registration stamp

3) Table of Contents

4) Project Overview and Description
   - Size and location of project site (vicinity map)
   - Property zoning
   - Type of development/proposed improvements
   - Watershed description
   - Permits required (local, state, federal)
   - Existing vs. post-construction conditions

5) Methodology
   - Drainage at existing site
     - Potential impacts on the proposed site from existing conditions
     - Potential impacts from the proposed site on existing drainage
     - Techniques for mitigating potential conflicts or problems
   - Infiltration testing results
   - Narrative that defines the proposed stormwater management techniques, including discharge point(s) for runoff from private and public impervious areas
   - Stormwater hierarchy category justification

6) Analysis
   - Design Assumptions
     - Design storms used
     - Computation methods
     - Software used
     - Safety factors, curve numbers, and design coefficients
     - Clarify variations from the norm
   - PAC narrative form and printouts
   - Conveyance requirements and design

- Table of impervious area treated (differentiates public vs. private and roof vs. pavement). See example table 1 below ("Catchment and Facility Table").
- Comparison table of the flow rates for pre and post construction. Table must show that the project meets the flow control requirements set forth in **Section 1.3.2**. See example Table 2 below ("Pre vs. Post Construction Flow Rates").
- Determination of the escape route or inundation level for the 24-hour 100-year event

Example Table 1

Catchment and Facility Table *(shows each catchment on proposed site as well as proposed facility)*

Catchment/ Facility ID	Source (roof/road/other)	Impervious Area (sf/ac)	Ownership (private/public)	Facility Type	Facility Size (sf/ac)	Curve #
AA						
BB						

Example Table 2

Pre vs. Post Construction Flow Rates

Facility ID	Peak Flow Rate (cfs)								ToC (min)	
	2 yr		5 yr		10 yr		25 yr			
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Project Site										
AA										
BB										

7) Engineering Conclusions
- Based on compliance with Stormwater Management Manual
- How water quality, flow control, and discharge requirements are satisfied
- Post-construction peak flow=½ pre-development peak flow (2-yr 24-hr events)

8) Stormwater Facility Details/Exhibits
- Contour maps of pre and post development
  - Impervious area identification
  - Existing and new drainageways
  - Watershed delineation
  - Point(s) of discharge
- Delineation of each catchment (area treated by one facility)
- Landscape plans (see **Appendix D.1**)

9) Operations and Maintenance Plan and O&M Form 3 (See **Chapter 3.2**)
- Must include entity responsible for long-term fiscal responsibilities of O&M

10) Additional Forms
- Source Control Special Circumstances Installations (if applicable)
- Special Circumstances (if applicable)

11) Associated Reports Submitted

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APPENDIX D.5 PERFORMANCE APPROACH SUBMITTAL GUIDE

If the proposed stormwater management plan meets the intent of all the *Stormwater Management Manual* requirements, but not as specified under the Simplified or Presumptive Approach, the applicant may submit the project under the Performance Approach and request an administrative technical review. The application must demonstrate that the proposed management plan meets or exceeds all of the City of Portland's stormwater requirements. Refer to **Section 2.2.3** for more information about the Performance Approach.

Technical staff under the direction of the Chief Engineer or designee will review Performance Approach submittals. The applicant can initiate a Performance Approach review by completing a Stormwater Management Report (as specified in **Appendix D.4**). The applicant shall provide additional materials and supporting information based on the specific request.

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APPENDIX D.6 OPERATIONS & MAINTENANCE SUBMITTAL GUIDE

City of Portland code requires the submittal of an operations and maintenance plan for all required stormwater management facilities. BES must review and approve the plan. Failure to properly operate or maintain a stormwater management facility according to the O&M plan may result in a civil penalty, as specified in 17.38.045: Enforcement.

For facilities designed under the Simplified Approach, the O&M Specifications described in **Section 3.2.1** and provided in **Section 3.3.1** can serve as the required O&M plan. See those sections for more information.

For facilities designed under the Presumptive Approach or Performance Approach, a site-specific O&M Plan must be provided, as described in **Section 3.2.2** and outlined in **Section 3.3.2.** See those sections for more information.

In addition to the O&M Specifications or site-specific O&M Plan, an O&M Form is required for all projects. The O&M Form is provided on the following pages. The applicant must sign the form, and the signature must be notarized. The O&M Form and a site plan must be recorded and filed with the county Department of Assessment and Taxation in the county where the property site is located. When completed accurately, this form meets the recording requirements in Multnomah, Clackamas, and Washington counties.

A copy of the O&M Form must be filed with BES. Submit completed O&M Forms to:

Bureau of Environmental Services
Document Services
1900 SW Fourth Ave., Suite 5000
Portland, OR 97201

County Recorder's Office Information

Multnomah County Recorder
Room 158
501 SE Hawthorne St.
Portland, OR 97214
Http://www.co.multnomah.or.us/at/services.html
Phone: 503-988-3034

Washington County Recording Office
155 N. First Ave.
Suite 130, MS 9
Hillsboro, OR 97124
Http://www.co.washington.or.us/deptmts/at/recordng/record.htm
Phone: 503-846-8751

Clackamas County Recording Division
104 11th St.
Oregon City, OR 97045
Http://www.co.clackamas.or.us/recording/legible.htm
Phone: 503-655-8661

O&M Plan Outline

Please refer to **Section 3.3** for guidance in creating the O&M Plan.

O&M Plan Outline

I. Description
- Summary of overall Stormwater Management Plan.
- Table identifying each stormwater facility, its size, the stormwater source to each facility, square footage treated, and discharge point.
- Specific location of stormwater facilities.
- Identification of who will assume responsibility for ongoing operations.

II. Schedule
- When and how often facilities will be inspected.
- Specific intervals between particular O&M duties.
- Definition of what size storms require additional inspections.
- Irrigation Schedule

III. Procedures
- Specific procedures for each facility type.
- Likely deficiencies and corrective actions.
- Course of action for unexpected deficiencies.

IV. Inspection and Maintenance Logs
- Example and instructions for maintaining required logs.

FORM 2

OPERATIONS & MAINTENANCE

Required in accordance with City Code Chapter 17.38

for official county use only

Date: ____________________

Expected Construction Completion Date: ____________________

Permit # __________________

R # ______________________
(6 digit property ID)

Permit Application No .____

Owner Name:____

Phone: *(area code required)* ____

Mailing Address: *(return address for records)* ____

City/State/Zip:____

Site Address: ____

City/State/Zip:____

Site Legal Description: ____

____

____

1 Responsible Party for Maintenance (*check one*)

☐ Homeowner association ☐ Property Owner ☐ Other *(describe)* ______________________________

2 Contact Information for Responsible Party(ies) if Other than Owner

Daytime Phone: (*area code required*) _______- _________-____________ Emergency/After Hours Phone: _______- _________-___________

Contact Name and Address: ____

Instructions

Simplified Sizing Approach: Attach O&M Specifications from the Stormwater Management Manual (SWMM) Section 3.3.1.

Presumptive and Performance Sizing Approach: Attach the site-specific O&M Plan (See SWMM Section 3.3.2).

Form 2 - OPERATIONS & MAINTENANCE

3 Site Plan
Show all facility locations in relation to labeled streets, buildings, or other permanent features on the site. Also show the sources of runoff entering the facility, and the final onsite/offsite discharge point.
Please complete the table below

Maintaining the stormwater management facility on this site plan is a required condition of building permit approval for the identified property. The property owner is required to operate and maintain this facility in accordance with the O&M specifications or plan on file with the City of Portland. That requirement is binding on all current and future owners of the property. Failure to comply with the O&M specifications or plan may result in enforcement action, including penalties. The O&M specifications or plan may be modified by written consent of new owners and written approval by re-filing with the Bureau of Environmental Services.

Complete and recorded O&M Forms shall be submitted to:
Bureau of Environmental Services, 1900 SW 4th Avenue, Room 5000, Portland, OR, 97201
Office hours are 8 - 5, Monday through Friday. Call 503-823-7761 for assistance.

Required Site Plan (insert here or attach separate sheet)

☐ I Have Attached a Site Plan

Please complete this table

Facility Type	Size (sf)	Drainage is from:	Impervious Area Treated (sf)	Discharge Point

4 Maintenance practices and schedule for the stormwater facility are included in the facility-specific O&M specifications or plan filed with City of Portland, Bureau of Environmental Services, and are attached to this document. The operation and maintenance practices are based on the current version of the City of Portland Stormwater Management Manual on the date of permit approval.

Preparation date: ______/______/______.

Prepared by: ____ Contact #: ____________________________________

Form 2 - OPERATIONS & MAINTENANCE

BY SIGNING BELOW *filer accepts and agrees to the terms and conditions contained in this O&M Form and in any document executed by filer and recorded with it. To be signed in the presence of a notary.*

____
Filer signature

____
Filer signature

INDIVIDUAL Acknowledgement

STATE of OREGON county of: ______________________________

This instrument was acknowledged before me on: ______________________________

By: ______________________________

Notary Signature: ______________________________

My Commission Expires: ______________________________ *for notary seal*

CORPORATE Acknowledgement

STATE of OREGON county of: ______________________________

This instrument was acknowledged before me on: ______________________________

By: ______________________________

As (title): ______________________________

Of (corporation): ______________________________

Notary Signature: ______________________________

My Commission Expires: ______________________________ *for notary seal*

APPENDIX D.7 SPECIAL CIRCUMSTANCES AND APPEALS SUBMITTAL GUIDE

Special Circumstances

Special circumstances on a proposed site may make it impractical to implement onsite pollution reduction or flow control to the standards specified in Chapter 1 of this manual. In that case, the Bureau of Environmental Services (BES) will determine if all or a portion of the stormwater management obligations may be fulfilled offsite. See the **Special Circumstances Form** in this appendix to request offsite management.

No exceptions to meeting the stormwater management obligations are allowed. The applicant must account for the management of all stormwater runoff from the site. Onsite stormwater management must be achieved to the maximum extent feasible, as approved by BES, in all cases before any offsite facilities or fees will be allowed.

Properties are not eligible for special circumstances if they were divided or partitioned after this *Stormwater Management Manual* was adopted (July 1, 1999) and the division or partition resulted in the special circumstance (e.g., structural or other physical limitations at the site).

If BES approves a special circumstances claim, the applicant must construct an appropriately sized offsite facility or pay a fee to the City to construct offsite facilities. This offsite management fee is currently **$2.76** per square foot of unmanaged impervious surface. The fee may be pro-rated to account for portions of the stormwater management obligation met onsite (as determined by the City's review of proposed onsite facilities).

Special circumstances review will be conducted by an Administrative Review Committee of City staff and the BES Systems Development Manager.

How to Prepare a Special Circumstances Application

A complete special circumstances application consists of:

- Completed **Form 3: Special Circumstances.**
- One set of plans (site plan and any necessary details).
- Fee of $100.
- Supplemental information specific to the project circumstances.

It is critical that information provided in the special circumstances application be clear, concise, accurate, and completely written. Each special circumstances request must stand on its own merit and will be reviewed based on the specific conditions related to the project under consideration.

Form: The **Special Circumstances Form** (provided in this appendix) consists of the following sections:

1. **Project Information.** Provide information about the project, its location, the property owner, and the project team.

2. **Special Circumstance.** Specify the request being made and the features of the project that make it a special circumstance.

3. **Stormwater Management Information**. Generally explain the proposed stormwater management facilities. Summarize how stormwater will be managed for pollution reduction, flow control, and infiltration, and indicate the proposed discharge point.

Plans: One set of plans (in addition to any plans submitted for permit processing) must accompany the special circumstance application. Plans should provide sufficient information to detail the areas considered to be a special circumstance, as well as any areas that may be affected by or that may affect those circumstances.

Fee: A fee of $100 is required.

Supplemental information (optional): Submitting supplemental information (engineering analyses, test data, etc.) that will help clarify the request or make it easier to understand is encouraged.

How to File a Special Circumstances Application

The complete special circumstances application must be received by 4:00 pm on Friday to be considered the following week. Applications will be screened for completeness, and the applicant will be notified within 3 working days that the application has been received and is complete. Submittal of inaccurate or incomplete applications may cause a delay in considering the request.

Note: If the owner is different from the applicant, both the owner and the applicant are required to sign any required forms and attend any meetings as arranged.

Application packets should be mailed or delivered to:

Bureau of Environmental Services
Attention: Stormwater Management Special Circumstances
1120 SW 5th Avenue, Suite 1000
Portland, OR 97204

For questions regarding the special circumstances submittal, call 503-823-7761.

Decisions

Administrative reviews will be completed within 21 days of receipt of the submittal. An appointed staff member will review the submittal before calling an Administrative Review Committee meeting to present a brief overview. Decisions are reached by consensus. The decisions will be recorded and mailed to the appellant within 5 business days of the decision.

Appeals

Applicability

This appeals process applies to special circumstances decisions, as described above. It also applies to administrative or technical decisions related to other requirements of Chapters 1 through 3 (except Section 1.3.3). **Appendix D.9** describes a separate appeals process for Section 1.3.3 and for the source control requirements in Chapter 4.

The appeals process allows applicants to appeal staff interpretation of the City Code and of adopted policies and procedures that guide the review of development proposals. Applicants may appeal any issue related to interpretation of the stormwater management policy. For example, an applicant may appeal staff assessment of a site's stormwater management level or a permit denial. Applicants may not appeal the content or requirements of the policy, or technical parameters such as design storms, coefficients, and other technical criteria through this process.

This appeals process is not intended to address requested changes to technical specifications as adopted in the 2007 *Portland Standard Construction Specifications* or the Bureau of Environmental Services (BES) *Sewer and Drainage Facilities Design Manual*. In those cases, applicants should contact the BES Development Review Team (503-823-7761) to request consideration by the BES Standards and Practices Committee. That committee has a separate process to consider changes to technical standards.

Process

Appellants not satisfied with administrative or technical decisions may request in writing a public hearing by the BES Appeals Board, which comprises the Chief Engineer, Systems Development Manager, Pollution Prevention Services Manager, and Watershed Services Manager (or their designees). An outside member may also be included at the discretion of the Chief Engineer, depending on the nature of the appeal. The Systems Development Manager will schedule a BES Appeals Board meeting to occur within 14 working days of receipt of the written appeal application. The applicant will be notified of the meeting date, place, and time. Public notice of the appeal request is given. At least three members of the board must be present for the meeting to take place. A member of the Administrative Review Committee or Technical Review Committee will present an overview of the request and the decision.

The applicant, if present, may briefly address the board. Decisions are reached by a majority opinion of the board and are binding.

How to Prepare an Appeal Application

A complete appeal review application consists of:

- A written request to the Systems Development Manager explaining the reason for the appeal.
- A copy of the Administrative Review Committee's or Technical Review Committee's original determination.
- Appeal fee of $250.
- One set of plans.
- Supplemental information specific to the project circumstances.

It is critical for information provided in the appeal application to be clear, concise, accurate, and complete. Each appeal must stand on its own merit and will be reviewed based on the specific conditions related to the project under consideration.

Written Request: The written request must include:

- Information about the project, its location, the property owner, and the project team.
- The decision being appealed.
- General reasons for the denial and new information rebutting the denial.
- General summary of the proposed stormwater management approach, including how stormwater is being managed for pollution reduction, flow control, and infiltration and the discharge point.

Plans: One set of plans (in addition to any plans submitted for permit processing) must accompany the appeal application. Plans should provide sufficient information to detail the areas that are being appealed, as well as any areas that may be affected by or affect the appeal.

Fee: A fee of $250 is required.

Supplemental information (optional): Supplemental information (engineering analyses, test data, etc.) that will help clarify the appeal is a welcome accompaniment to the submittal.

How to File an Appeal

The complete appeal application must be received by 4:00 pm on Friday to be heard the following Wednesday. Applications will be screened for completeness. Submittal of inaccurate or incomplete applications may cause a delay in hearing the appeal.

Note: If the owner is different from the applicant, both the owner and the applicant are required to sign any required forms and attend any meetings as arranged.

Application packets should be mailed or delivered to:

> Bureau of Environmental Services
> Attention: Stormwater Management Appeals
> 1120 SW 5th Avenue, Suite 1000
> Portland, OR 97204

For questions regarding the appeal packet submittal, call 503-823-7761.

Decisions

Decisions will be recorded and mailed to the appellant within 5 business days.

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FORM

3 SPECIAL CIRCUMSTANCES

Office use only
Received by: ______________________
Date: ___________________________

This form is required when applicant proposes to:

✔ **Pay an offsite stormwater management fee**

Please fill this form out completely. For assistance completing it, consult with the Bureau of Environmental Services (BES) reviewer assigned to your project or with BES staff in the Development Services Center. The details of your special circumstance or requirement you are appealing must appear on this sheet. Additional information may be included if pertinent to the item being considered. Refer to Appendix D.7 of the 2008 Stormwater Management Manual for more information.

A fee of $100 along with one (1) set of plans (**exclusive of any plans submitted for plan check**) must be submitted along with this form. Plans are to clearly indicate the new or redeveloped impervious area and proposed facilities.
Checks are to be made payable to City of Portland

Special Circumstances applications must be submitted by no later than 4:00 PM on Friday. Applications received by this deadline will be scheduled for the next available hearing date. In most cases, applications submitted by the Friday deadline will be considered the following Wednesday. However, an application may be deferred to a later date due to the number of applications scheduled for hearing, the complexity of the application being submitted, an incomplete submittal, or other unforeseen factors. Information about the status of your application may be obtained by calling the BES hotline at 503-823-7761. Results of the hearing will not be available until the day following the hearing. Applicants will receive a copy of final decision in the mail.

PROJECT INFORMATION

1 Project Information

Permit/LUR Number: ________________________ **Site Tax Account Number (s):** R ____________________

Project/Site Street Address: ____

City/State/Zip: ____

Cross Streets: ____

Project Name (if applicable): ____

Applicant Name: ______________________________ Firm Name: ______________________

Applicant Street Address: ____

City/State/Zip: ____

Applicant Phone Number(s): ____

Owner Name (if different than applicant): ____

Owner Street Address: ____

City/State/Zip: ____

Owner Phone Number(s): ____

May we contact you by email to respond to this request? ☐ Yes ☐ No

Email Address: ____

Form 3 - SPECIAL CIRCUMSTANCES

PROJECT INFORMATION *continued*

Engineer Name (if applicable): ____________________ Firm Name: ____________________

Engineer Street Address: ____________________

City/State/Zip: ____________________

Engineer Phone Number(s): ____________________

Architect Name (if applicable): ____________________ Firm Name: ____________________

Architect Street Address: ____________________

City/State/Zip: ____________________

Architect Phone Number(s): ____________________

Describe the development or redevelopment project *(one set of plans must be submitted with this form)*:

____

____

____

____

____

____

____

SPECIAL CIRCUMSTANCE INFORMATION

2 Special Circumstances Information

I would like to pay an offsite management fee for a ☐ portion ☐ all of the stormwater requirements
(check one)

Explain the request in more detail:

____

____

____

____

____

____

____

____

Form 3 - SPECIAL CIRCUMSTANCES

3 Stormwater Management

Describe your proposed stormwater management plan if this special circumstances request is approved:

____
____
____
____
____
____
____
____
____
____
____
____
____
____

Indicate the proposed infiltration and discharge method:

Infiltration onsite ☐ ______%
(refer to Section 1.3.1 of the Manual)

Discharge offsite ☐ 100% ☐ ______%
(refer to Section 1.3.1 of the Manual)

Overflow will be directed to *(check all that apply)*:

☐ **Subsurface facility** ☐ **Surface water**
☐ **Stormwater sewer** ☐ **Combined Sewer**

Describe the method and location:

____
____
____
____
____
____
____
____

Form 3 - SPECIAL CIRCUMSTANCES

STORMWATER MANAGEMENT continued

For the following requirements, indicate the percentage of impervious area that you plan to meet onsite:

Flow Control ☐ 100% ☐ _____% ☐ N/A *(explain below)*
(refer to Section 1.3.2 of the Manual)

Pollution Reduction ☐ 100% ☐ _____% ☐ N/A *(explain below)*
(refer to Section 1.3.3 of the Manual)

If you checked N/A for either pollution reduction or flow control, please explain:

____

____

____

____

____

____

____

Signed: *(Applicant)* ______________________________ Date: ________________

Signed: *(Owner if different)* ______________________________ Date: ________________

TO BE COMPLETED BY SYSTEM DEVELOPMENT DIVISION

4 **To Be Completed By The System Development Division**

Date Received: ________________

☐ Approved ☐ Denied ☐ Other *(see comments below)*

Date: __________ Signature: ______________________________

City Comments: ____

____

____

____

____

____

____

APPENDIX D.8 DEWATERING SUBMITTAL REQUIREMENTS

Before applying for City permits, it is recommended the applicant contact the DEQ Land and Water Quality Divisions before plan submittal and obtain the DEQ's approval or denial of a private system management proposal. Depending on the disposal location for the discharge, the DEQ requires National Pollutant Discharge Elimination System (NPDES) permits and Water Pollution Control Facility (WPCF) permits.

Testing and water analysis are usually required as outlined in **Section 4.4** of Chapter 4. Obtaining the results of the analysis is highly recommended prior to submitting building permit applications. Submitting the analytical data prior to permit submittal will help the review team strive to meet the timeline goals of the project.

The City reviews for capacity in the City conveyance system for all discharges. Estimated discharge rates are required to be submitted with the building permit application. It is recommended the estimated discharge rates be submitted in a timely manner to help the review team strive to meet the timeline goals of the project.

When temporary or permanent dewatering is proposed, the minimum submittal requirements are as follows:

1. **Scaled Site Plans –** minimum scale is 1 inch to 10 ft, and at a minimum includes:
   - Property lines
   - North Arrow
   - Footprints of structures, if any
   - Surface drainage
   - Location and details of groundwater or stormwater treatment system, if applicable
   - Estimated groundwater flow rate of discharge during all phases of development, if groundwater will be encountered
   - Dewatering plan if collecting/channelizing or impounding stormwater or encountering groundwater
   - DEQ 1200C general construction NPDES permit number
   - Erosion Control Plan sheets that match the DEQ 1200C submitted erosion control sheets.
   - Proposed discharge location
   - Submeter – must meet submeter specifications
   - Sampling location and structure details
   - Utility plans, includes both private and public, existing and proposed storm and sanitary conveyance systems.

   Also, see Bureau of Development Services Site Plan checklist www.portlandonline.com/bds.

The site plan information should be located on the erosion/civil sheets of the plan set.

2. The **Dewatering Form 4** must be completely filled out and signed. It must be submitted with the appropriate accompanying application(s) (**Batch Discharge Application Form 5, Submeter Application Form 6, Long-Term Discharge Application Form 7**) as identified on the Dewatering form.

3. **Dewatering Plan**: If Dewatering the site of stormwater or groundwater, the Submittal of the Erosion Control Plan and Dewatering Plan required by the DEQ 1200 C general construction permit is required to accompany the submittal package. If the development is not required to obtain a DEQ 1200C permit, the submittal of a dewatering plan is required to accompany the submittal package.

4. **Analytical data**, if applicable, for groundwater or stormwater. Analytical data is required if the site is contaminated. Please submit the Environmental Phase II, if available. The analytical data must include the chain-of-custody and detection limits.

5. When using a private onsite management facility for groundwater flows, the **O&M Form** (**Appendix D.2**) must be recorded with the appropriate county and submitted. This applies to permanent groundwater dischargers that have vegetated facilities or other permanent dewatering water quality treatment devices.

FORM

4 Source Control DEWATERING FORM

Date: ____________________

Building Permit Application # ____________

All building permit applications for new construction, additions, or improvements that will perform below-grade excavation or discharge groundwater, or perform ground-disturbing activities during the winter months (Oct-May) must complete and submit this form with the documents requested within this form.

Site and Contact Information:

Property Site Address: ____________________

Name of Responsible Party: ____________________

Responsible Party Phone: (*area code required*) ____________________

Responsible Party Mailing Address: ____________________

City/State/Zip: ____________________

Name of Contractor *(if different than responsible party)*: ____________________

Contractor Phone Number: ____________ **Contractor Email Address:** ____________

Discharge Information:

1 **Will there be temporary dewatering and discharges of groundwater** (includes mixed groundwater & stormwater)?
☐ Yes ☐ No *(If yes, applicant must fill out submeter application, and batch discharge application. Submit those applications with this form.)*

2 **Will there be permanent dewatering and discharges of groundwater?** ☐ Yes ☐ No *(If yes, applicant must complete a submeter application and long-term dewatering application, submit a recorded O&M plan, if applicable, and include with this form.)*

3 **Will there be stormwater only dewatering discharges during construction?** *(Applicable only if question 1 & 2 are answered NO)*
☐ Yes ☐ No *(If yes, fill out the batch discharge application and include it with this form. If no, sign this form and submit with building plans.)*

Projected Discharge Rate: *(If the rate will change based on the depth of the excavation, list those depths with the projected rates.)*

____

Maximum Discharge Rate (gpm): ____________________

Duration of Discharge *(dates from and to)*: from ____________ to ____________

If site conditions change and a discharge offsite is needed, you must call 503-823-5320 or 503-823-7180.

4 DEWATERING FORM

Intended Receiving System for the Discharge? *(check the following relevant box)*

- ☐ City storm
- ☐ City sanitary
- ☐ City combined
- ☐ Private storm
- ☐ Private infiltration
- ☐ Private UIC (drywell) - City UIC is prohibited
- ☐ Other: ______________________________

If proposing discharge to a private system, please ensure that the Department of Environmental Quality (DEQ) has been notified.

BES may require correspondence from DEQ stating they have been informed of the proposed discharge.

Statement

By signing this form I acknowledge I am the responsible party for the above address and acknowledge that discharges off this site to a City conveyance system are regulated under City Code Chapters 17.39, 17.38, 17.36 and 17.34. By answering no to all three discharge questions, I certify there will be no channelized or pumped stormwater associated with construction activities or groundwater entering a City conveyance system on a permanent or temporary basis. I am also aware that sewer volume charges or system development charges may apply per chapter 17.36 for this discharge. If it is found there is an offsite discharge of either groundwater or stormwater as defined in this statement and the discharge has not been authorized, I am aware that penalties can be assessed per City Code Chapters 17.39 and 17.34. If site conditions change, and a discharge to a city system is needed, I will contact the city by calling 503-823-7122 or 503-823-7180 to obtain authorization to discharge.

Signature: ______________________________

Printed Name: ______________________________

Date Signed: ______________________________

for official use only

City Staff

Date Received: ______________________________

Received by: ______________________________

Approved Date: ______________________________

Approved by: ______________________________

Approved Receiving System: ______________________________

FORM
5
Source Control
BATCH DISCHARGE APPLICATION

Date of Request: ____________________

for official use only

Batch Discharge Number:

______________ - __________

Fee Required: ☐ Yes ☐ No

Fee Paid: ☐ Yes ☐ No Check No. _________

This form is required for requests to discharge temporary groundwater or channelized / impounded or pumped stormwater associated with construction activities into a city conveyance system.

Requested By

Contact Name: ____________________

Company Name: ____________________

Company Address: ____________________

City/State/Zip: ____________________

Telephone: *(area code required)* ____________________ **Cellular:** ____________________

Facsimile: ____________________ **Pager:** ____________________

Email Address: ____________________

Discharge Generator

Facility Name: ____________________

Facility Address: ____________________

City/State/Zip: ____________________

Facility Contact: ____________________ **Telephone:** ____________________

Description of Wastewater *(if applicable, attach analytical data report)*: ____________________

____

____

Proposed Date(s) of Discharge: ____________________

Discharge Volume: ______________ gallons per day **Requested Rate of Discharge:** __________ gallons per minute

Building Permit/City Project Number: ____________________

City of Portland Project Manager *(if applicable)*: ____________________

Proposed Point of Disposal *(attach diagram)*: ____________________

____

____

Signature: ____________________

Date: ____________________

FORM 6 Source Control

SUBMETER APPLICATION
Construction and Groundwater Discharge

Date of Request: ______________________

Building Permit Number: ______________________

Project Information

Project Name: ______________________

Site Address: ______________________ *Portland Oregon Zip:* __________

Contact Name: ______________________

Company Address: ______________________ City/State/Zip: ______________________

Mailing Address: ______________________ City/State/Zip: ______________________

Telephone *(include area code)*: ______________________ Fax: ______________________

Anticipated Construction Start Date: ______________________ End Date: ______________________

Will ongoing dewatering activities occur onsite once construction is complete?

☐ Yes *(Complete Section 1 and 2, below)* ☐ No *(Complete Section 1 only)*

Billing Information

Have you opened a sewer account with Portland Utilities?

☐ Yes Acct. No.: ______________________ ☐ No *(Contact the City of Portland, 503-823-7856 to set up an account)*

Section 1 - Contact Information During Construction

Contact Person: ______________________

Company Name: ______________________

Billing Address: ______________________

City/State/Zip: ______________________

Telephone: ______________ Fax: ______________

Section 2 - Contact Information Post-Construction

Contact Person: ______________________

Company Name: ______________________

Billing Address: ______________________

City/State/Zip: ______________________

Telephone: ______________ Fax: ______________

Meter Information

City Code 17.36.050 - ALL meters shall register in cubic feet

Meter Serial Number	Meter Dials	Stationary Zeros	Install Read
No. 1: ______________	1: ______	1: ______	1: ______________
No. 2: ______________	2: ______	2: ______	2: ______________

Applicant Signature: ______________________ Date: ______________

Print Applicant Name: ______________________

for official use only

Date App. Rec'd *(Month/Date/Year)* : ______________________

Receiving Sewer Type: ☐ Sanitary/combined ☐ Storm

Meter Type: ☐ Odometer ☐ Digital

Reviewed By: ______________________ Date: ______________

FORM
7 Source Control
LONG-TERM DEWATERING APPLICATION

This form is required for requests to permanently discharge groundwater into a city conveyance system.

Date of Request: ______________________________

for official use only

Permit or Authorization Number:

__________________ - __________

Fee Required: ☐ Yes ☐ No

Fee Paid: ☐ Yes ☐ No Check No. ________

Requested By

Contact Name: ______________________________

Company Name: ______________________________

Company Address: ______________________________

City/State/Zip: ______________________________

Telephone: (*area code required*) ____________________ **Cellular:** ____________________

Facsimile: ____________________ **Pager:** ____________________

Email Address: ______________________________

Discharge Generator

Facility Name: ______________________________

Facility Address: ______________________________

City/State/Zip: ______________________________

Facility Contact: ____________________ **Telephone:** ____________________

Description of Discharge (*attach analytical data report if applicable*): ______________________________

____

____

____

Discharge Volume: ____________ gallons per day **Requested Rate of Discharge:** ________ gallons per minute

Building Permit/City Project Number: ______________________________

City of Portland Project Manager (*if applicable*): ______________________________

Proposed Point of Disposal (*attach diagram*): ______________________________

____

____

Signature: ______________________________

Date: ______________________________

APPENDIX D.9 SOURCE CONTROL ADMINISTRATIVE REVIEWS AND APPEALS SUBMITTAL GUIDE

The administrative review and appeals process described in this appendix applies to requirements outlined in Chapter 1.3.3 (Additional Pollution Reduction Requirements for Vehicle and Equipment Traffic Areas) and Chapter 4 (Source Control Requirements). **Appendix D7** provides a separate appeals process for the requirements of Chapters 1 through 3 (except Section 1.3.3).

Administrative Reviews

There are two types of source control administrative reviews: technical review and advanced technical and engineering review. The type of administrative review is determined by the criteria and process presented in this appendix.

Technical Review

If the proposed (alternative) source control meets the intent but not the letter of the requirements, or if some (not all) of the requirements may not be met because of zoning, property constraints, or other regulations, the applicant may request approval through a technical review process. This applies only to the following sections of Chapter 4:

4.5: Solid Waste Storage Areas, Containers, and Trash Compactors
4.6: Material Transfer Areas/Loading Docks
4.7: Fuel Dispensing Facilities and Surrounding Traffic Areas
4.9: Equipment and/or Vehicle Washing Facilities
4.12: Covered and Uncovered Vehicle Parking Areas

The applicant must demonstrate that the proposed system meets or exceeds the protection provided by the source control requirements.

The technical reviewer cannot evaluate a request for more than one exception from the same section in Chapter 4 (e.g., a request to eliminate both the sanitary drain and cover in a washing area) or a complete exception from the requirements. Those requests require an advanced technical and engineering review (see next page).

Technical staff will evaluate technical reviews under the direction of the Pollution Prevention Manager or designee. The applicant can initiate a technical review by completing the **Source Control Special Circumstances Form** located in this appendix and submitting site plans and additional materials that support the request. There is no fee for a technical review. Applicants are not allowed to attend the technical review meeting.

Advanced Technical and Engineering Review

If the proposed (alternative) source control meets the intent but not the letter of the requirements or does not qualify for the technical review outlined above, the applicant may request approval through an advanced technical and engineering review process. This applies only to the following sections of the manual:

- **1.3.3: Additional Pollution Reduction Requirements for Vehicle and Equipment Traffic Areas**
- **4.4: Dewatering and Discharge**
- **4.8: Above-Ground Storage of Liquid Materials, Including Tank Farms**
- **4.10: Exterior Storage of Bulk Materials**
- **4.11: Soil, Stormwater, and Groundwater Management for Development on Land with Suspected or Known Contamination or Adjacent to Contaminated Sites**
- **4.13: Water Reclaim and Reuse Systems**

The applicant must demonstrate that the proposed system meets or exceeds the source control requirements.

An Administrative Review Committee of City staff and the project's BES Environmental Manager will evaluate advanced technical and engineering reviews. The applicant can initiate an advanced technical and engineering review by completing the **Source Control Special Circumstances Form 8** located in this appendix and submitting site plans and additional materials, based on the request. There is a $100 fee. The applicant may elect to attend the advanced technical and engineering review meeting.

How to Prepare an Application for a Technical Review/Advanced Technical and Engineering Review

A complete application consists of:

- Completed **Source Control Special Circumstances Form 8.**
- One complete set of plans.
- Fee of $100 (only for advanced technical and engineering review).
- Supplemental information specific to the project circumstances.

It is critical that information in the application be clear, concise, accurate, and completely written. Each application must stand on its own merit and will be reviewed based on the specific conditions of the project under consideration.

Form: The form consists of the following sections:

1. **Facility Information.** Provide the facility's name and phone number, location, type of business, and contact person or owner.

2. **Applicant Information.** Provide the applicant's name, address, phone number, and email address and the building permit number.

3. **Review Type and Special Circumstance.** Specify the type of review (as outlined above) and the request being made, along with the features of the project that make it a special circumstance.

4. **Accompanying Items.** Provide the required accompanying items.

Plans: One complete set of plans (in addition to any plans submitted for permit processing) must accompany the application. Plans should provide sufficient information to detail the areas considered to be a special circumstance, as well as any areas that may be affected by or that may affect those circumstances.

Fee: A fee of $100 is required only for advanced technical and engineering review. It must be made payable to the City of Portland, Bureau of Environmental Services and included with the application.

Supplemental information (optional): Supplemental information (engineering analyses, test data, etc.) that will help clarify the request or make it easier to understand is a welcome accompaniment to the submittal.

How to File a Source Control Special Circumstances Application

The complete application must be received by 4:00 pm on Friday to be considered the following Wednesday. Applications will be screened for completeness. Submittal of an inaccurate or incomplete application may cause a delay in considering the request.

Technical review applications can be emailed to the appropriate source control plan reviewer or mailed or delivered to:

> Bureau of Environmental Services
> Attention: Source Control Special Circumstances
> 1900 SW 4th Ave, Suite 5000
> Portland, Oregon 97201

Advanced technical and engineering review applications should be mailed or delivered to:

> Bureau of Environmental Services
> Attention: Source Control Special Circumstances
> 6543 N Burlington Ave
> Portland, OR 97203

For questions about the source control application, call 503-823-7122.

Decisions

Administrative reviews will be completed within 14 business days of receipt of the submittal. The Administrative Review Committee will consist of City staff assigned by the project's Environmental Manager. An appointed staff member will review the submittal before calling a committee meeting to present a brief overview. Decisions are reached by consensus. The decisions will be recorded and mailed to the appellant within 5 business days of the decision.

Note: In the Columbia South Shore Well Field Wellhead Protection Area, some source control measures in Chapter 4 are protective measures that cross over to the Water Bureau's *Columbia South Shore Well Field Wellhead Protection Area Reference Manual* (June 25, 2003). Therefore, if an alternative or exception is allowed from the BES source control requirements, other or additional protective measures from the Water Bureau manual may apply. The manual can be found on the Water Bureau website at http://www.portlandonline.com/water/index.cfm?c=29602

Appeals

Appellants not satisfied with administrative review decisions may request in writing a public hearing by the BES Appeals Board, which comprises the Chief Engineer, Systems Development Manager, Pollution Prevention Services Manager, and Watershed Services Manager (or their designees). An outside member may also be included at the discretion of the Chief Engineer or Pollution Prevention Manager, depending on the nature of the appeal. The project's Environmental Manager will schedule a BES Appeals Board meeting to occur within 14 days of receipt of the written appeal application. The applicant will be notified of the meeting date, place, and time. Public notice of the appeal request is given. At least three members of the board must be present for the meeting to take place. A member of the Administrative Review Committee will present an overview of the request and the decision. The applicant, if present, may briefly address the board. Decisions are reached by a majority opinion of the board and are binding.

Applicants may appeal staff interpretation of the City Code and of adopted policies and procedures that guide the review of development proposals. Applicants may appeal any issue related to interpretation of the stormwater management policy (e.g., staff assessment of a site's stormwater management level or a permit denial). Applicants may not appeal the content or requirements of the policy, or technical parameters such as designs for oil water separators, storms, coefficients, and other technical criteria through this appeal process.

How to Prepare an Application for Appeals Board Review

A complete appeal review application consists of:

- A written request to the project's Environmental Manager explaining the reason for the appeal.
- A copy of the original Administrative Review Committee's determination.
- Appeal fee of $250.
- One set of plans.
- Supplemental information specific to the project circumstances

It is critical for information provided in the appeal application to be clear, concise, accurate, and complete. Each appeal must stand on its own merit and will be reviewed based on the specific conditions of the project under consideration.

Written Request: The written request must include:

- Information about the project, its location, the property owner, and the project team.
- The decision being appealed.
- General summary of the proposed source control systems and approach, including how this approach will meet the intent of the requirements.

Plans: One set of plans (in addition to any plans submitted for permit processing) must accompany appeal applications. Plans should provide sufficient information to detail the areas that are being appealed, as well as any areas that may be affected by or affect the appeal.

Fee: A fee of $250 must be included with the application. It must be made payable to the City of Portland, Bureau of Environmental Services.

Supplemental information (optional): Supplemental information (engineering analyses, test data, etc.) that will help clarify the appeal is a welcome accompaniment to the submittal.

How to File an Appeal

The appeal application must be received by 4:00 pm on Friday to be heard the following Wednesday. Applications will be screened for completeness. Submittal of an inaccurate or incomplete application may cause a delay in hearing the appeal.

Application packets should be mailed or delivered to:

Bureau of Environmental Services
Attention: Source Control Appeals
6543 N Burlington Ave
Portland, OR 97203

For questions about the appeal application submittal, call 503-823-7122.

Decisions

Decisions will be recorded and mailed to the appellant within 5 business days.

FORM 8

Source Control

SPECIAL CIRCUMSTANCES

Office use only

Received by: ______________________

Date: ___________________________

This form is required if you are requesting alternatives to standard structural source controls, or exceptions per Chapter 4 of the City's Stormwater Management Manual, and other special requests you would like reviewed by the Source Control Division.

Special Circumstances will require an additional review process and may delay issuance of related building permits. If this request cannot be satisfied by the administrative review process, the appeals process, as described in Appendix D.9 of the Stormwater Management Manual, may be implemented by the applicant.

1 Facility Information *(please print)*

Facility Name *(if applicable)*: ______________________________

Phone No.: ______________________________

Facility Address or Location: ______________________________

City/State/Zip: ______________________________

Type of Business/Facility: ______________________________

Facility Contact or Owner: ______________________________

2 Applicant Information

Applicant's Name: ______________________________

Phone No.: ____________________ **Applicant's Email Address:** ____________________

Applicant's Mailing Address: ______________________________

City/State/Zip: ______________________________

Building Permit No. *(if applicable)*:______________________________

3 Review Type

(select one)

☐ Technical Review (chapter 4 sections 4.5, 4.6, 4.7, 4.9, 4.12)

OR

☐ Advanced Technical and Engineering Review (chapter 4 sections 4.4, 4.8, 4.10, 4.11, 4.13 and chapter 1 section 1.3.3)

Special Circumstance *(check appropriate box)*

☐ Request for an alternative source control method. Alternative description: ______________________________

____

____

Review Type continued

☐ Request for review of EXCEPTION qualifications. Exception description: ____
____
____

☐ Other: ____
____

4 The following items need to accompany this form:

- A detail or vendor specification for each alternative source control.
- A site plan of the facility/property clearly identifying the location on the site that will be impacted by this special request. Existing and proposed utilities may need to be shown to ensure regulatory compliance with local, state and federal regulations. *(A hand-drawn sketch, not to scale, is acceptable as long as it is legible.)*
- A check made payable to the City of Portland for $100 if this is an Advanced Technical and Engineering Review type.

Provide a brief explanation for your request *(use additional pages if necessary)*:

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Office use only

Fee Required: ☐ Yes ☐ No

Fee Paid: ☐ Yes ☐ No Check No. __________

☐ **Approved** ☐ **Denied** ☐ **Other** *(see comments below)*

City Comments: ____
____
____

Date: _________________________ **Signature:** ____

APPENDIX D.10 SAMPLE LONG-TERM DEWATERING NOTICE OF CONDITIONS

After Recording Return Copy to: This Space Reserved For Recorder's Use:

PORTLAND BUREAU OF ENVIRONMENTAL SERVICES (BES)
SOURCE CONTROL DIVISION
1900 SW Fourth Avenue, Suite 5000
Portland, OR 97201

NOTICE OF DEVELOPMENT PERMIT APPROVAL CONDITIONS

This notice pertains to the lot or parcel described as [insert legal description] located at [Site Address]. Approval of the development permit for this parcel is based in part on compliance with Portland City Code Title 17.38. Section 17.38.035 requires that long-term dewatering flows obtain authorization and that the authorization establish volume, flow rate, and pollutant load limits for the site's specific long-term discharge. To maintain continued compliance with the authorization, the parcel or lot owners and future parcel/lot owners are required to notify the Bureau of Environmental Services (BES) of ownership changes and any discharge characteristic changes e.g. volume or flow rates and pollutant loadings. The written notification must be sent to BES, Source Control Division, 6543 N Burlington, Ave, Portland, OR 97203. Parcel or lot owners and future parcel/lot owners are advised to verify the constraints on their property in the applicable land use and building permit decisions and conditions of approval, and with BES land use review staff.

DATED this ________ day of ___________________, 2008.

____
Name

____
Title

State of OREGON

County of Multnomah

This instrument was acknowledged before me on ________________, 2008 by

____.

____
Notary Public – State of Oregon

Appendix E.1 STORMWATER POLLUTION REDUCTION STORM DEVELOPMENT METHODOLOGY

May 20, 2004

INTRODUCTION

The development of design storms for the sizing of stormwater pollution reduction (treatment) facilities generally involves a statistical analysis of local rainfall data, whereas a certain storm volume, duration, and peak intensity (or rainfall distribution) is identified to achieve a predetermined treatment volume goal. This treatment volume goal will vary from jurisdiction to jurisdiction, but is generally 80 to 95% of the average annual runoff. It can be linked to each jurisdiction's municipal stormwater discharge permit (MS4 permit) definition of MEP (maximum extent practicable) as it relates to the removal of pollutants from stormwater. This definition is rarely clear, but justification for the treatment volume goal generally involves social/political, economic, and environmental considerations. Without a firm grasp on the environmental consideration at this time (i.e. what percentage of average annual runoff volume needs to be treated such that the effluent water quality isn't harmful to fish or aquatic systems or groundwater resources?), the economic and social/political considerations are most widely used. An optimization model can be developed to determine a treatment volume that will result in the "biggest bang for the buck", or the point at which additional percentage points of annual treatment volume begin to require a disproportionately large increase in treatment facility size (see attached Figure 4). However the treatment volume goal is justified, the link to how treatment facilities are actually sized, and whether they end up achieving the intended goal, can be lost in translation.

TREATMENT VOLUME GOAL

Before the adoption of the September 2004 Stormwater Management Manual revision, Portland relied on a single treatment storm methodology, using a storm of 0.83 inches over 24 hours (NRCS Type 1A rainfall distribution). Used since 1994, the original intent of this design storm was to: 1) treat the "first-flush" or first 0.5 inches of runoff from all storm events and 2) pass 100% of 95% of all storm events through the treatment facility. There did not seem to be a direct environmental or economic justification for choosing 95% of storm events at the time. The justification was mainly social/political in that it sounded like a reasonable standard.

The City of Eugene uses a treatment goal of 80% of the average annual runoff, and the justification seems to be both social/political and economic, as an attempt was made to choose a treatment intensity at the "knee" of an intensity versus percentage of annual runoff volume treated curve. Gresham also uses 80% of the average annual runoff, with a similar justification (URS performed both studies). The Washington State Department of Ecology (and thus many other jurisdictions in Washington) uses 91%, and claims that an economic analysis was performed to justify the goal.

Rather than stating a treatment volume goal without a link to environmental or economic considerations, Portland has chosen to consider economic factors to provide the most "bank for the buck". From a social/political and environmental perspective it is also desirable to set a minimum value to this goal. A continuous simulation analysis, summarized as Figure 4, has been performed on multiple years of rainfall data to determine the percentage of average annual rainfall that should be treated to maximize treatment efficiency. This analysis indicates a knee in the curve somewhere between 80 and 85 percent of the average annual volume. It may not be desirable to set the treatment goal directly at the economically optimal point, as stormwater treatment facilities do not always operate at their optimal design flow rates. Filters blind over time, or swales accumulate sediments that decrease the effective treatment flow rate through them. A margin of safety should be incorporated into the treatment volume goal. For these reasons, the City of Portland has chosen to set its treatment volume goal at 90% of the average annual rainfall volume.

TREATMENT STORM ANALYSIS

Over the past several years, Portland's 0.83" storm and justification have been questioned by other northwest jurisdictions. Agencies such as NOAA Fisheries are unsure which stormwater management regulations to use in the Pacific Northwest, as from an outside perspective the water quality storms and overall treatment goals used by various jurisdictions seem to vary dramatically. On the surface, Washington State DOE appears to use a treatment volume roughly double that of Portland's, although with the incorporation of the Vb/Vr (volume of basin / volume of runoff) factor they are basically equal (both result in the use of 2/3rd of the 2-year, 24-hour storm volume). The City of Eugene uses 1.4"/ 24 hours, and the City of Gresham uses 1.2"/12 hours. Their treatment storm volumes appear greater than Portland's (1.4" and 1.2" compared with 0.83"), but with the incorporation of the Vb/Vr ratio, are actually less (1.4" and 1.2" compared with 1.66").

While the City of Eugene uses 1.4"/ 24 hours for volume based treatment facilities, they use the intensities of 0.13"/hr and 0.22"/hr (for off-line and on-line facilities, respectively) for flow rate based facilities. These dual sizing standards result in treatment of 80% of the average annual runoff for rate based facilities, and 100% treatment of the 80th percentile storm for volume based facilities. At this time it is unclear how the treatment of X% of the average annual runoff with rate based systems is comparable to treating the Xth percentile storm with volume based facilities. Rather than sizing to the Xth percentile storm for volume based facilities, it is recommended to use a different methodology (see discussion under Volume Based Treatment Systems). In either case, the need for separate rate and volume based facility sizing standards is clear if the treatment volume goal is to remain consistent.

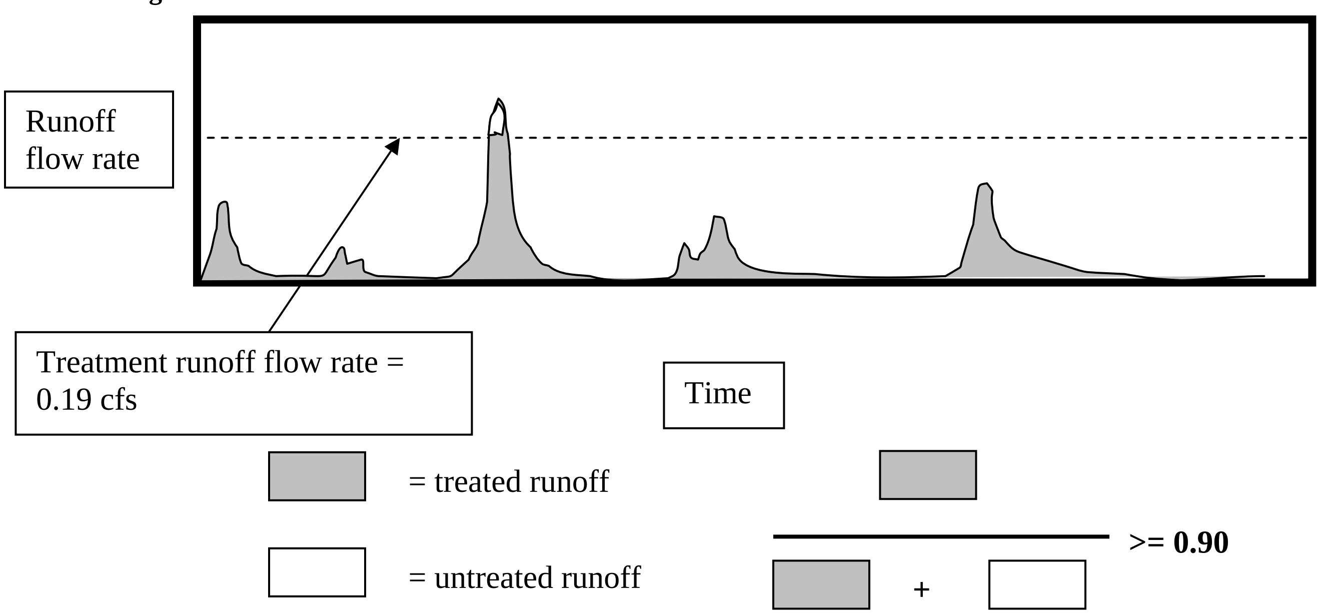
RATE BASED TREATMENT SYSTEMS

Stormwater treatment systems can be divided into two categories based on the methods used to size them: rate (or flow) and volume (or detention) based systems. Rate based systems used in Portland include swales, sand filters, and Stormfilter cartridge systems. Rate based systems remove pollutants with physical processes that settle or filter particulates as the flow passes through the system. The actual volume of the facility doesn't play a major role in the pollutant removal process, as there isn't a significant detention period for the water to remain in the system for any length of time.

A continuous simulation model can easily be used to determine the average annual runoff volume percentage treated by a rate based system. An assumption is that 100% of the runoff less than or equal to the peak treatment flow rate is fully treated, while the flows that exceed the peak treatment flow rate receive no treatment. Different assumptions can be made for on and off-line treatment systems. Likewise, an analysis of continuous rainfall intensity data can determine the average annual rainfall volume that is associated with a particular range of rainfall intensities. This type of analysis was completed for four different rain gages representing the different quadrants of Portland, and is summarized in Exhibit 5. 5, 10 and 20-minute intensities were analyzed to determine the intensities associated with the 90% rainfall volume goal. For 5-minute intensities, rainfall intensities of 0.19 inches per hour or less were determined to account for 90% of the average annual rainfall volume.

Eugene performed an analysis on 50 years of Eugene Airport rainfall data and also concluded that a rainfall intensity of 0.19"/hr would be needed to treat 90% of the average annual runoff volume.

Figure 1: Continuous simulation determination of 90% treatment flow rate



VOLUME BASED TREATMENT SYSTEMS

Unlike rate based systems, volume (or detention) based systems provide a significant storage volume for water to accumulate and be detained for a period of time. Pollutants are removed through physical (settlement) and/or biological processes. Volume based facilities used in Portland include wet ponds and wetlands. Unlike rate based systems, it is not easy to model volume based systems with continuous simulation models or rainfall analysis. Storm detention time needs to be factored into the model, and the mixing of water within the facility from one storm to the next creates a complex process that cannot be simulated accurately at this time. The currently accepted methodology used to size volume based treatment facilities (in Portland's SWMM, Gary Minton's *Stormwater Treatment* textbook, and many other jurisdictions) is to set the wet portion of the pond or wetland (permanent pool) equal to the full volume of runoff generated by the predetermined water quality storm, and apply a safety factor (Vb/Vr ratio).

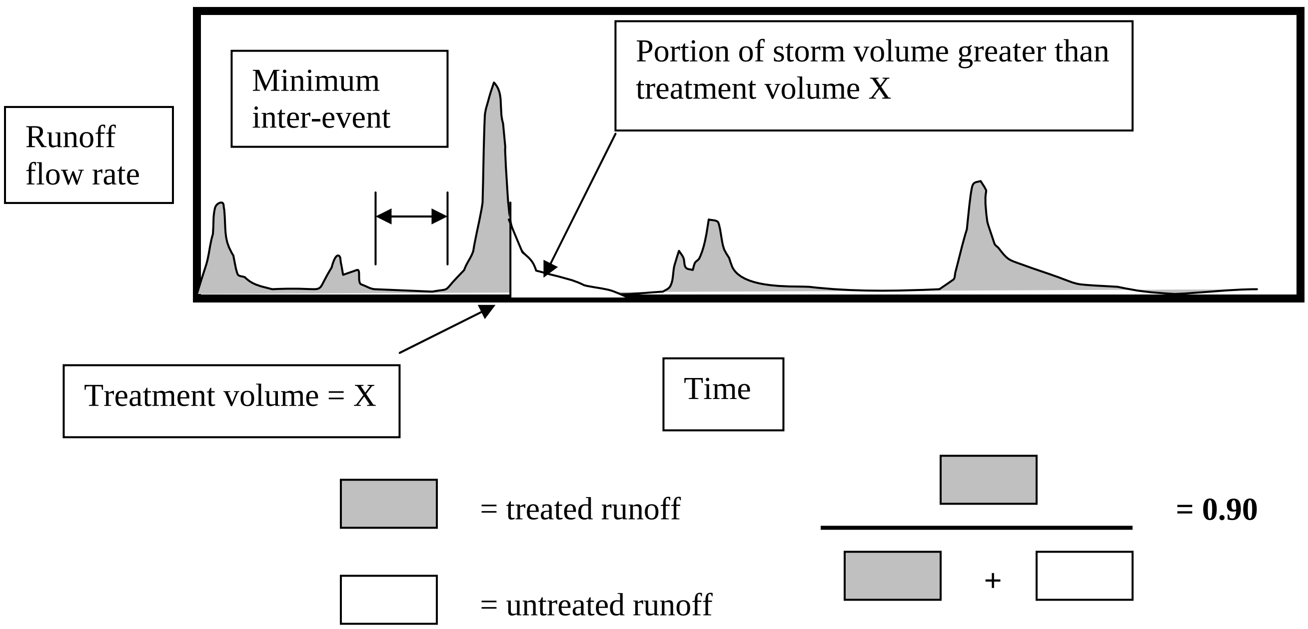
The volumes of most jurisdictions' water quality storms are set at their average annual treatment volume goal. For example, if the goal is to treat 80% of the average annual flow volume, the treatment storm depth is set to the 80% percentile storm. Eugene's goal is to treat 80% of the average annual volume. Their water quality storm is 1.4"/24 hours, which is equal to the 80th percentile storm. 80% of their storm events have a depth of 1.4 inches or less. In Portland's case, the 0.83" storm is not equal to the 90th percentile storm. An estimate would put it somewhere between the 60th and 65th percentile storm. This had been compensated for in the September 2002 Stormwater Management Manual by requiring volume-based facilities to use twice the volume of runoff generated by the 0.83" storm, or a Vb/Vr ratio of 2, but this factor should most likely be a function of soil type. In a recent version of *Stormwater Treatment Northwest* (Vol 9, No 4), Gary Minton and Roger Sutherland suggest that Pacific Northwest monitoring data indicates that a Vb/Vr ration of 1 may be adequate to achieve a TSS removal of 80%.

The City of Eugene has performed an analysis on 50 years of Eugene Airport rainfall data, and concluded that 90% of rainfall events are less than 2.4 inches in depth. Hourly rainfall intensity data was used in the analysis, storm depths of 0.01 inches or less were eliminated from the analysis, and a minimum inter-event time of 6 hours was used. A slight change in the modeling assumptions has a significant impact on the outcome. In the December 2003 issue of *Stormwater Treatment Northwest*, Gary Minton stated that an analysis he did of 24-hour rainfall data from the Seattle-Tacoma International Airport indicated that with a storm depth of about 1.35 inches, 90% of the runoff would be treated over time. The specific assumptions that were used in Dr. Minton's analysis are not known, but he was not using the 90th percentile Seattle-Tacoma storm. The Washington State Department of Ecology's Western Washington Stormwater Manual targets the capture of 91% of the average annual runoff for water quality, which they equate to two-thirds of a 2-year storm event (roughly 1.65 inches). Again, this storm event is not equivalent to the 91st percentile Western Washington storm.

A way of modeling the rainfall that could result in a clearer link to the treatment goal may be to determine the volume of a wet basin that will result in an average storm detention time of 24, 36, or 48 hours, depending on the anticipated TSS settling velocity in the vicinity of the site. The assumed inter-event time could be adjusted to ensure that enough detention time is provided between each storm event. An assumption could be made that storms with total volumes less than the "90% treatment storm" would receive 100% treatment. Storms with total volumes greater than the "90% treatment storm" would receive partial treatment- 100% treatment for the volume equal to the 90% storm volume, and 0 treatment for the volume greater than the 90%

storm volume. This may be overly conservative, as some very long, drawn-out storms (>24 hours) with total volumes greater than the designated treatment volume, may in fact receive greater than 24 hours of detention time for the entire storm, or 100% effective treatment.

Figure 2: Continuous simulation determination of 90% treatment volume



CONCLUSION AND RECOMMENDATION

The Portland water quality design storm shall be stated as a volume treatment goal- e.g. "90% of the average annual runoff shall be treated", and will be clarified by stating the peak rainfall intensity, and total volume components. This achieves two things:

1) Volume based facilities and rate based facilities will be theoretically sized to achieve treatment of the same percentage of average annual runoff volume.
2) With the treatment rainfall intensity already given, the SBUH or other hydrograph based hydrologic analysis method won't be needed to size rate based treatment facilities, simplifying the design process. Rather, the Rational Method can be used to calculate the runoff treatment flow rate, based on the site's time of concentration.

To achieve the treatment of 90% of the average annual rainfall volume, rate based facilities must be sized to treat rainfall at 0.19 inches per hour for sites with 5-minute time of concentration or less, 0.16 inches per hour for sites with a 10-minute time of concentration, and 0.13 inches per hour for sites with a 20-minute time of concentration.

For volume based facilities, Portland shall continue to size wet basins using 0.83 inches of rainfall over 24 hours (NRCS Type 1A rainfall distribution), with a Vb/Vr ratio of 2. Further analysis will be completed during the September 2010 Stormwater Management Manual revision process.

There should no longer be the perception of extreme water quality design storm discrepancies between Portland's Stormwater Management Manual and the Department of Ecology's Stormwater Management Manual for Western Washington, answering questions raised by NOAA Fisheries during review of Portland's manual.

In the long term, as more is learned about the capabilities of stormwater treatment facilities and their relationship to environmental, economic, and social considerations, Portland's treatment storm characteristics shall be re-analyzed and compared with those of other local jurisdictions periodically to determine if changes are necessary.

Figure 3: Water Quality Design Storm Pacific Northwest Comparison

Jurisdiction	Average Annual Rainfall (inches)	Treatment Goal (average annual runoff %)	WQ Storm Volume (inches) Vr	Volume Based Facility Sizing Factor	WQ Storm Duration (hours)	WQ Storm Intensity for Off-Line Facilities (in/hr)	WQ Storm Intensity for On-Line Facilities (in/hr)
City Of Gresham	37.4	80	1.2	1	12	0.11	0.20
City Of Eugene	46.6	80	1.4	1	24	0.13	0.22
City Of Corvallis	43.2	90	0.90, 0.3 mean ann. storm for wet ponds	3	24	Not Specified: 0.90" storm peak 10 min intensity (per NRCS 1A dist.) = 0.29 in/hr	
Clean Water Services-Oregon	36	85	0.36	1	4	WQ Volume / 4 hours = 0.09 in/hr	
DOE Western Washington SWMM	Varies 36-46	91	"6-month storm volume"- Varies	1	24	91% treatment: varies by jurisdiction, HSPF continuous simulation, different on & off-line	
City Of Tacoma	37.6	91	"6-month storm volume"	1	24	91% treatment, HSPF continuous simulation, different on & off-line	
City Of Seattle	38.6	Not Clear	"Mean annual storm" = 0.47	1	24	6-month storm (64% of 2-year storm or 1.08 inches) peak 10-min intensity using SBUH = 0.35 in/hr	
King County-Washington	38.6	95	"Mean annual storm" = 0.47- 0.65	3	24	60% of 2-yr storm flow rate using KCRTS continuous simulation, or 64% of 2-yr storm flow rate using SBUH	
Oregon State DEQ	Varies 37 approx. average	Not Clear	2-year storm: 2.4" in Portland	1	24	Not Specified: 2.4" storm peak 10 min intensity (per NRCS 1A dist.) = 0.78 in/hr	
City Of Portland (1996-Sept. 2004)	36	Not Clear: 95% Claim	0.83	2	24	Not Specified: 0.83" storm peak 10 min intensity (per NRCS 1A dist.) = 0.27 in/hr	
City Of Portland (Recom-mended for Sept. 2004)	36	90	90% Ave. annual treatment volume*	1 if Vr = 1.7, 2 if Vr = 0.83	24	90% treatment as shown by continuous simulation (see Figure 5) = 0.19 to 0.13 in/hr, depending on site's TofC	

* As defined by the recommended analysis of 24 years of Portland rainfall data, assuming a minimum inter-event time of 12 hours and minimum rainfall amount of 0.01 inches (see Figure 6). Portion of storm volume below specified treatment volume receives 100% treatment, portion of storm volume above specified treatment volume receives 0% treatment.

Figure 4: Rainfall Intensity Versus Percentage of Annual Rainfall Volume	8/12/2004
Rainfall data taken from each of four Portland quadrants, then averaged.	Fancher

5-minute intensity in/hr	% Annual Rainfall Volume
0	0
0.01	7
0.02	14
0.03	21
0.04	28
0.05	35
0.06	42
0.07	48.5
0.08	55.5
0.09	62.5
0.1	69.5
0.11	76.5
0.12	83.5
0.13	84.5
0.14	85.5
0.15	86
0.16	87
0.17	88
0.18	89
0.19	90
0.2	90.5
0.21	91.5
0.22	92.5
0.23	93
0.24	94
0.25	95
0.3	96
0.4	98
0.5	98

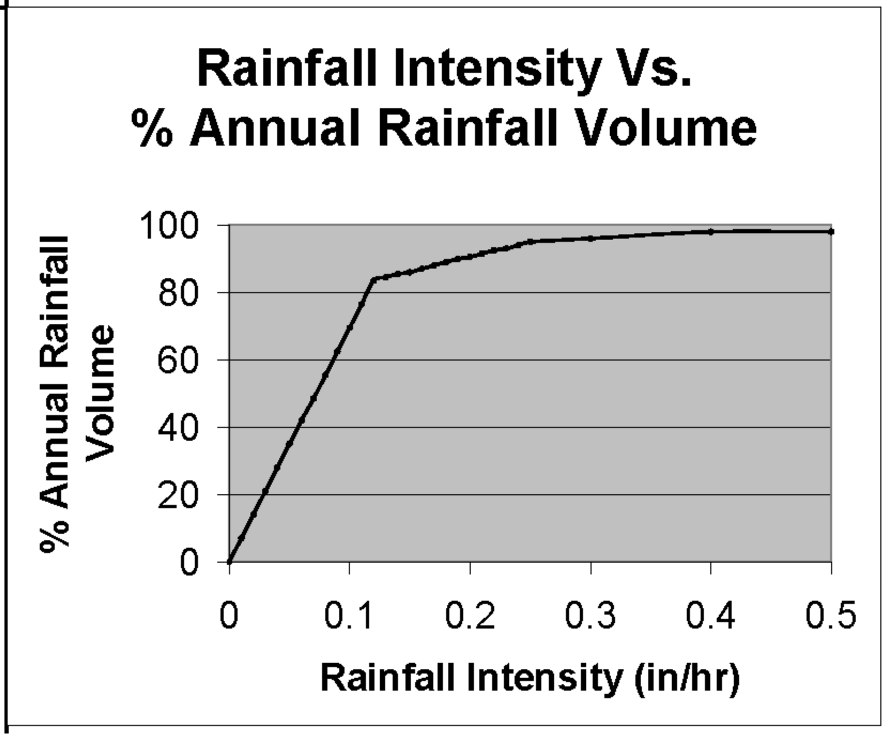


Figure 5: BES Stormwater Pollution Reduction Storm Analysis April 30, 2004

Intensities Resulting in Treatment of 90% of Rainfall Volume (in/hr)
Assumption: Percentage of rainfall less intense than specified intensity receives 100% treatment, percentage of rainfall more intense than specified intensity receives 0 treatment.

5 minute intensity NW	0.19	Average = 0.19 in/hr
5 minute intensity SW	0.19	
5 minute intensity SE	0.20	
5 minute intensity NE	0.19	
10 minute intensity NW	0.15	Average = 0.16 in/hr
10 minute intensity SW	0.15	
10 minute intensity SE	0.165	
10 minute intensity NE	0.16	
20 minute intensity NW	0.13	Average = 0.13 in/hr
20 minute intensity SW	0.12	
20 minute intensity SE	0.14	
20 minute intensity NE	0.135	

Figure 6: BES Stormwater Pollution Reduction Storm Analysis April 30, 2004

Volumes Resulting in Treatment of 90% of Rainfall Volume (in/hr)
Assumptions: Percentage of storm volume less than specified volume receives 100% treatment, percentage of storm volume greater than specified volume receives 0 treatment. Storm event is defined by a minimum of 0.01 inches of rainfall with a minimum inter-event period of 12 hours.

Place & Time	Total Rainfall (in)	Number of 12-hr Storms	Average Storm Size (in)	90% Treatment Storm Size (in)	Average 90% Treatment Storm Size (in)
NW 97-98	80.15	169	0.47	1.6	Average = 1.7 in
NW 90-91	65.5	163	0.40	1.3	
NW 83-84	83.9	202	0.42	1.9	
NW 80-81	95.37	247	0.39	2.1	
SW 97-98	73.85	176	0.42	1.4	Average = 1.7 in
SW 90-91	61.83	180	0.34	1.25	
SW 83-84	82.37	201	0.41	1.9	
SW 80-81	67.45	160	0.42	2.1	
SE 97-98	74.41	185	0.40	1.6	Average = 1.8 in
SE 90-91	63.71	184	0.35	1.3	
SE 83-84	82.75	192	0.43	2.0	
SE 80-81	65.41	163	0.40	2.3	
NE 97-98	74.00	180	0.41	1.4	Average = 1.7 in
NE 90-91	64.62	176	0.37	1.2	
NE 83-84	72.27	217	0.33	1.7	
NE 80-81	65.37	188	0.35	2.3	

Appendix: Local Pollution Reduction Storm Specifications

MEMORANDUM

TO: Greg Gescher, CP&P Supervisor

FROM: Bruce Moser, Project Manager

DATE: December 15, 2003

SUBJECT: **Stormwater Quality Facility Design Storm**

This memo reviews the stormwater quality design storm event for the City of Corvallis, and recommends using a NRCS Type 1A storm event of 0.9 inch in 24 hours.

Background

NPDES Phase 1 and 2 Stormwater regulations require agencies to implement stormwater quality treatment by the use of best management practices. NPDES Phase 1 and 2 Permits do not include a specific requirement for meeting a design storm and treatment level. The State of Oregon DEQ has not established stormwater quality criteria for NPDES Phase 1 for receiving streams that are not water quality limited (TMDLs have not been established).

The Corvallis SWMP includes the requirement to retrofit all existing stormwater outfalls with water quality facilities, and to require new development to install stormwater quality facilities. The SWMP includes Technical Memorandum No. 3, dated Nov. 10, 1999, in which Brown&Caldwell staff recommended that the City of Corvallis use 2/3's of the 2 year, 24 hour rainfall event, or 1.67 inches for 24 hours for the stormwater treatment design storm event. This level of treatment exceeds the level other agencies in Oregon are currently using.

Discussion

Agencies in Oregon that have NPDES stormwater permits have established differing criteria for the stormwater quality design storm event to capture and treat. Agencies have reviewed local rainfall data to determine the level of storm event to capture that represents a percentage of the total rainfall. This methodology is based on the assumption that the majority of pollutants are mobilized and transported prior to the peak of a large rainfall event. Several stormwater quality studies have substantiated this assumption.

The process for review of rainfall data involves review of historical rainfall events to establish a level of 24 hour precipitation that represents a given percentage of the total volume of rainfall. The City of Portland has established design criteria of 95% of total stormwater runoff is to be treated to remove 70% of Total Suspended Solids (TSS). The design storm to capture has been established as 0.83 inches in 24 hours, using NRCS Type 1A curve. The City of Eugene has established the design criteria of 90% of total stormwater runoff to be treated, but the TSS removal criteria is not mentioned. City of Eugene staff assume that a properly designed stormwater quality BMP will remove 80% of TSS. City of Eugene has established the design storm as 0.21 inches in one hour for on-line facilities, and 0.12 inches in one hour for off-line facilities. This is based on using 1.0 inch in 24 hour as the design storm, using the NRCS Type 1A curve. The on-line facilities have a greater design storm based on the assumption that the effectiveness of an on-line facility will be impacted by flow when compared to an off-line facility.

Establishing Stormwater Quality Treatment Design Storm Event for Corvallis

The design rainfall event and treatment level is not currently identified under existing or anticipated regulatory requirements for the City of Corvallis. The SWMP does not specify treatment levels, but community input frequently referenced the water quality requirements that larger Oregon cities were meeting. A reasonable expectation for the implementation of stormwater quality facilities in Corvallis would be meeting community standards established in other Oregon cities that require stormwater treatment.

The stormwater receiving streams in Corvallis do not have established TMDL's, and none are anticipated to be implemented in the foreseeable future. In addition, the EPA Implementation Plan for Corvallis has not established a water quality treatment requirement with the exception of water temperature.

The methodology for developing the storm event for design treatment levels for the City of Corvallis uses review of historical daily rainfall over the last 42 years from the Hyslop rainfall gage (located 4 miles north of Corvallis) to determine the 24 hour event that would provide 90% capture for treatment. The 42 year historical data was tabulated to establish the average yearly rainfall of 43.20 inches. The amount of yearly rainfall that equals 90% of this yearly rainfall is 38.87 inches. The next step of the methodology was to establish ~~ed~~ a daily rainfall amount that collectively meets the 38.88 inches over the 42 years of data. The historical rainfall data was input to a spreadsheet "if, then" command to record all daily rainfall less than or equal to 0.9 inches. Rainfall greater than 0.9 inches was converted to 0.9 inches for the 24 hour period. The data was again tabulated and averaged to determine the yearly average rainfall amount, which was calculated to be 38.99 inches. This level nearly matches the target the yearly average for 90% rainfall of 38.88 inches.

The following table compares the annual average rainfall and design storm events for Portland, Corvallis, and Eugene.

City	Portland	Corvallis	Eugene
Annual Ave. Rainfall (inches)	37.07	43.20	50.90
24 Hr. Design Storm (inch/24 hour)	0.83	0.90	1.00

Recommendation

Based on review of other agency design storm methodology and review of local rainfall data, the stormwater quality design storm event for the City of Corvallis is recommended to be 0.9 inches in 24 hours, using the NRCS Type 1A distribution curve.

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Clean Water Services Our commit

Home > D&C Standards 04-09

Design & Construction Standards

Clean Water Services Design and Construction Standards c the administrative and technical requirements for the design of sanitary and surface water management systems which a of residential or commercial development. The new Design a Standards Resolution and Order 04-9 (R&O 04-9) became e March 1, 2004 and replaces the previous version of the stan 11.

Unless otherwise specifically identified in the land use condit new development submittals within the District's boundaries- development within cities--should comply with R&O 04-9.

- **Click here to view or download Resolution and Or (PDF).**
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- **You may also access Resolution and Order 03-11 January 1, 2005.**

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APPENDIX B:
WATER QUALITY & QUANTITY
FACILITY DESIGN

1.0 GENERAL REQUIREMENTS FOR WATER QUALITY AND QUANTITY FACILITIES

1.1 Erosion Protection

a. Inlets to water quality and quantity facilities shall be protected from erosive flows through the use of an energy dissipater or rip rap stilling basin of appropriate size based on flow velocities. Flow shall be evenly distributed across the treatment area.

b. All exposed areas of water quality and quantity facilities shall be protected using coconut or jute matting. Coconut matting or high density jute matting (Geojute Plus or approved equal) shall be used in the treatment area of swales and below the WQV levels of ponds. Low density jute matting (Econojute or approved equal) may be used on all other zones.

1.2 Vegetation

a. Vegetation shall be in accordance with the Appendix D: Landscape Requirements.

b. No invasive species shall be planted or permitted to remain within the facility which may affect its function, including, but not limited to the following:

1. Himalayan blackberry (Rubus discolor)
2. Reed canarygrass (Phalaris arundinacea)
3. Teasel (Dipsacus fullonum)
4. English Ivy (Hedra helix)
5. Nightshade (Solanum sp.)
6. Clematis (Clematis ligusticifolia and C. vitabla)
7. Cattail (Typhus latifolia)
8. Thistle (Cirsium arvense and C. vulgare)
9. Scotch Broom (Cytisus scoparius)

8) A vehicle turnaround shall be provided when the access road exceed 40' in length.

2.0 WATER QUALITY FACILITY DESIGN

This section presents methodology for designing water quality facilities.

2.1 Water Quality Volumes and Flows

(Reproduced from Appendix A: Hydrology and Hydraulics; Section 1)

The water quality storm is the storm required by regulations to be treated. The storm defines both the volume and rate of runoff.

a. Water Quality Storm: Total precipitation of 0.36 inches falling in 4 hours with a storm return period of 96 hours.

b. Water quality volume (WQV) is the volume of water that is produced by the water quality storm.

c. Water Quality Volume (WQV): 0.36-inches over 100-percent of the new impervious area.

$$\textit{Water Quality Volume (cf)} = \frac{0.36(in) \times Area\ (sf)}{12\ (in/ft)}$$

d. Water Quality Flow (WQF): The average design flow anticipated from the water quality storm.

$$\textit{Water Quality Flow (cfs)} = \frac{\textit{Water Quality Volume (cf)}}{14{,}400\ Sec}$$

Or

$$\textit{Water Quality Flow (cfs)} = \frac{0.36(in) \times Area\ (sf)}{12(in/ft)(4\ hr)(60\ min/hr)(60\ sec/min)}$$

2.2 Pretreatment

a. Pretreatment Required

Sheet flow of impervious surfaces into water quality facilities will not be allowed without pretreatment. Incoming flows to the water quality facility must be pretreated using a water quality manhole in accordance with section 2.3 or other pre-treatment method as approved by the District/City. Other methods of pretreatment may include proprietary devices, filter

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Stormwater Management Manual for Western Washington

Volume I - Minimum Technical Requirements and Site Planning
Volume II - Construction Stormwater Pollution Prevention
Volume III - Hydrologic Analysis and Flow Control Design/BMPs
Volume IV - Source Control BMPs
Volume V - Runoff Treatment BMPs

Prepared by:

Washington State Department of Ecology
Water Quality Program

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Chapter 4 - General Requirements for Stormwater Facilities

Note: All Figures in Chapter 4 are courtesy of King County

This chapter addresses general requirements for treatment facilities. Requirements discussed in this chapter include design volumes and flows, sequencing of facilities, liners, and hydraulic structures for splitting or dispersing flows.

4.1 Design Volume and Flow

4.1.1 Water Quality Design Storm Volume

The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm).

Wetpool facilities are sized based upon use of the NRCS (formerly known as SCS) curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm. Treatment facilities sized by this simple runoff volume-based approach are the same size whether they precede detention, follow detention, or are integral with the detention facility (i.e., a combined detention and wetpool facility).

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

4.1.2 Water Quality Design Flow Rate

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

An approved continuous runoff model should identify the 2-year return frequency flow rate discharged by a detention facility that is designed to meet the flow duration standard.

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

- *Off-line facilities*: For treatment facilities not preceded by an equalization or storage basin, and when runoff flow rates exceed the water quality design flow rate, the treatment facility should continue to receive and treat the water quality design flow rate to the applicable treatment performance goal. Only the higher incremental portion of flow rates are bypassed around a treatment facility. Ecology encourages design of systems that engage a bypass at higher flow rates provided the reduction in pollutant loading exceeds that achieved with bypass at the water quality design flow rate.

  Treatment facilities preceded by an equalization or storage basin may identify a lower water quality design flow rate provided that at least 91 percent of the estimated runoff volume in the time series of a continuous runoff model is treated to the applicable performance goals (e.g., 80 percent TSS removal at the water quality design flow rate and 80 percent TSS removal on an annual average basis).

- *On-line facilities*: Runoff flow rates in excess of the water quality design flow rate can be routed through the facility provided a net pollutant reduction is maintained, and the applicable annual average performance goal is likely to be met.

Estimation of Water Quality Design Flow Rate for Facilities Preceding Detention or when Detention Facilities are not required:

Until a continuous runoff model is available that identifies the water quality design flow rate directly, that flow rate shall be estimated using Table 4.1, and its following directions for use:

Step 1 Determine whether to use the 15-minute time series or the 1-hour time series. At the time of publication, all BMPs except wetpool-types should use the 15-minute time series.

Step 2 Determine the ratio corresponding with the effective impervious surface associated with the project. For effective impervious areas between two 5 percent increments displayed in the table, a straight line interpolation may be used, or use the higher 5 percent increment value.

Step 3 Multiply the 2-year return frequency flow for the post-developed site, as predicted by an approved continuous runoff model, by the ratio determined above.

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Volume I
Minimum Technical Requirements and Site Planning

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Tacoma Public Works
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related natural resources. Based upon gross level applications of continuous runoff modeling and assumptions concerning minimum flows needed to maintain beneficial uses, watersheds must retain the majority of their natural vegetation cover and soils, and developments must meet the Flow Control Minimum Requirement of this chapter, in order to avoid significant natural resource degradation in lowland streams.

The Roof Downspout Control BMPs described in Chapter 3 of Volume III, and the Dispersion and Soil Quality BMPs in Chapter 5 of Volume V are insufficient to prevent significant hydrologic disruptions and impacts to streams and their natural resources. Therefore, Ecology has suggested that the City and other local governments should look for opportunities to encourage and require additional BMPs such as those in Sections 5.2 through 5.4 of Volume V through updates to their site development standards and land use plans.

3.5.6 Minimum Requirement #6: Runoff Treatment

Thresholds

The following require construction of stormwater treatment facilities (see Table 3.1):

- **Projects in which the total of effective pollution-generating impervious surface (PGIS) is 5,000 square feet or more in a threshold discharge area of the project, or**
- **Projects in which the total of pollution-generating pervious surfaces (PGPS) is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there is a surface discharge in a natural or man-made conveyance system from the site.**

Treatment Facility Sizing

Water Quality Design Storm Volume: The volume of runoff predicted from a 24-hour storm with a 6-month return frequency (a.k.a., 6-month, 24-hour storm). Wetpool facilities are sized based upon the volume of runoff predicted through use of the Natural Resource Conservation Service curve number equations in Chapter 2 of Volume III, for the 6-month, 24-hour storm.

Water Quality Design Flow Rate:

- ***Preceding Detention Facilities or when Detention Facilities are not required*: The flow rate at or below which 91% of the runoff volume will be treated, as estimated by an approved continuous runoff model. Design criteria for treatment facilities are assigned to achieve the applicable performance goal at the water quality design flow rate.**
- **Volume V includes performance goals for Basic, Enhanced, Phosphorus, and Oil Control treatment, and a menu of facility options for each treatment type. Treatment facilities that are**

Stormwater Treatment Technical Requirements Manual

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City of Seattle

Title 22.800 Stormwater, Grading & Drainage Control Code

Volume 1: Source Control Technical Requirements Manual
Volume 2: Construction Stormwater Control Technical Requirements Manual
Volume 3: Flow Control Technical Requirements Manual
Volume 4: Stormwater Treatment Technical Requirements Manual

concentration. TC depends on several factors, including ground slope, ground roughness, and distance of flow.

The Soil Conservation Service (SCS) runoff curve number to be used with the SBUH method shall be 98 for impervious surfaces, and 85 or greater for pervious surfaces unless one of the following conditions is met:

- A lower SCS curve number is justified for an area incorporating one or more site design options (see City of Seattle Directors' Rule for Flow Control), or
- A soil report by an experiences geotechnical/civil engineer indicates site soils are sufficiently pervious to allow a smaller SCS curve number to be used.

In the City of Seattle, the design storm used by the SBUH method *for design of treatment facilities* is based on a *standard* SCS Type 1A storm event hyetograph where, during the peak 10-minute period, 5.40% of the total rainfall occurs. Note that *for design of flow control facilities*, a *modified* SBUH method is used where 9.92% of the rainfall occurs during the ten-minute period at the peak of the storm event (see Appendix A).

Water Quality Design Flow

Flow-through treatment structures, such as biofiltration facilities, media filtration facilities, and oil control facilities, must be sized based on runoff from the 6-month, 24-hour storm event, which has a rainfall runoff volume of 1.08 inches. This value is based on the assumption that the 6-month, 24-hour storm volume is 64% of the volume of the 2-year, 24-hour storm event.[4] For these types of facilities, water quality design flow, Q_{wq}, is equal to the peak flow (measured in cfs). Using the SBUH method, this peak occurs during the ten-minute interval between 470 and 480 minutes, when 5.40% of the total rainfall volume occurs. Additional information on the SBUH method is provided in Appendix A. For *storage* treatment facilities, such as wetponds, wetvaults, and stormwater wetlands, sizing is based on the volume of runoff from the *mean annual storm event*, which for Seattle is 0.47 inches. Additional information on determining water quality design flows for storage treatment facilities is contained in Chapter 4.

2.2 SEQUENCE OF FACILITIES

As specified in the water quality menus, where more than one water quality facility is used, the order is often prescribed. This is because the specific pollutant removal role of the second or third facility in a treatment train often assumes that significant solids settling has already occurred. For example, phosphorus removal using a two-facility treatment train relies on the second facility (sand filter) to remove a finer fraction of solids than those removed by the first facility.

There is a larger question, however, of whether water quality facilities should be placed upstream or downstream of detention facilities. In general, all water quality facilities may be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. Not all water quality facilities, however, can be located

[4] Ref: Stormwater Management Manual for the Puget Sound Basin; The Technical Manual (1992). Publication 91-75, Washington State Department of Ecology, Olympia. Washington.

********FEBRUARY 2004 UPDATE DRAFT********

Strike-Out-and-Underline Revisions

CHAPTER 6

WATER QUALITY DESIGN

KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

*9/1/98

6.2 GENERAL REQUIREMENTS FOR WQ FACILITIES

This section presents the general requirements for water quality (WQ) facilities. When detail in the WQ designs is lacking, refer to Chapter 5 for guidance. In cases where requirements are extremely costly, a less expensive alternative that is functionally equivalent in terms of performance, environmental effects, health and safety, and maintenance can be sought through the adjustment process (see Section 1.4).

Use of Metal Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. High zinc concentrations, sometimes in the range that can be toxic to aquatic life, have been observed in the region.[12] Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other metals, such as aluminum or stainless steel, or plastics are available, they should be used.

6.2.1 WATER QUALITY DESIGN FLOWS

Water Quality Design Flow

The water quality design flow is defined as follows:

- *Preceding detention*: **60% of the developed two-year peak flow rate, as determined using the KCRTS model** with 15-minute time steps calibrated to site conditions (see Chapter 3). *Note: If KCRTS is not being used on a project, the WQ design flow may also be estimated using 64% of the 2-year 24-hour precipitation in the SBUH model.*[13]
- *Downstream of detention*: The full **2-year release rate from the detention facility**.

The KCRTS model will typically be used to compute the WQ design flow. When examining the peak flow rates associated with various runoff volumes, it was found that detained flows and undetained flows must be described differently. However, unlike peak flows, the KCRTS model computation of volume of runoff is unaffected by whether or not the runoff is detained. Therefore, facilities such as wetponds, which are sized by a simple volume-based approach that does not route flows through a detention ~~pond~~facility, are the same size whether they precede or follow detention.

Note that facilities which are sized based on volume and which include routing of flows through a detention ~~pond~~facility, such as the detailed sand filter method, are significantly smaller when located downstream of detention, even though the same volume of water is treated in either situation. This is because the detention ~~pond~~facility routing sequence stores peaks within the pond and releases them at a slow rate, reducing the size of the sand filter pond subsequently needed (the volume needed to store the peaks need not be provided again in the sand filter pond).

Flow Volume to be Treated

When water quality treatment is required pursuant to the core and special requirements of this manual, it is intended that a minimum of **95% of the annual average runoff volume** in the (8 year) time series, as determined with the KCRTS model, be treated. Designs using the WQ design flow (as discussed above) will treat this minimum volume.

Treatable Flows

As stated in Chapter 1, only runoff from target pollution-generating surfaces must be treated using the water quality facility options indicated in the applicable water quality menu. These surfaces include both

[12] Finlayson, 1990. Unpublished data from reconnaissance of Metro Park and Ride lot stormwater characteristics.

[13] The Department of Ecology WQ design flow is based on the flow predicted by the SBUH model for 64% of the 2-year 24-hour precipitation. This is roughly equivalent to the WQ design flows given here for the KCRTS model.

6.4.1.1 METHODS OF ANALYSIS

This section describes methods of analysis for the following two wetpond sizes:

- **Basic wetpond** (see below)
- **Large wetpond** (see page 6-73).

❑ BASIC WETPOND

The primary design factor that determines a wetpond's **particulate removal efficiency** is the volume of the wetpool in relation to the volume of stormwater runoff from the *mean annual storm*.[25] The larger the wetpond volume in relation to the volume of runoff, the greater the potential for pollutant removal. Also important are the avoidance of short-circuiting and the promotion of plug flow. *Plug flow* describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are as follows:

- Dissipating energy at the inlet
- Providing a large length-to-width ratio
- Providing a broad surface for water exchange across cells rather than a constricted area.

Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Wetponds designed using the method below (with the volume = $3V_r$) and the required design criteria in Section 6.6.2.2 are expected to meet the Basic WQ menu goal of 80% TSS removal. The actual performance of a wetpond may vary, however, due to a number of factors, including design features, maintenance frequency, storm characteristics, pond algae dynamics, and waterfowl use.

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume factor (f). A basic wetpond requires a volume factor of 3. This means that the required wetpond volume is 3 times the volume of runoff V_r from the mean annual storm (see Steps 2 and 3).

Step 2: Determine rainfall (R) for the mean annual storm. The rainfall for the mean annual storm R is obtained by locating the project site on Figure 6.4.1.A (p. 6-71) and interpolating between isopluvials. Convert to feet for use in Equation (6-13).

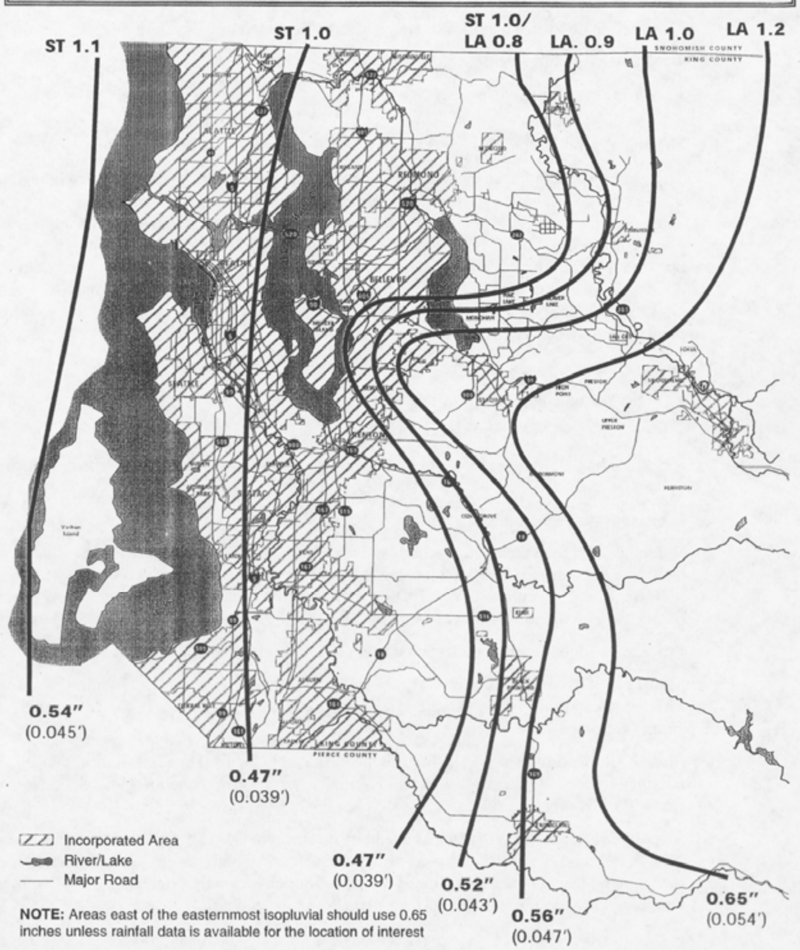
Step 3: Calculate runoff from the mean annual storm (V_r) for the developed site. The runoff volume V_r is the amount of rainfall that runs off a particular set of land covers. To determine V_r, each portion of the wetpond tributary area is assigned to one of four cover types, each having a different runoff coefficient: impervious surface, till grass, till forest, or outwash.

- **Impervious surface** is a compacted surface, such as pavement, gravel, soil, or other hard surfaces, as well as open water bodies. *Note: The effective impervious computations given in Chapter 3, Table 3.2.2.~~D~~ E may be used, unless more detailed information is available ~~if desired~~.*

- **Till grass** is post-development grass or landscaped area and onsite forested land on till soil that are not permanently in sensitive area buffers or covenants. *Till* is soil that does not drain readily and, as a

[25] The *mean annual storm* is a statistically derived rainfall event defined by the U.S. Environmental Protection Agency in "Results of the Nationwide Urban Runoff Program", 1986. It is defined as the annual rainfall divided by the number of storm events in the year. The NURP studies refer to pond sizing using a V_b/V_r ratio: the ratio of the pond volume V_b to the volume of runoff from the mean annual storm V_r. This is equivalent to using a volume factor f times V_r.

FIGURE 6.4.1.A PRECIPITATION FOR MEAN ANNUAL STORM IN INCHES (FEET)



NOTE: Areas east of the easternmost isopluvial should use 0.65 inches unless rainfall data is available for the location of interest

[24] The mean annual storm is a conceptual storm found by dividing the annual precipitation by the total number of storm events per year

result, generates large amounts of runoff. For this application, till soil types include Buckley and bedrock soils, and alluvial and outwash soils that have a seasonally high water table or are underlain at a shallow depth (less than 5 feet) by glacial till. U.S. Soil Conservation Service (SCS) hydrologic soil groups that are classified as till soils include a few B, most C, and all D soils. See Chapter 3 for classification of specific SCS soil types.

Appendix F Table of Contents

APPENDIX F.1 DEPTH TO GROUNDWATER INVESTIGATION

Several areas within the City of Portland have known shallow groundwater. Within areas of known or suspected shallow groundwater, additional information about the depth to groundwater (DTW) must be collected to ensure that the proposed underground injection control (UIC) system meets minimum separation distances between the bottom of a UIC and seasonal high groundwater, as required by Oregon Department of Environmental Quality (DEQ) guidelines for private UICs or by the requirements of the water pollution control facility (WPCF) permit for publicly owned UICs that DEQ issued to the City of Portland on June 1, 2005. Exhibit F.1-1 shows the minimum separation distances.

When a public or private[1] UIC is proposed within the regulated area, a site-specific investigation is required to determine the seasonal high depth to groundwater. DTW investigations are required for areas identified on the *Estimated Depth to Seasonal High Groundwater* map (see **Appendix H.3**) where the estimated depth to seasonal high groundwater contour is less than the 50-foot contour. The City of Portland derived this map from the *Estimation of Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area,* prepared by the United States Geological Survey (USGS). The USGS is currently reviewing this report for publication, and the data are considered provisional. Therefore, before using the map in Appendix H.3, the user should check the City of Portland website (http://www.portlandonline.com/bes/index.cfm?c=35122&%20) for the most recent version of the map to determine if the proposed UIC(s) is located in an area that requires investigation.

Exhibit F.1-1: Minimum Separation Distance

Depth of UIC	Minimum Separation Distance between the Bottom of the UIC and Seasonal High Groundwater
> 5 feet deep	10 feet
≤5 feet deep	5 feet

[1] The requirements in this document do not apply to UICs specifically excluded by DEQ (e.g., privately owned residential footing and roof drains).

Depth to Groundwater Investigation Requirements

The DTW investigation requires sufficient time to plan for and perform the necessary steps to collect a reliable measurement, including obtaining permits, performing utility locates, borings, piezometer/well installation, collection of water level measurements, and decommissioning of the monitoring well. The DTW investigation, including design, installation oversight, water measurements, and decommissioning, must be performed by an Oregon licensed registered geologist (RG), certified engineering geologist (CEG), or professional engineer (PE) with experience in hydrogeologic investigations and well design and installation; the investigation may include either the installation of a temporary piezometer(s) or groundwater monitoring well(s). The qualified professional is responsible for developing an appropriate scope of work to document the DTW, including:

- Determining the number and location(s) of the DTW measurements needed to address project objectives. (It is recommended, but not required, to have each piezometer or well location surveyed to a datum.)

- Determining the appropriate method for obtaining DTW measurements (e.g., piezometer or monitoring well).

- Determining the appropriate depth of the boring(s). (Boring depth must be a minimum of 20 feet deeper than the proposed UIC depth.)

- Observing and describing soils encountered during drilling.

- Developing an appropriate well or piezometer design.

- Ensuring that construction and abandonment of piezometer or monitoring well complies with Oregon Administration Rules 690-240.

- Obtaining depth to groundwater measurements.[2]

- Estimating the measured DTW to be representative of the "groundwater seasonal high," based on available data and best professional judgment.

- Documenting the procedures used and the results of the DTW investigation.

- Submitting a signed and stamped DTW investigation report.

To the extent practicable, DTW measurements should be obtained in the immediate vicinity (less than or equal to 75 feet) of the proposed UIC. If high-quality shallow groundwater level data is available (e.g., piezometer, monitoring well, drinking water well, irrigation well) within 200 feet of the proposed UIC location, this data may be considered in lieu of site-specific data.

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[2] If groundwater is not encountered (e.g., saturated conditions are not observed, no water seeps are observed) within 20 feet of the proposed bottom of the UIC, a piezometer or monitoring well does not need to be installed.

Requirements and Guidelines for Obtaining DTW Measurements

Using the following guidelines to collect and evaluate site-specific groundwater information will ensure that new UICs will meet the vertical separation requirement.

Permitting

Piezometers, monitoring wells, temporary wells, geotechnical holes, and other holes must by drilled, installed, and abandoned in accordance with Oregon Administrative Rules (OAR) 690-240 *Construction, Maintenance, Alteration, Conversion and Abandonment of Monitoring Wells, Geotechnical Holes and Other Holes in Oregon*. These rules require the licensed well constructor to provide notice and pay the associated fee(s) to the Oregon Water Resources Department (OWRD) prior to drilling or abandoning any new monitoring well, piezometer, or geotechnical hole. Additional information is available on OWRD's website: www.wrd.state.or.us.

Utility Clearance

Boring locations must be checked for underground utilities prior to any drilling activity. The Oregon Utility Notification Center's (OUNC) one-call number provides a free service to home owners, contractors, and other excavators, informing them of any buried facilities in the area where they are planning to dig. The OUNC must be called two business days prior to digging. To request locates for proposed excavation, call the One-Call Center at 1-800-332-2344.

Piezometer/Well Design

The piezometer or well design should include the following, where necessary:

- Total boring depth.
- Appropriate well screen interval.
- Piezometer or well materials (e.g., well screen, filter pack, casing). Factory-fabricated prepacked wells screens may be used. New or reused equipment must be thoroughly decontaminated by steam cleaning or high-pressure hot water washing unless delivered in packaging with documentation of proper decontamination.
- Appropriate annular seal.
- Appropriate surface seal and security casing.

Piezometer/Well Borehole Drilling and Installation

Continuous soil sampling is recommended to allow detailed characterization of subsurface soil and identification of groundwater depth. The RG, CEG, or PE must prepare and submit a detailed boring log of subsurface conditions. Soil boring logs should be in accordance with the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)* (ASTM D2488-00). Borings must be advanced to the groundwater level, or to a minimum of 20 feet below the proposed total depth of the UIC or 10 feet below a proposed UIC of 5 feet or less. If water is encountered in the boring, it must be noted on the drilling log.

The appropriate drilling method should be selected by the RG, CEG, or PE in conjunction with the driller, based on anticipated site-specific geologic and hydrogeologic conditions, anticipated boring depth, site accessibility, availability of equipment, and piezometer/well design. All equipment placed into the boreholes must be properly decontaminated prior to use.

Any investigation-derived material (e.g., soil cutting, water, personal protective gear) generated during drilling activities must be properly contained, characterized, and disposed in accordance with applicable state and federal regulations. Soil and water disposal must be documented.

Depth to Water Measurements

Following piezometer/well installation, water levels must be allowed to equilibrate for a minimum of 24 hours in fine-grained soils. After the water level has stabilized, an electronic water level indicator or a weighed tape should be used to measure the depth to water. Measurements should be made relative to ground surface and to the nearest 1/8 inch (~0.01 feet). The observer must make at a minimum two measurements over a period of about 15 minutes to show the results are static.

Estimating Depth to Seasonal High Groundwater

The site-specific DTW measurement must be used to estimate the depth to seasonal high groundwater. Seasonal water-table fluctuations were evaluated in the draft *Estimation of Depth to Ground Water and Configuration of the Water Table in the Portland, Oregon Area* report, prepared by the USGS and used to determine the seasonal correction factor (SCF). The SCF represents a long-term measurement of the seasonal water-table fluctuations. The SCF was set at 6 feet, using the USGS estimated mean of observed seasonal water table fluctuations for the unconsolidated sedimentary aquifer. To correct for seasonal variation, the SCF used to estimate depth to seasonal high groundwater is applied during periods of seasonal groundwater lows (late fall) and water level transition (summer and winter months). In March through May (seasonal high groundwater), no correction is added.

To correct site-specific DTW measurements to seasonal high DTW estimates, the following correction should be made:

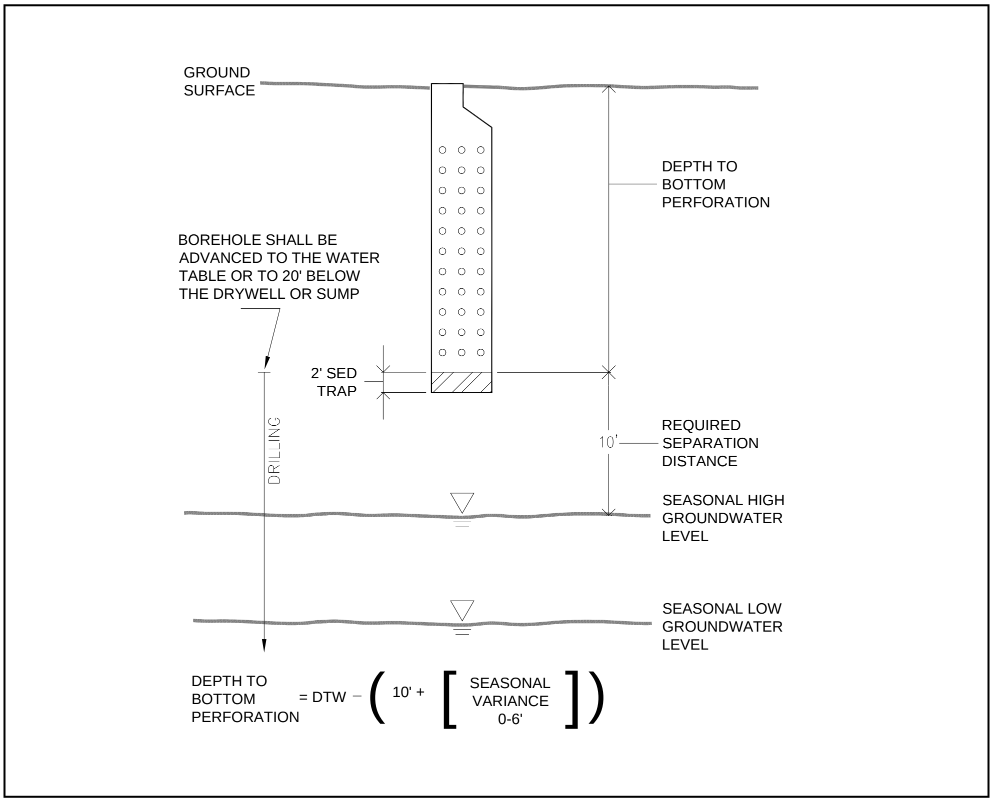
$$DTW_{SH} = DTW_{SS} - SCF$$

Where: DTW_{SH} = Estimated seasonal high depth to groundwater (feet)
DTW_{SS} = Measured site-specific depth to groundwater (time specific)
SCF = Seasonal correction factor
6 feet for measurements June through February
0 feet for measurements in March through May

If water is not encountered in the soil boring, advanced 20 feet below the proposed UIC completion depth, it must be documented on the boring log and in the investigation report. In this case, the depth to water is assumed to be outside the range of seasonal fluctuation; the minimum required separation distance for the proposed bottom of the UIC to seasonal high groundwater is therefore met by default. The borehole may be decommissioned immediately, in accordance with OAR 690-240.

Exhibit F.1-2 illustrates the depth to groundwater investigation.

Exhibit F.1 -2: Depth to Groundwater Investigation



Decommissioning

Borings, piezometers, temporary wells, and wells must be abandoned in accordance with OAR 690-240. Specific decommissioning procedures must be determined by a licensed driller and the registered geologist or professional engineer.

Minimum Requirements for DTW Investigation Report

The DTW Investigation report must contain, but is not limited to:

- A copy of the State of Oregon Monitoring Well Log Report or Geotechnical Hole Report, as appropriate.
- A map showing the final location of each well or piezometer and tax lot boundaries.
- Latitude and longitude of each well or piezometer.
- Description of field procedures (drilling method, sampling method, development method, depth to groundwater measurements, etc.).
- Measured water level to the nearest hundredth of a foot.
- Detailed soils log prepared by, or under the direct supervision of, the RG, CEG, or PE.
- Construction diagram for each well/piezometer.
- Summary of groundwater depth measurements (depth measured, elevation, date, time).
- Discussion/basis for estimation of seasonal high depth to groundwater measurement.
- Construction and investigation reports stamped and signed by the RG, CEG, or PE.

Depth to Groundwater Investigation Report Submittal and Usage

Two copies of the OWRD well or piezometer construction report and the signed and stamped DTW investigation report must be submitted with the development permit application to the City and to DEQ with the UIC rule authorization application, which can be obtained at http://www.deq.state.or.us/wq/uic/forms.htm.

The corrected site-specific depth to seasonal high groundwater must be used to verify that the proposed UIC will meet the separation distances set by DEQ to obtain rule authorization for private UICs or ensure compliance under the City's WPCF permit. If separation distances cannot be met, an alternative design must be developed that meets separation distance requirements.

APPENDIX F.2 INFILTRATION TESTING

To properly size and locate stormwater management facilities, it is necessary to characterize the soil infiltration conditions at the location of the proposed facility. All projects that require a stormwater management facility must evaluate existing site conditions and determine:

1. If the site's infiltration rate is adequate to support the proposed stormwater management facility (satisfied through the Simplified Approach infiltration test or a boring log for a sump or drywell)

   or

2. The design infiltration rate prior to facility design (satisfied through Presumptive or Performance infiltration testing).

The following sections provide the approved standard infiltration testing specifications. City staff reserve the right to require additional testing.

Simplified Approach Open Pit Infiltration Test

The Simplified Approach open pit test is applicable only to projects on private property with less than 10,000 square feet of new or redeveloped impervious area (see **Section 2.2.1**). The results of infiltration testing must be documented on the Simplified Approach Form (see **Appendix D.3**).

The Simplified Approach cannot be used to find a design infiltration rate. The intent of the open pit test is to determine whether or not the local infiltration rate is adequate (2 inches/hour) for the pre-designed stormwater facilities described in **Section 2.3** (infiltration swales, basins, planters, drywells, and trenches). The Simplified Approach infiltration test does not need to be conducted by a licensed professional, but it is recommended.

Open Pit Testing Instructions

1. A simple open pit infiltration test is required for each facility designed through the Simplified Approach. The test should be where the facility is proposed or within the direct vicinity.
2. Excavate a test hole to the depth of the bottom of the infiltration system, or otherwise to 4 feet. The test hole can be excavated with small excavation equipment or by hand using a shovel, auger, or post hole digger.
3. If a layer hard enough to prevent further excavation is encountered, or if noticeable moisture/water is encountered in the soil, stop and measure this

depth from the surface and record it on the Simplified Approach Form. Proceed with the test at this depth.

4. Fill the hole with water to a height of about 6 inches from the bottom of the hole (or to one-half the maximum depth of the proposed facility), and record the exact time. Check the water level at regular intervals (every 1 minute for fast-draining soils to every 10 minutes for slower-draining soils) for a minimum of 1 hour or until all of the water has infiltrated. Record the distance the water has dropped from the top edge of the hole.
5. Repeat this process two more times, for a total of three rounds of testing. These tests should be performed as close together as possible to accurately portray the soil's ability to infiltrate at different levels of saturation. The **third test** provides the best measure of the saturated infiltration rate.
6. For each test pit required, submit all three testing results with the date, duration, drop in water height, and conversion into inches per hour.

If the results of the Simplified Approach open pit test show an infiltration rate greater than 2.0 inches per hour, the applicant can proceed with Simplified Approach facility design (where applicable). If the applicant would like to use an infiltration rate for design purposes, a Presumptive or Performance Infiltration Test must be conducted.

Boring Log Preliminary Evaluation **(Presumptive and Performance Approaches)**

Boring logs may be used as a guide during preliminary evaluation of the feasibility of drywells and sumps. The logs cannot be used in lieu of post-construction testing or as an infiltration test to establish a design infiltration rate.

The submittal for each boring log must include an associated soil classification consistent with ASTM D2488-00, Standard Practice for Classification for Description and Identification of Soils (Visual-Manual Procedure). The submittal should also include any additional pertinent subsurface information, such as soil moisture conditions, depth and description of undocumented or engineered fill, soil color and mottling conditions, soil stiffness or density, and approximate depth of contact between soil types.

Based on DEQ requirements and conformance with **Appendix F.1**, the boring log must be continued to a depth adequate to show separation between the bottom of the infiltration facility and the seasonal high groundwater level. (The boring depth will vary, based on facility depth.) See **Appendix F.1** for further details on depth to water investigations.

Boring logs may be used to characterize the soils for a proposed facility as long as the log follows ASTM D2488-00, is performed by a qualified professional (Professional Engineer, Registered Geologist, or Certified Engineering Geologist), and demonstrates the potential for infiltration. Logs from outside the immediate vicinity of the proposed facility may be used if the qualified professional can determine that the soil strata are consistent between the proposed facility and the borehole.

Presumptive and Performance Infiltration Testing

The Presumptive Approach (**Section 2.2.2**) or Performance Approach (**Section 2.2.3**) must be used for all public and private developments where the Simplified Approach is not applicable. The qualified professional must exercise judgment in the selection of the infiltration test method. The three infiltration available testing methods used to determine a design infiltration rate are:

- Open pit falling head (see **page F.2-5**)
- Encased falling head (see **page F.2-6**)
- Double-ring infiltrometer (see **page F.2-8**)

Testing Criteria

1. Testing must be conducted or observed by a qualified professional. This professional must be a Professional Engineer (PE), Registered Geologist (RG), or Certified Engineering Geologist (CEG) licensed in the State of Oregon.

2. The location and depth of the test must correspond to the facility location and depth.

3. Infiltration testing should not be conducted in engineered or undocumented fill.

4. Boring logs should be provided as supporting information with infiltration and depth to groundwater tests.

Note: All testing data must be documented in the project's Stormwater Management Report (see **Sections 2.2.2** and **2.2.3**). The Stormwater Management Report must adequately demonstrate that the proposed facilities 1) are appropriate to the assessment and characterization of the site, 2) will work, based on in situ infiltration tests, and 3) are sized appropriately, based on design infiltration rates.

<u>Depth and Location of Required Tests</u>

Infiltration tests must be performed at the base of the proposed facility.

If a confining layer, or soil with a greater percentage of fines, is observed during the subsurface investigation to be within 4 feet of the bottom of the planned infiltration system, the testing should be conducted within that confining layer.

Tests must be performed in the immediate vicinity of the proposed facility. Exceptions can be made to the test location provided the qualified professional can support that the strata are consistent from the proposed facility to the test location.

For relatively deep stormwater facilities, a hollow stem auger with an electronic measuring tape can be used, provided there is an adequate seal between the auger and the native soil.

Minimum Number of Required Tests

Land Division

- A total of two infiltration tests for every 10,000 square feet of lot area available for new or redevelopment.
- An additional test for every 10,000 square feet of lot area available for new or redevelopment.
- At least one test for any potential street facility.
- One test for every 100 lineal feet of infiltration facility.
- No more than five tests are required per development (at the discretion of the qualified professional assessing the site, as well as the City of Portland).

Building Permits

- The Simplified Approach requires one infiltration test for every proposed facility.
- The Presumptive and Performance Approaches:
    - Require at least one test for any proposed street facility.
    - Require one test for every 100 lineal feet of proposed infiltration facility.
    - The number or tests is at the discretion of the qualified professional assessing the site, as well as the City of Portland.

Tests performed at the Land Division will be used at the building permit stage as long as the results of the test are submitted with the separate applications.

Where multiple types of facilities are used, it is likely that multiple tests will be necessary, since an infiltration test can test only a single soil stratum. It is highly recommended to conduct an infiltration test at each stratum used.

Correction Factors

Exhibit F.2-1 lists correction factors. The maximum design infiltration rate is 20 inches per hour.

Exhibit F.2-1: Infiltration Rate Safety Factor

Test Method	Required Correction Factor
Encased Falling Head	3
Open Pit Falling Head	2
Double-Ring Infiltrometer	Public Facilities: 1 Private Facilities: 2

Presumptive & Performance Infiltration Testing Instructions

Open Pit Falling Head Procedure

The open pit falling head procedure is based on the Environmental Protection Agency (EPA) Falling Head Percolation Test Procedure (*Onsite Wastewater Treatment and Disposal Systems Design Manual,* EPA/625/1-80-012, 1980). The test is performed in an open excavation and therefore is a test of the combination of vertical and lateral infiltration.

1. Excavate an approximately 2-foot by 2-foot-wide hole into the native soil to the elevation of the proposed facility bottom (see **Exhibit F.2-2**). The test can be conducted in a machine-excavated pit or a hand-dug pit using a shovel, posthole digger, or hand auger. If smooth augering tools or a smooth excavation bucket is used, scratch the sides and bottom of the hole with a sharp pointed instrument, and remove the loose material from the bottom of the test hole.

2. A 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scour and sloughing.

3. Fill the hole with clean water a minimum of 1 foot above the soil to be tested, and maintain this depth of water for at least 4 hours (or overnight if clay soils are present) to presoak the native material.

   Percolation rate measurements must be made after 15 hours and no more than 30 hours after the soaking period begins. It is important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained. Any soil that sloughed into the hole during the soaking period must be removed and the water level shall be adjusted to 6 inches above the added gravel (or 8 inches above the bottom of the hole).

In sandy soils with little or no clay, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

4. The measurements should be made with reference to a fixed point. A lath placed in the test pit prior to filling or a sturdy beam across the top of the pit are convenient reference points. The tester and excavator should conduct all testing in accordance with OSHA regulations.

5. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has drained. At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

6. Successive trials must be run until the measured infiltration rate between two successive trials does not vary by more than 5 percent. At least three trials must be conducted. After each trial, the water level is readjusted to the 12-inch level. Enter results into the data table (See **Exhibit F2-3**).

7. The results of the last water level drop are used to calculate the tested infiltration rate. The final rate must be reported in inches per hour. See the calculation following **Exhibit F.2-3**.

8. For very rapidly draining soils, it may not be possible to maintain a water head above the bottom of the test pit. If the infiltration rate meets or exceeds the flow of water into the test pit, conduct the test in the following manner:
   A. Approximate the area over which the water is infiltrating.
   B. Using a water meter, bucket, or other device, measure the rate of water discharging into the test pit.
   C. Calculate the infiltration rate by dividing the rate of discharge (cubic inches per hour) by the area over which it is infiltrating (square inches).

Upon completion of the testing, the excavation must be backfilled.

Encased Falling Head Test

The encased falling head procedure is based on a modification of the EPA Falling Head Percolation Test Procedure (*Onsite Wastewater Treatment and Disposal Systems Design Manual*, EPA/625/1-80-012, 1980). The most significant modification is that this test is performed with a 6-inch casing that is embedded approximately 6 inches into the native soil. The goal of this field test is to evaluate the vertical infiltration rate through a 6-inch plug of soil, without allowing any lateral infiltration. The test is not appropriate in gravelly soils or in other soils where a good seal with the casing cannot be established.

1. Embed a solid 6-inch diameter casing into the native soil at the elevation of the proposed facility bottom (see **Exhibit F2-2**). Ensure that the embedment provides a good seal around the pipe casing so that percolation will be limited to the 6-inch plug of the material within the casing. This method can also be applied to testing within hollow stem augers, provided the driller and tester are reasonably certain that a good seal has been achieved between the soil and auger.

2. A 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scour and sloughing.

3. Fill the pipe with clean water a minimum of 1 foot above the soil to be tested, and maintain this depth for at least 4 hours (or overnight if clay soils are present) to presoak the native material.

   Percolation rate measurements must be made after 15 hours and no more than 30 hours after the soaking period begins. It is important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained. Any soil that sloughed into the hole during the soaking period must be removed and the water level shall be adjusted to 6 inches above the added gravel (or 8 inches above the bottom of the hole).

   In sandy soils with little or no clay, soaking is not necessary. If after filling the hole twice with 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.

4. To conduct the first trial of the test, fill the pipe to approximately 6 inches above the soil and measure the water level to the nearest 0.01 foot (⅛ inch). The level should be measured with a tape or other device with reference to a fixed point. The top of the pipe is often a convenient reference point. Record the exact time.

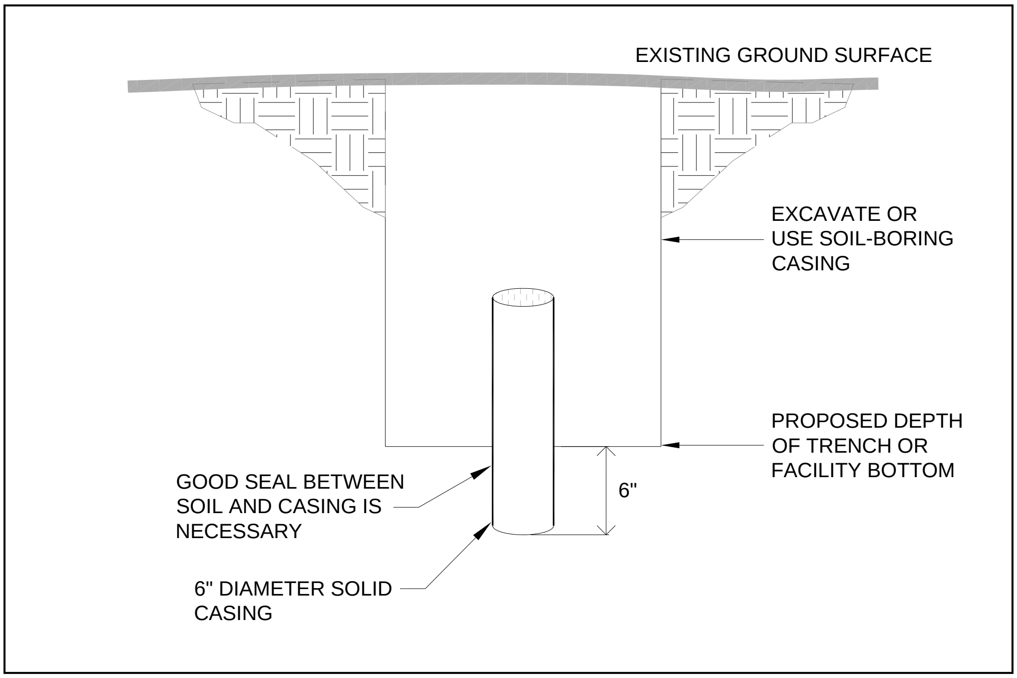
5. Measure the water level to the nearest 0.01 foot (⅛ inch) at 10-minute intervals for a total period of 1 hour (or 20-minute intervals for 2 hours in slower soils) or until all of the water has drained. The infiltration test is continued until the measured infiltration rate between two successive trials does not vary by more

than 5 percent. At least three trials must be conducted. After each trial, the water level is readjusted to the 6 inch level. Enter results into the data table (see **Exhibit F.2-3**). At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

6. The result of the last water level drop is used to calculate the tested infiltration rate. The final rate must be reported in inches per hour. See the calculation following **Exhibit F.2-3**.

7. Upon completion of the testing, the casings must be immediately pulled, and the test pit must be backfilled.

Exhibit F.2-2: Encased Falling Head Procedure



Double Ring Infiltrometer Test

The double-ring infiltrometer test procedure must conform with ASTM 3385-94. The test is performed within two concentric casings embedded and sealed to the native soils. The outer ring maintains a volume of water to diminish the potential of lateral infiltration through the center casing. The volume of water added to the center ring to maintain a static water level is used to calculate the infiltration rate. The double-ring infiltrometer is appropriate only in soils where an adequate seal can be established.

This test may be difficult to perform where the tested soil strata are in a pit, since careful regulation of the static volumes is necessary.

Reporting Requirements

In addition to the information required by the state for a signed and stamped geotechnical report, the following information should be included in the project's Stormwater Management Report:

1. Infiltration results in inches per hour.

2. Location and depth of excavation. The excavation should be deep enough to verify that there is a 5-foot separation between the final depth of the facility (rock gallery) and the seasonal high groundwater or soil layer that could reduce the infiltration rate.

3. Summary and discussion of infiltration testing, including number of tests, amounts of water used in each test (inches, gallons, etc.), and time of each test. Testing is required to show that an accurate rate was achieved.

4. Discussion of how the test was performed:

    - Encased falling head
        - Pipe type
        - Embedment depth
        - Size of pipe

    - Double ring infiltrometer
        - Pipe type
        - Embedment depth
        - Size of pipe

    - Open pit (size of area)

5. Soil types with depth.

6. Groundwater observations – seasonal high groundwater level estimation.

Exhibit F.2-3: Infiltration Test Data Table

<table>
<tr><td colspan="3">Location: Lot 105,
Low Point Heights Subdivision</td><td colspan="2">Date: 6/28/2008</td><td>Test Hole Number: 3</td></tr>
<tr><td colspan="3">Depth to bottom of hole: 57 inches</td><td colspan="2">Diameter of hole: 0.5 feet</td><td>Test Method: Encased Falling Head</td></tr>
<tr><td colspan="6">Tester’s Name: C.J. Tester
Tester’s Company: Tester Company
Tester’s Contact Number: 555-1212</td></tr>
<tr><td colspan="3">Depth (feet):</td><td colspan="3">Soil Texture:</td></tr>
<tr><td colspan="3">0-0.5</td><td colspan="3">Black Top Soil</td></tr>
<tr><td colspan="3">0.5-1.0</td><td colspan="3">Brown SM</td></tr>
<tr><td colspan="3">1.0-2.2</td><td colspan="3">Brown ML</td></tr>
<tr><td colspan="3">2.2-5.1</td><td colspan="3">Brown CL</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>Time:</td><td>Time interval (minutes):</td><td>Measure ment, (feet):</td><td>Drop in water level, (feet):</td><td>Percolation rate, (inches per hour):</td><td>Remarks:</td></tr>
<tr><td>9:00</td><td>0</td><td>3.75</td><td>-</td><td></td><td>Filled with 6”</td></tr>
<tr><td>9:20</td><td>20</td><td>3.83</td><td>0.08</td><td></td><td></td></tr>
<tr><td>9:40</td><td>20</td><td>3.91</td><td>0.08</td><td>2.88</td><td></td></tr>
<tr><td>10:00</td><td>20</td><td>3.98</td><td>0.07</td><td>2.52</td><td></td></tr>
<tr><td>10:20</td><td>20</td><td>4.04</td><td>0.06</td><td>2.16</td><td></td></tr>
<tr><td>10:40</td><td>20</td><td>4.11</td><td>0.07</td><td>2.52</td><td></td></tr>
<tr><td>11:00</td><td>20</td><td>4.17</td><td>0.06</td><td>2.16</td><td></td></tr>
<tr><td>11:20</td><td>20</td><td>4.225</td><td>0.055</td><td>1.98</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Adjusted to 6” level for Trial #2</td></tr>
</table>

Calculation is performed for each water level drop
= (Drop in water level/Time interval) x conversion
= 0.055ft/20min x (12in/ft) x (60min/hr)
= 1.98 inches per hour

The design infiltration rate of two successive trials must have a difference of 5% or less.

Location:	Date:	Test Hole Number:
Depth to bottom of hole:	Diameter of hole:	Test Method:
Tester's Name: Tester's Company: Tester's Contact Number:		

Depth (feet):	Soil Texture:

Time:	Time Interval (minutes):	Measure ment, (feet):	Drop in water level, (feet):	Percolation rate, (inches per hour):	Remarks:

APPENDIX F.3 GROWING MEDIUM SPECIFICATION FOR VEGETATED STORMWATER SYSTEMS

The following specification includes two soil blends (also referred to as growing medium) formulated for the City of Portland's vegetated stormwater facilities. Facilities include swales, planters, curb extensions, and basins.

NOTE: This specification is required for all public facilities and serves as a general guide for private facilities. Testing and submittals are not required for private facilities unless they are requested by the Bureau of Development Services.

A. **Standard Blend for Public and Private Facilities**. This blend is for all vegetated stormwater management facilities except those that meet the criteria for the "Infiltration Blend for the Right- of- Way" specified in Section B, **page F.3-4**.

(1) General Composition. The medium shall be any blend of loamy soil, sand, and compost that is 30-40 percent compost (by volume) and meets the other criteria in this specification.

(2) Analysis Requirements for the Blended Material.

a. Particle Gradation. A particle gradation analysis of the blended material, including compost, shall be conducted in conformance with ASTM C117/C136 (AASHTO T11/T27). The analysis shall include the following sieve sizes: 1 inch, 3/8 inch, #4, #10, #20, #40, #60, #100, #200. The gradation of the blend shall meet the following gradation criteria.

Sieve Size	Percent Passing
1 inch	100
# 4	75 -100
# 10	40-100
# 40	15-50
# 100	5-25
# 200	5-15

The blend shall have a Coefficient of Uniformity (D60/D10) equal to or greater than 6 to ensure that it is well graded (has a broad range of particle sizes). The coefficient is the ratio of two particle diameters on a grain-size distribution curve; it is the particle diameter at 60 percent passing divided by the particle diameter at 10 percent passing.

b. Organic Matter Content. An analysis of soil organic matter content shall be conducted in conformance with ASTM D2974 (loss on ignition test). The soil organic matter content shall be a minimum of 10 percent, as reported by that test.

c. pH. The pH of the blended material shall be tested. The material shall have a pH of 5 to 8.

(3) General Requirements for the Blended Material.

a. The material shall be loose and friable.
b. It shall be well mixed and homogenous.
c. It shall be free of wood pieces, plastic, and other foreign matter.
d. It shall have no visible free water.

(4) Compost. The compost shall be derived from plant material and provided by a member of the US Composting Council Seal of Testing Assurance (STA) program. See www.compostingcouncil.org for a list of providers in Portland.

The compost shall be the result of the biological degradation and transformation of plant-derived materials under conditions designed to promote aerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have no visible free water and produce no dust when handled. It shall meet the following criteria, as reported by the US Composting Council STA Compost Technical Data Sheet provided by the vendor.

a. 100 percent of the material must pass through a ½-inch screen.
b. The pH of the material shall be between 6 and 8.
c. Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0 percent by weight.
d. The organic matter content shall be between 35 and 65 percent.
e. Soluble salt content shall be less than 6.0 mmhos/cm.
f. Germination (an indicator of maturity) shall be greater than 80%.
g. Stability shall be 5-7.
h. Carbon/nitrogen ration shall be less than 25:1.
i. Trace metals test result = "pass."

(5) Submittals. At least 14 working days in advance of construction, the Contractor must submit the following to the BES Project Representative for approval.

a. Two 5-gallon buckets of the blended material (at the request of the BES Project Representative).

b. Documentation for the three analyses described in A(2) of this specification (particle gradation with calculated coefficient of uniformity; organic matter content; pH). The analyses shall be performed by an accredited laboratory with certification maintained current. The date of the analyses shall be no more than 90 calendar days prior to the date of the submittal. The report shall include the following information:
   i. Name and address of the laboratory.
   ii. Phone contact and e-mail address for the laboratory.
   iii. Test data, including the date and name of the test procedure.

c. A compost technical data sheet from the vendor of the compost. The analysis and report must be consistent with the sampling and reporting requirements of the US Composting Council Seal of Testing Assurance (STA) program. The analysis shall be performed and reported by an approved independent STA program laboratory. The date of the analysis shall be no more than 90 calendar days prior to the date of the submittal.

d. A description of the location, equipment, and method proposed to mix the material.

(6) General

a. Protection of the Growing Medium. The growing medium shall be protected from all sources of contamination, including weed seeds, while at the supplier, in conveyance, and at the project site.

b. Placement of the Growing Medium. The medium shall be placed in loose lifts, not to exceed 8 inches each, and each lift shall be compacted with a water-filled landscape roller. The material shall not otherwise be mechanically compacted.

c. Timing of Plant Installation. Weather permitting, plants shall be installed as soon as possible after placing and grading the growing medium in order to minimize erosion and further compaction.

d. Erosion Control. Temporary erosion control measures are required until permanent stabilization measures are functional, including protection of overflow structures.

e. Protection of the Facility.

- In all cases, the facility must be protected from foot or equipment traffic that is unrelated to the construction of the facility. Temporary fencing or walkways should be installed as needed to keep workers, pedestrians, and equipment out of the facility. Under no circumstances should materials and equipment be stored in the facility.

- Stormwater facilities shall be kept clean and shall not be used as erosion and sediment control structures during or after construction.

f. Installation in Wet and Winter Conditions.

- Placement of the growing medium will not be allowed when the ground is frozen or saturated or when the weather is too wet, as determined by the BES Project Representative.

- There are many reasons to avoid construction during the wet winter months (November through February): damage to the facility from compaction and sedimentation, the difficulty of controlling erosion, and the potential to lose new plantings to the weather. All of these issues can result in a requirement for corrective action on the part of the contractor.

B. Infiltration Blend for the Right-of-Way. This sand/compost blend is for facilities in the right-of-way at sites where compaction from foot traffic is a concern. Approval is required; this blend may carry some risk for plant health without watering during the summer dry period.

(1) General Composition. The medium shall be a mix of sand and compost, blended by volume. The medium shall consist of 60-70 percent sand and 30-40 percent compost.

(2) Analysis Requirements. The requirements are the same as those specified in section A(2) for the “Standard Blend for Public and Private Facilities.” The single difference is the particle gradation criteria, which are as follows.

Sieve Size	Percent Passing
1 inch	100
# 4	60-100
# 10	40-100
# 40	15-50
# 100	5-20
# 200	1-5

(3) General Requirements for the Blended Material. See A(3).

(4) Compost. See A(4).

(5) Submittals. See A(5).

(6) General. See A(6).

APPENDIX F.4 PLANT LISTS

Zone A: Area of the facility defined as the bottom of the facility to the designed high water mark. This area has moist to wet soils and plants located here shall be tolerant of mild inundation.

Zone B: Area of the facility defined as the side slopes from the designed high water line up to the edge of the facility. This area typically has dryer to moist soils, with the moist soils being located further down the side slopes. Plants here should be drought tolerant and help stabilize the slopes.

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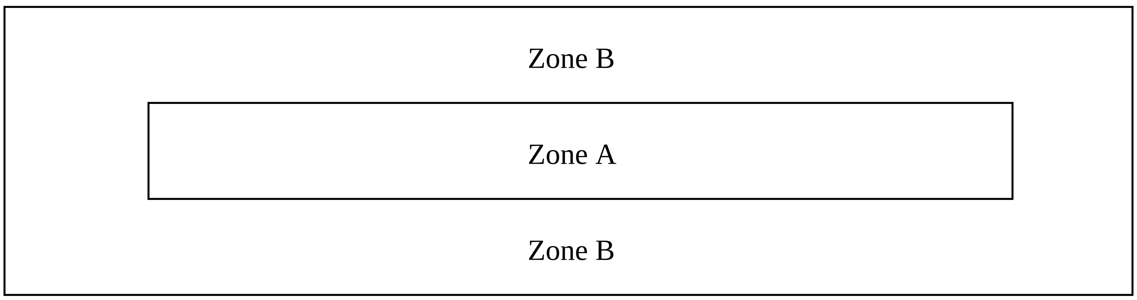
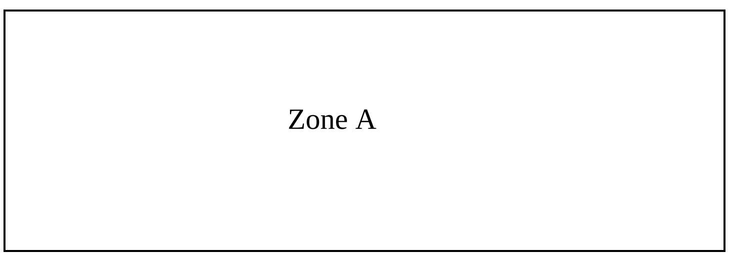
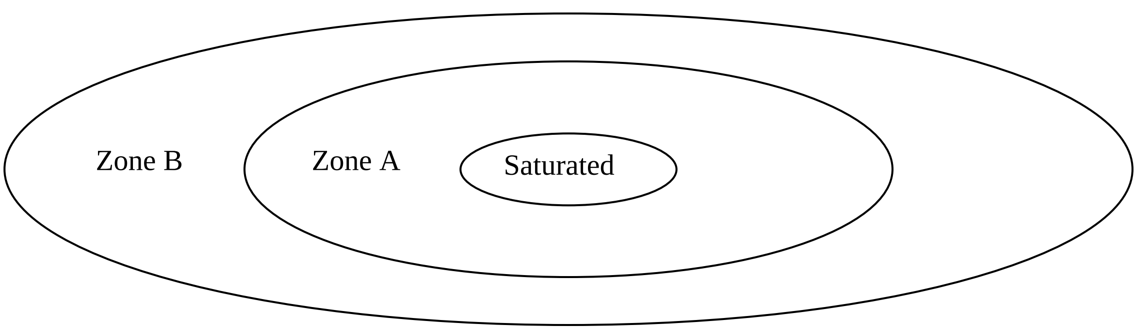
Swale Planting Zones



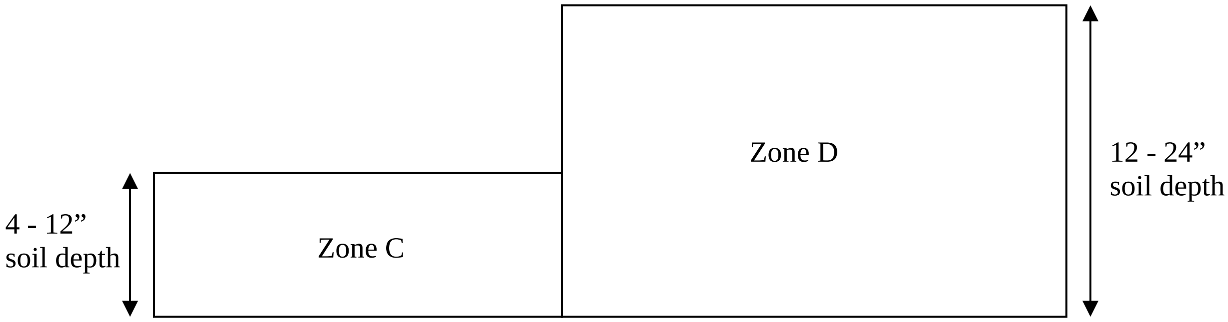
Planter Planting Zones



Basin Planting Zones



Ecoroof Planting Zones



Grassy Swale Native Seed Mix

<u>Percentages are by weight:</u>

Hordeum brachyantherum (Meadow Barley)	= 25%
Danthonia californica (California Oat-grass)	= 15%
Elymus glaucus (Blue Wild Rye)	= 10%
Bromus carinatus (California Brome)	= 10%
Festuca romerii (Roemer's fescue)	= 10%
Deschampsia cespitosa (Tufted hairgrass)	= 10%
Agrostis exarata (Spike bentgrass)	= 10%
Alopecurus geniculatus (Water foxtail)	= 5%
Deschampsia elongata (Slender hairgrass)	= 5%

Facility Plant List

Plant Name		**Proposed Facility Type**						**Characteristics**			
		Private					Public				
Botanic name, Common Name	Zone	Swale	Planter	Basin	Dry Pond	Wet Pond	Basin	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Herbaceous Plants											
Aster suspicatus , Douglas' Aster	B	X		X				Y	N	36"	12"
Athyrium felix-femina, Lady Fern	B	X		X			X	Y	N	36"	24"
Blechnum spicant, Deer Fern	B	X		X			X	Y	N	24"	24"
Bromus carinatus, Califonia Brome Grass	A			X			X	Y	Y	18"	12"
Bromus sitchensis, Alaska Brome	A			X			X	Y	Y	18"	12"
Bromus vulgaris, Columbia Brome	A			X			X	Y	Y	18"	12"
Camassia leichtlinii , Camas Lily	A	X	X	X				Y	N	24"	12"
Camassia quamash , Common Camas	A/B	X	X	X			X	Y	N	24"	12"
Carex deweyanna, Dewey Sedge	A	X	X	X			X	Y	Y	36"	12"
Carex densa , Dense Sedge	A	X	X	X			X	Y	Y	24"	12"
Carex obnupta , Slough Sedge	A	X	X	X			X	Y	Y	4'	12"
Carex rupestris , Curly Sedge	A	X	X	X				N	Y	14"	12"
Carex stipata , Sawbeak Sedge	A	X	X	X				N	N	20"	12"
Carex testacea , New Zealand Orange Sedge	A	X	X	X			X	N	Y	24"	12"
Carex vesicaria, Inflated Sedge	A	X	X	X			X	Y	N	36"	12"
Deschampsia cespitosa , Tufted Hair Grass	A/B	X	X	X			X	Y	N	36"	12"
Eleocharis acicularis, Needle Spike Rush	A	X	X	X			X	Y	Y	30"	12"
Eleocharis ovata, Ovate Spike Rush	A	X	X	X			X	Y	Y	30"	12"
Eleocharis palustris , Creeping Spike Rush	A			X			X	Y	Y	30"	12"
Elymus glaucus, Blue Wild Rye	B	X		X			X	Y	Y	24"	12"

Facility Plant List

Plant Name		**Proposed Facility Type**						**Characteristics**			
		Private					Public				
Botanic name, Common Name	Zone	Swale	Planter	Basin	Dry Pond	Wet Pond	Basin	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Festuca occidentalis, Western Fescue Grass	A	X		X			X	Y	N	24"	12"
Festuca rubra, Red Fescue	B	X		X			X	Y	Y	24"	12"
Glycera occidentalis, Western Manna Grass	A			X			X	Y	Y	18"	12"
Hebe 'Autumn Glory', Hebe	B	X		X				N	Y	14"	12"
Iris douglasiana, Douglas Iris	B	X		X			X	Y	N	18"	12"
Iris sibirica, Siberian Iris	A	X	X	X				N	N	36"	12"
Iris tenax, Oregon Iris	B	X		X			X	Y	N	18"	12"
Juncus balticus, Baltic Rush	A	X	X	X				N	N	20"	12"
Juncus effusus var. pacificus, Soft rush	A	X	X	X			X	Y	Y	36"	12"
Juncus ensifolius, Dagger-leaf Rush	A	X	X	X			X	N	N	10"	12"
Juncus patens, Spreading Rush	A	X	X	X			X	N	Y	36"	12"
Juncus tenuis, Slender Rush	A	X	X	X			X	Y	Y	36"	12"
Lupinus micranthus, Small Flowered Lupine	B	X		X			X	Y	N	18"	12"
Lupinus polyphyllus, Large-leaved Lupine	A/B	X		X				Y	N	36"	12"
Polypodium glycrrhiza, Licorice Fern	A	X	X	X				Y	Y	12"	12"
Polystichum munitum, Sword Fern	A/B	X		X			X	Y	Y	24"	24"
Pteridium aquilinum, Bracken Fern	B	X		X				Y	Y	5'	12"
Scriptus acutus, Hardstem Bulrush	A	X	X	X				N	N	10"	12"
Scriptus americanus, American Bulrush	A	X	X	X			X	Y	Y	30"	12"
Scriptus mIcrocarpus, Small Fruited Bulrush	A			X			X	Y	Y	24"	12"
Scriptus validus, Softstem Bulrush	A	X	X	X				N	N	5'	12"
Sedum oreganum, Oregon Stonecrop	B	X						Y	Y	4"	12"
Sisyrinchium californicum, Yellow-eyed Grass	A/B	X	X	X				N	Y	6"	12"

Facility Plant List

Plant Name		**Proposed Facility Type**						**Characteristics**			
		Private					Public				
Botanic name, Common Name	Zone	Swale	Planter	Basin	Dry Pond	Wet Pond	Basin	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Veronica liwanensis, Speedwell	A	X		X				N	N	2"	12"
Large Shrubs and Small Trees											
Acer circinatum, Vine Maple	A/B	X	X	X			X	Y	N	15'	10'
Amelanchier alnifolia, Western Serviceberry	B	X		X			X	Y	N	20'	10'
Ceanothus sanguineus, Oregon Redstem Ceanothus	B	X		X			X	Y	Y	7'	4'
Holodiscus discolor, Oceanspray	B	X		X			X	Y	N	6'	4'
Lonicera involucrata, Black Twinberry	B	X		X			X	Y	N	5'	4'
Oemleria cerasiformis, Indian Plum	B	X		X			X	Y	N	6'	4'
Philadelphu lewisii, Wild Mock Orange	B	X		X			X	Y	N	6'	4'
Ribes sanguineum, Red-Flowering Current	B	X		X			X	Y	N	8'	4'
Rubus parviflorus, Thimbleberry	B	X		X			X	Y	N	8'	4'
Rubus spectabilis, Salmonberry	A	X	X	X			X	Y	N	10'	4'
Salix fluviatalis, Columbia Willow	A/B	X	X	X			X	N	N	13'	6'
Salix lucida var. 'Lasiandra', Pacific Willow	A	X	X	X			X	Y	N	13'	6'
Salix purpurea nana, Blue Arctic Willow	B	X		X				N	N	8'	6'
Salix stichensis, Sitka Willow	A	X	X	X			X	Y	N	20'	6'
Sambucus cerulea, Blue Elderberry	B	X		X			X	Y	N	10'	10'
Sambucus racemosa, Red Elderberry	B	X		X			X	Y	N	10'	10'
Spriaea douglasii, Douglas Spiraea	A/B	X	X	X			X	Y	N	7'	4'
Viburnum edule, Highbush Cranberry	A/B	X	X	X			X	Y	N	6'	4'

Facility Plant List

Plant Name		Proposed Facility Type						Characteristics			
		Private					Public				
Botanic name, Common Name	Zone	Swale	Planter	Basin	Dry Pond	Wet Pond	Basin	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Shrubs											
Ceanothus velutinus, Snowbrush	B	X		X			X	Y	Y	4'	3'
Cornus sericea, Red-twig Dogwood	A	X	X	X			X	Y	N	6'	4'
Cornus sericea 'Kelseyii', Kelsey Dogwood	B	X		X			X	N	N	24"	24"
Gaultheria shallon, Salal	B	X		X			X	Y	Y	24"	24"
Mahonia aquifolium, Oregon Grape	B	X		X			X	Y	Y	5'	3'
Mahonia nervosa, Dull Oregon Grape	B	X		X			X	Y	Y	24"	24"
Physocarpus capitatus, Pacific Ninebark	A/B	X	X	X				Y	N	10'	3'
Rosa gymnocarpa, Baldhip Rose	B	X		X			X	Y	N	3'	3'
Rosa nutkana, Nootka Rose	B	X		X			X	Y	N	8'	3'
Rosa pisocarpa, Swamp Rose	A/B	X	X	X			X	Y	N	8'	3'
Symphoricarpos alba, Common Snowberry	B	X		X			X	Y	N	6'	3'
Groundcovers											
Arctostaphylos uva-ursi, Kinnickinnick	B	X		X				Y	Y	6"	12"
Fragaria chiloensis, Coastal Strawberry	B	X		X				Y	Y	6"	12"
Fragaria vesca, Woodland Strawberry	B	X		X				N	Y	10"	12"
Fragaria virginiana, Wild Strawberry	B	X		X				N	Y	10"	12"
Helictotrichon sempervirens, Blue Oat Grass	B	X		X				N	Y	24"	12"
Mahonia repens Creeping Oregon Grape	B	X		X				Y	Y	12"	12"
Trees											
Abies grandis, Grand Fir	B			X			X	Y	Y	150'	

Facility Plant List

Plant Name		**Proposed Facility Type**						**Characteristics**			
		Private					Public				
Botanic name, Common Name	Zone	Swale	Planter	Basin	Dry Pond	Wet Pond	Basin	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Acer griseum , Paperbark Maple	B	X		X				N	N	30'	
Acer macrophyllum, Big Leaf Maple	B	X		X			X	Y	Y	60'	
Alnus rubra , Red Alder	A	X		X			X	Y	N	80'	
Arbutus menziesii, Madrone	B			X			X	Y	N	35'	
Crataegus douglasii , Black Hawthorn	A	X		X			X	Y	N	40'	10'
Fraxinus latifolia , Oregon Ash	A/B	X		X			X	Y	N	30'	
Malus fusca , Pacific Crabapple	A	X	X	X			X	Y	N	30'	10'
Metasequoia glyptostroboides , Dawn Redwood	B			X			X	N	N	80'	
Populus tremuloides , Quaking Aspen	A			X			X	Y	N	40'	
Prunus emarginata var. mollis, Bitter Cherry	A/B	X	X	X			X	Y	N	50'	
Pseudotsuga menziesii , Douglas Fir	B	X		X			X	Y	Y	200'	
Quercus garryana , Oregon White Oak	B	X		X			X	Y	N	100'	
Rhamnus purshiana , Cascara	A/B	X	X	X			X	Y	N	30'	
Salix hookeriana, Hooker's Willow	A/B	X	X	X			X	Y	N	15'	
Salix scouleriana, Scouler's Willow	A/B	X	X	X			X	Y	N	15'	
Thuja plicata , Western Red Cedar	A			X			X	Y	Y	150'	
Tsuga hetrophylla, Western Hemlock	A	X		X			X	Y	Y	125'	
Tsuga mertensiana , Mountain Hemlock	B	X		X			X	Y	Y	125'	

Ecoroof Plant List

Plant Name		Characteristics					
Botanic name, Common Name	Zone	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Full Sun	Partial Shade
Sedums and Succulents							
Delosperma ssp., Ice Plant	C	N	Y	4"		X	
Malephora crocea var. purpureo crocea 'Tequila Sunrise', Coppery Mesemb	C	N	Y	10"		X	
Sedum 'Autumn Joy'	C	N	N	24"		X	
Sedum acre, Biting Stonecrop	C	N	Y	2"		X	
Sedum album, White Stonecrop	C	N	Y	3"		X	
Sedum divergens, Pacific Stonecrop	C	N	Y	3"		X	
Sedum hispanicum, Spanish Stonecrop	C	N	Y	3"		X	
Sedum kamtschaticum, Kirin-so	C	N	N	6"		X	
Sedum oreganum, Oregon Stonecrop	C	Y	Y	4"		X	X
Sedum sexangular, Tasteless Stonecrop	C	N	Y	4"		X	
Sedum spathulifolium, Stonecrop	C	Y	Y	4"		X	
Sedum spurium, Two-row Stonecrop	C	N	Y	6"		X	X
Sempervivum tectorum, Hens and Chicks	C	N	Y	6"		X	
Herbaceous Plants							
Achillea millefolium, Common Yarrow	C	N	N	36"		X	
Achillea tomentosa, Wooly Yarrow	C	N	N	8"		X	
Arenaria montana, Sandwort	C	N	N	4"		X	
Artemesia 'Silver Mound', Artemesia	C	N	N	12"		X	
Aurinia saxatilis, 'Compacta'	C	N	N	6"		X	
Castilleja foliosa, Indian Paintbrush	C	Y	N	10"		X	

Ecoroof Plant List

Plant Name		Characteristics						
Botanic name, Common Name	Zone	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Full Sun	Partial Shade
Dianthus ssp.	C	N	N	12"		X	X
Erigeron discoideus, Fleabane	C	N	N	12"		X	X
Festuca glauca, Blue Fescue	C	N	Y	12"		X	X
Fragaria chiloensis, Coastal Strawberry	C	Y	Y	10"		X	X
Fragaria virginiana, Wild Strawberry	C	Y	Y	10"		X	X
Gaillardia aristata, Birds-eye gilia	C	N	N	20"		X	X
Gazania linearis 'CO Gold', Gazania	C	N	N	6"		X	
Gilia capitata, Blue Thimble Flower	C	Y	N	12"		X	
Koelaria macrantha, June Grass	C	N	N	24"		X	X
Linaria reticulate, Purplenet Toadflax	C	N	N	20"		X	
Lobularia maritima, Sweet Alyssum	C	N	N	12"		X	
Polypodium glycrrhiza, Licorice Fern	C	Y	Y	12"		X	X
Polystichum munitum, Sword Fern	C	Y	Y	24"		X	X
Potentilla nepalensis, Nepal Cinquefoil	C	N	N	14"		X	X
Potentilla neumanniana, Cinquefoil	C	N	N	14"		X	
Thymus serphyllum, Creeping Thyme	C	N	N	3"		X	
Veronica liwanensis, Speedwell	C	N	N	2"		X	X
Shrubs and Small Trees							
Amalanchier alnifolia, Saskatoon Serviceberry	D	Y	N	20'		X	
Berberis thunbergii, Japanese Barberry	D	N	N	4'		X	

Ecoroof Plant List

Plant Name		**Characteristics**						
Botanic name, Common Name	Zone	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Full Sun	Partial Shade
Gaultheria shallon , Salal	D	Y	Y	24"		X	X
Lavandula angustifolia 'Hidcote' , Dwarf English Lavander	D	N	Y	30"		X	
Mahonia aquifolium , Oregon Grape	D	Y	Y	5'		X	X
Mahonia nervosa , Dull Oregon Grape	D	Y	Y	24"		X	X
Mahonia repens , Creeping Oregon Grape	D	Y	Y	12"		X	X
Nanadina domestica , Heavenly Bamboo	D	N	N	4'		X	X
Ribes sanguineum , Red-Flowering Current	D	Y	N	12'		X	X
Rosa nutkana , Nootka Rose	D	Y	N	10'		X	
Symphoricarpos mollis , Creeping Snowberry	D	Y	N	18"		X	X
Thymus vulgaris , Common Thyme	D	N	Y	12"		X	X

Greenstreet Plant List

Plant Name		Facility Type			Characteristics				
		Public							
Botanic name, Common Name	Zone	Swale	Curb Extension	Planter	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Under Powerlines
Herbaceous Plants									
Camassia leichtlini, Great Camas	A/B	X	X	X	Y	N	24"	12"	
Camassia quamash , Common Camas	A/B	X	X	X	Y	N	24"	12"	
Carex comans, New Zealand Hair Sedge	A	X	X	X		Y	18"	12"	
Carex densa , Dense Sedge	A	X	X	X	Y	Y	24"	12"	
Carex obnupta , Slough Sedge	A	X	X	X	Y	Y	4'	12"	
Carex stipata , Sawbeak Sedge	A	X	X	X	N	N	20"	12"	
Carex testacea , New Zealand Orange Sedge	A	X	X	X	N	Y	24"	12"	
Deschampsia cespitosa , Tufted Hair Grass	A/B	X	X	X	Y	N	36"	12"	
Iris douglasiana, Douglas Iris	B	X	X		Y	N	18"	12"	
Iris tenax , Oregon Iris	B	X	X		Y	N	18"	12"	
Juncus patens , Spreading Rush	A	X	X	X	N	Y	36"	12"	
Polystichum munitum , Sword Fern	A/B	X	X		Y	Y	24"	24"	
Shrubs									
Cornus sericea 'Kelseyii', Kelsey Dogwood	A/B	X	X	X	N	N	24"	24"	
Euonymous japonicus 'Microphyllus' Boxleaf Evergreen Euonymus	B	X	X		N	Y	24"	24"	
Gaultheria shallon , Salal	B	X	X		Y	Y	24"	24"	
Lavandula angustifolia 'Hidcote Blue', Dwarf Lavander	B	X	X		N	N	24"	24"	
Mahonia nervosa , Dull Oregon Grape	B	X	X		Y	Y	24"	24"	

Greenstreet Plant List

Plant Name		Facility Type			Characteristics				
		Public							
Botanic name, Common Name	Zone	Swale	Curb Extension	Planter	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Under Powerlines
Spirarea betulifolia, Birchleaf Spiraea	A/B	X	X	X	Y	N	24"	24"	
Spiraea densiflora, Sub-alpine Spiraea	A/B	X	X	X	Y	N	24"	24"	
Rosmarinus officinalis 'Huntington Blue Carpet', Creeping Rosemary	B	X	X		N	N	12"	24"	
Viburnum opulus 'Nanum', Dwarf European Cranberry	B	X	X		N	N	24"	24"	
Groundcovers									
Arctostapylos uva-ursi, Kinnickinnick	B	X	X		Y	Y	6"	12"	
Fragaria chiloensis, Coastal Strawberry	B	X	X		Y	Y	6"	12"	
Fragaria vesca, Woodland Strawberry	B	X	X		Y	Y	6"	12"	
Fragaria virginiana, Wild Strawberry	B	X	X		N	Y	10"	12"	
Helictotrichon sempervirens, Blue Oat Grass	B	X	X		N	Y	24"	12"	
Mahonia repens Creeping Oregon Grape	B	X	X		Y	Y	12"	12"	
Street Trees									
Acer campestre 'Evelyn', Queen Elizabeth Hedge Maple	A/B	X	X	X	N	N	30'		N
Betula jacquemontii, Jacquemontii Birch	A/B	X	X	X	N	N	60'		N
Carpinus caroliniana, American Hornbeam	A/B	X	X	X	N	N	30'		Y
Celtis occidentalis, Hackberry	A/B	X	X	X	N	N	50'		N
Fraxinus pennsylvanica 'Johnson', Leprechaun Ash	A/B	X	X	X	N	N	30'		Y

Greenstreet Plant List

Plant Name		**Facility Type**			**Characteristics**				
		Public							
Botanic name, Common Name	Zone	Swale	Curb Extension	Planter	NW Native	Evergreen	Potential Hgt.	O.C. Spacing	Under Powerlines
Gleditsia triacanthos 'Impcole' , Imperial Honeylocust	A/B	X	X	X	N	N	30'		Y
Gleditsia triacanthos 'Skycole' , Skyline Honeylocust	A/B	X	X	X	N	N	70'		N
Koelreuteria paniculata , Goldenrain Tree	A/B	X	X	X	N	N	30'		Y
Nyssa sylvatica , Black Tupelo	A	X	X	X	N	N	50'		N
Prunus virginiana 'Canada Red' , Canada Red Chokecherry	A/B	X	X	X	N	N	25'		Y
Quercus shumardii , Shumard Oak	A/B	X	X	X	N	N	70'		N
Rhamnus purshiana , Cascara	A/B	X	X	X	Y	N	30'		Y

Pond Plant List

Plant Name	Planting Zone			Characteristics			
Botanic name, Common Name	Wet to Saturated	Moist to Dry	Dry/Upland	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Herbaceous Plants							
Alisma plantago-aquatica, Water Plantain	X			Y	N	24"	12"
Alopecurus geniculatus, Water Foxtail		X		Y	Y	18"	12"
Aster suspicatus , Douglas' Aster	X	X		Y	N	36"	12"
Bidens cernua, Nodding Beggerticks		X		Y	N	24"	12"
Blechnum spicant, Deer Fern	X	X		Y	N	24"	24"
Bromus sitchensis, Alaska Brome		X	X	Y	Y	18"	12"
Camassia quamash , Common Camas		X		Y	N	24"	12"
Carex deweyanna, Dewey Sedge	X	X		Y	Y	36"	12"
Carex obnupta , Slough Sedge	X			Y	Y	4'	12"
Deschampsia cespitosa , Tufted Hair Grass		X		Y	N	36"	12"
Eleocharis ovata, Ovate Spike Rush	X			Y	Y	30"	12"
Eleocharis palustris , Creeping Spike Rush	X			Y	Y	30"	12"
Elymus glaucus, Blue Wild Rye		X		Y	Y	24"	12"
Glycera occidentalis, Western Manna Grass	X	X		Y	Y	18"	12"
Lemna minor, Common Lesser Duckweed	X						
Juncus effusus var. pacificus , Soft rush	X	X		Y	Y	36"	12"
Juncus ensifolius , Dagger-leaf Rush	X	X		Y	Y	24"	12"
Juncus oxymeris, Pointed Rush	X	X		Y	Y	24"	12"

Pond Plant List

Plant Name	Planting Zone			Characteristics			
Botanic name, Common Name	Wet to Saturated	Moist to Dry	Dry/Upland	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Juncus patens , Spreading Rush	X	X		N	Y	36"	12"
Juncus tenuis, Slender Rush	X	X		Y	Y	36"	12"
Lupinus polyphyllus , Large-leaved Lupine		X		Y	N	36"	12"
Myosotis laxa, Small-flowered Forget-Me-Not	X			Y	N	18"	12"
Polystichum munitum , Sword Fern	X	X		Y	Y	24"	24"
Sagittaria latifolia, Wapato	X			Y	N	24"	12"
Potamogeton natans, Floating-leafed Pondweed	X			Y	Y	18"	12"
Scriptus acutus , Hardstem Bulrush	X			N	N	10"	12"
Scriptus mIcrocarpus, Small Fruited Bulrush		X		Y	Y	24"	12"
Sisyrinchium idahoense Blue-eyed Grass		X		N	Y	6"	12"
Sparganium emersum, Narrowleaf Bur-reed	X			Y	N	24"	12"
Veronica liwanensis , Speedwell	X	X		N	N	2"	12"
Viola palustris, Marsh Violet	X	X		Y	N	6"	6"
Large Shrubs and Small Trees							
Acer circinatum , Vine Maple	X	X		Y	N	15'	10'
Amelanchier alnifolia , Western Serviceberry			X	Y	N	20'	10'
Holodiscus discolor, Oceanspray			X	Y	N	6'	4'
Lonicera involucrata , Black Twinberry			X	Y	N	5'	4'
Oemleria cerasiformis, Indian Plum		X	X	Y	N	6'	4'
Philadelphu lewisii, Wild Mock Orange			X	Y	N	6'	4'

Pond Plant List

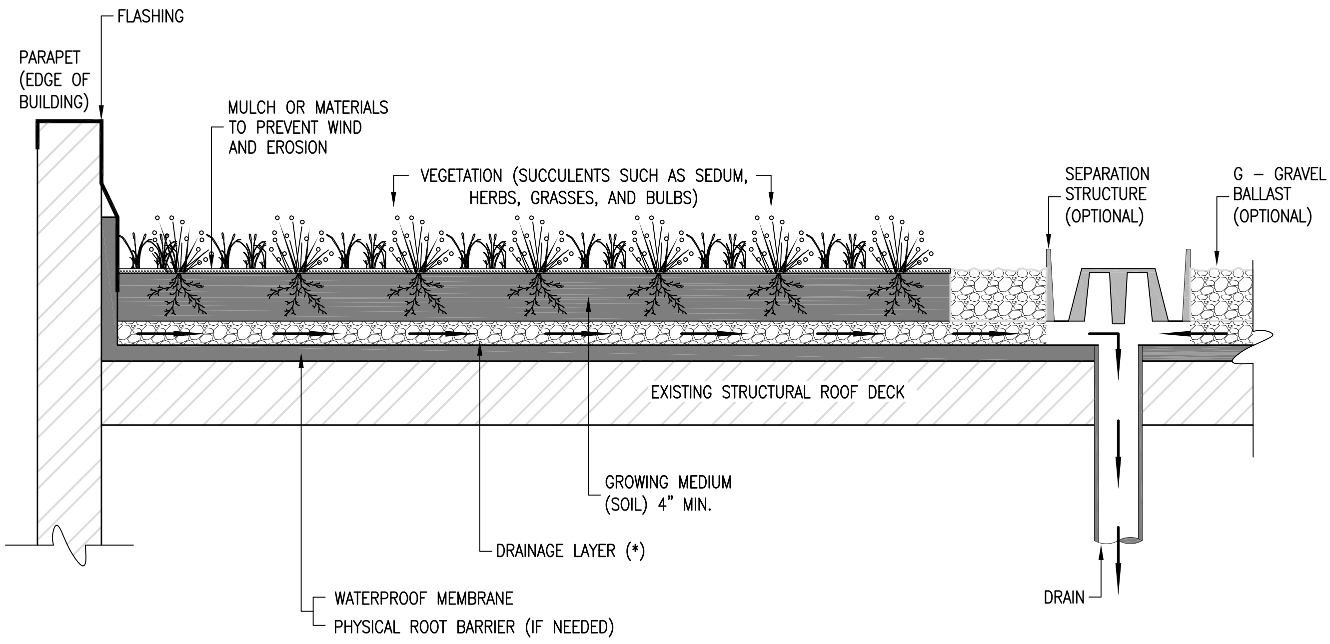
Plant Name *Botanic name,* Common Name	Planting Zone Wet to Saturated	Moist to Dry	Dry/Upland	Characteristics NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Ribes sanguineum , Red-Flowering Current			X	Y	N	8'	4'
Rubus parviflorus , Thimbleberry		X		Y	N	8'	4'
Rubus spectabilis , Salmonberry	X	X		Y	N	10'	4'
Salix fluviatalis, Columbia Willow	X	X		N	N	13'	6'
Salix lucida var. 'Lasiandra' , Pacific Willow	X	X		Y	N	13'	6'
Salix stichensis , Sitka Willow	X	X		Y	N	20'	6'
Sambucus racemosa, Red Elderberry		X		Y	N	10'	10'
Spriaea douglasii , Douglas Spiraea		X		Y	N	7'	4'
Viburnum edule, Highbush Cranberry		X		Y	N	6'	4'
Shrubs							
Cornus sericea , Red-twig Dogwood	X	X		Y	N	6'	4'
Fragaria vesca , Woodland Strawberry		X	X	N	Y	10"	12"
Fragaria virginiana , Wild Strawberry		X	X	N	Y	10"	12"
Mahonia aquifolium , Oregon Grape		X	X	Y	Y	5'	3'
Mahonia nervosa , Dull Oregon Grape		X		Y	Y	24"	24"
Physocarpus capitatus , Pacific Ninebark	X			Y	N	6'	3'
Rosa gymnocarpa, Baldhip Rose	X			Y	N	3'	3'
Rosa nutkana , Nootka Rose		X		Y	N	8'	3'
Rosa pisocarpa , Swamp Rose	X			Y	N	8'	3'

Pond Plant List

Plant Name	Planting Zone			Characteristics			
Botanic name, Common Name	Wet to Saturated	Moist to Dry	Dry/Upland	NW Native	Evergreen	Potential Hgt.	O.C. Spacing
Spiraea betulifolia, Birchleaf Spiraea		X		Y	N	24"	24"
Symphoricarpus alba, Snowberry		X		Y	N	3'	3'
Trees							
Abies grandis, Grand Fir		X		Y	Y	150'	
Acer macrophyllum, Big Leaf Maple		X		Y	Y	60'	
Alnus rubra , Red Alder	X	X		Y	N	80'	
Arbutus menziesii, Madrone			X	Y	N	35'	
Cornus nuttalii, Western flowering Dogwood		X	X	Y	N	20'	
Crataegus douglasii , Black Hawthorn	X			Y	N	40'	
Fraxinus latifolia , Oregon Ash	X	X		Y	N	30'	
Malus fusca , Pacific Crabapple	X	X		Y	N	30'	
Pinus ponderosa, Ponderosa Pine			X	Y	Y	70'	
Pinus monticola, Western White Pine		X	X	Y	Y	90'	
Prunus emarginata var. mollis, Bitter Cherry	X			Y	N	50'	
Pseudotsuga menziesii , Douglas Fir		X		Y	Y	200'	
Quercus garryana , Oregon White Oak		X		Y	N	100'	
Rhamnus purshiana , Cascara	X			Y	N	30'	
Salix hookeriana, Hooker's Willow	X	X		Y	N	15'	
Salix scouleriana, Scouler's Willow	X	X		Y	N	15'	
Thuja plicata , Western Red Cedar	X	X		Y	Y	150'	

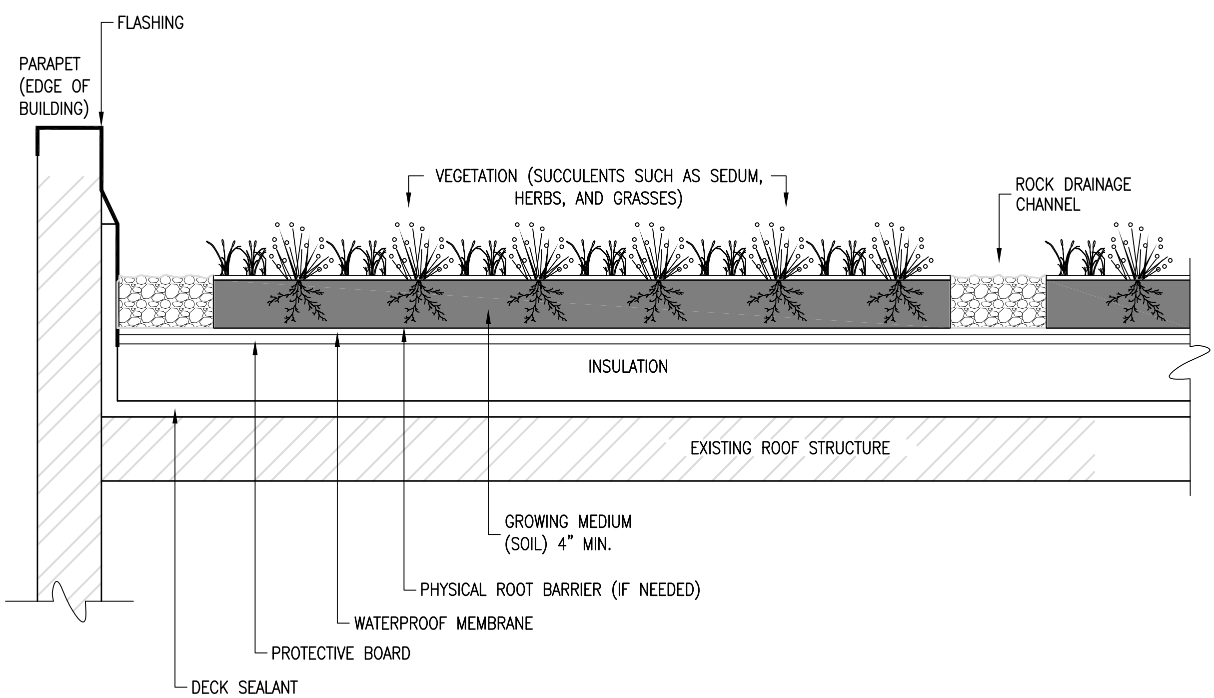
Appendix G Table of Contents

Appendix G.1 Table of Contents



ECOROOF WITH DRAINAGE LAYER

* SEE OTHER DETAIL BELOW FOR OPTION.



ECOROOF WITH DRAINAGE CHANNELS

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

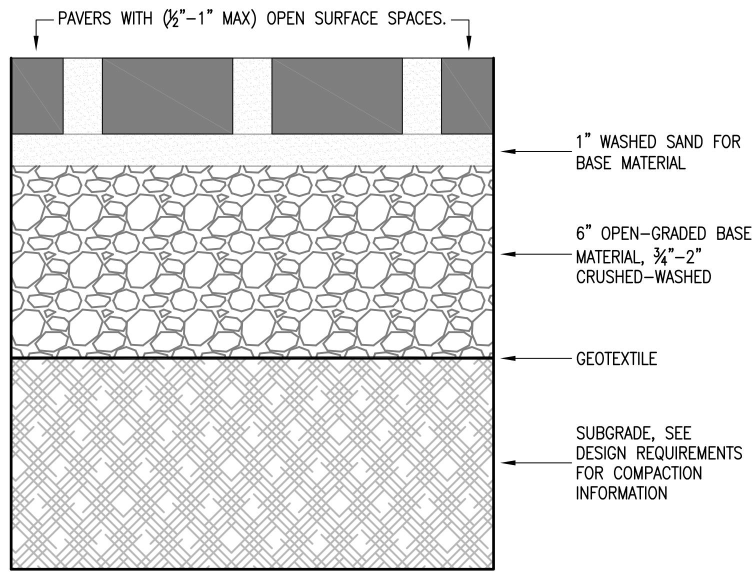
- Simplified / Presumptive Design Approach -

Ecoroof

NUMBER

SW-100

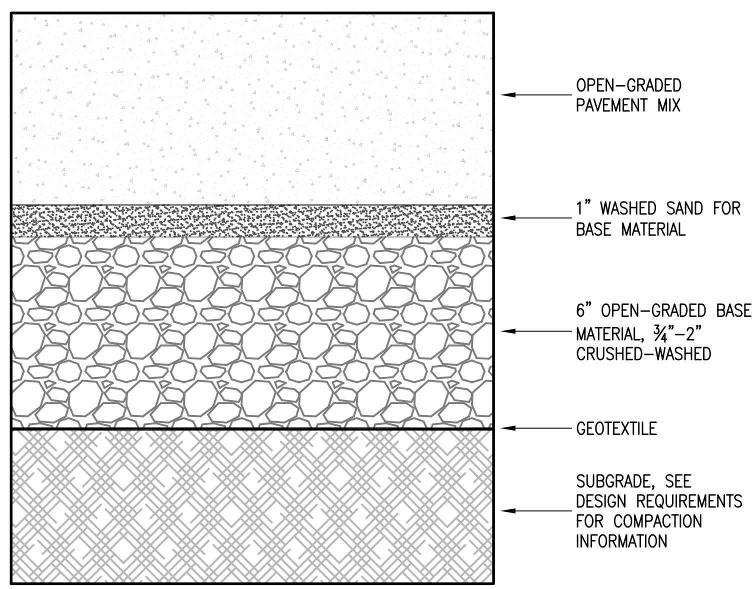
Bureau of Environmental Services



PERMEABLE CONCRETE BLOCK
OR "PAVER" SYSTEMS

	RESIDENTIAL DRIVEWAY OR PEDESTRIAN ONLY	PRIVATE STREET, PARKING LOT, OR FIRE LANE	PUBLIC STREET
CONCRETE	4"	4"	7"
ASPHALT	2 ½"	3"	6"
PAVERS	2 ⅜"	3 ⅛"	3 ⅛"
ENGINEERING REQ'D	NO	YES	YES
COMPACTION REQ'D	NO	YES	95%

EXHIBIT 2-8
PERVIOUS PAVEMENT REQUIREMENTS
FOR TOP LIFT DEPTH, ENGINEERING,
AND COMPACTION.



PERVIOUS (OPEN GRADED) CONCRETE
AND ASPHALT SYSTEMS

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

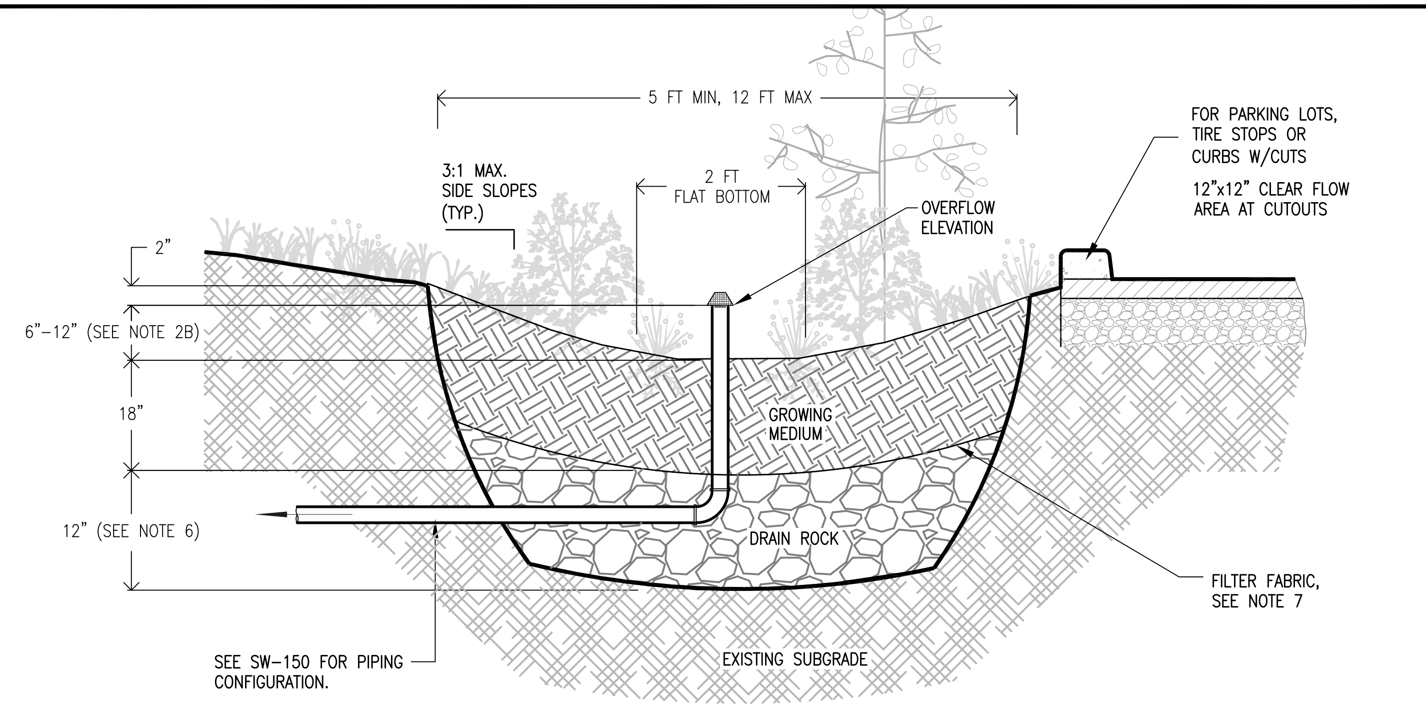
- Simplified / Presumptive / Performance Design Approach -

Pervious Pavement

NUMBER

SW-110

Bureau of Environmental Services



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Dimensions:
   a. Width of swale: 5' - 12'.
   b. Depth of swale ((from top of growing medium to overflow elevation); Simplified: 9", Presumptive: 6"-12".
   c. Longitudinal slope of swale: 6.0% or less.
   d. Flat bottom width: 2'.
   e. Side slopes of swale: 3:1 maximum.

3. Setbacks (from centerline of facility):
   a. Infiltration swales must be 10' from foundations and 5' from property lines.
   b. Flow-through swales must be lined with connection to approved discharge point according to SWMM Section 1.3.

4. Overflow:
   a. Overflow required for Simplified Approach
   b. Inlet elevation must allow for 2" of freeboard, minimum.
   c. Protect from debris and sediment with strainer or grate.

5. Piping: shall be ABS Sch.40, cast iron, or PVS Sch.40. 3" pipe required for up to 1,500 sq ft of impervious area, otherwise 4" min. Piping must have 1% grade and follow the Uniform Plumbing Code.

6. Drain rock:
   a. Size for infiltration swale: 1½" - ¾" washed
   b. Size for flow-through swale: ¾" washed
   c. Depth for Simplified: 12"
   d. Depth for Presumptive: 0-48", see calcs.

7. Separation between drain rock and growing medium: Use filter fabric (see SWMM Exhibit 2-4 Geotextile table) or a gravel lens (¾ - ¼ inch washed, crushed rock 2 to 3 inches deep).

8. Growing medium:
   a. 18" minimum
   b. See Appendix F.3 for specification or use sand/loam/compost 3-way mix.

9. Vegetation: Follow landscape plans otherwise refer to plant list in SWMM Appendix F. Minimum container size is 1 gallon. # of plantings per 100sf of facility area:
   a. Zone A (wet): 115 herbaceous plants OR 100 herbaceous plants and 4 small shrubs.
   b. Zone B (moderate to dry): 1 tree AND 3 large shrubs / small trees AND 4 small shrubs AND 140 groundcover plants.

   The delineation between Zone A and B shall be either at the outlet elevation or the check dam elevation, whichever is lowest.

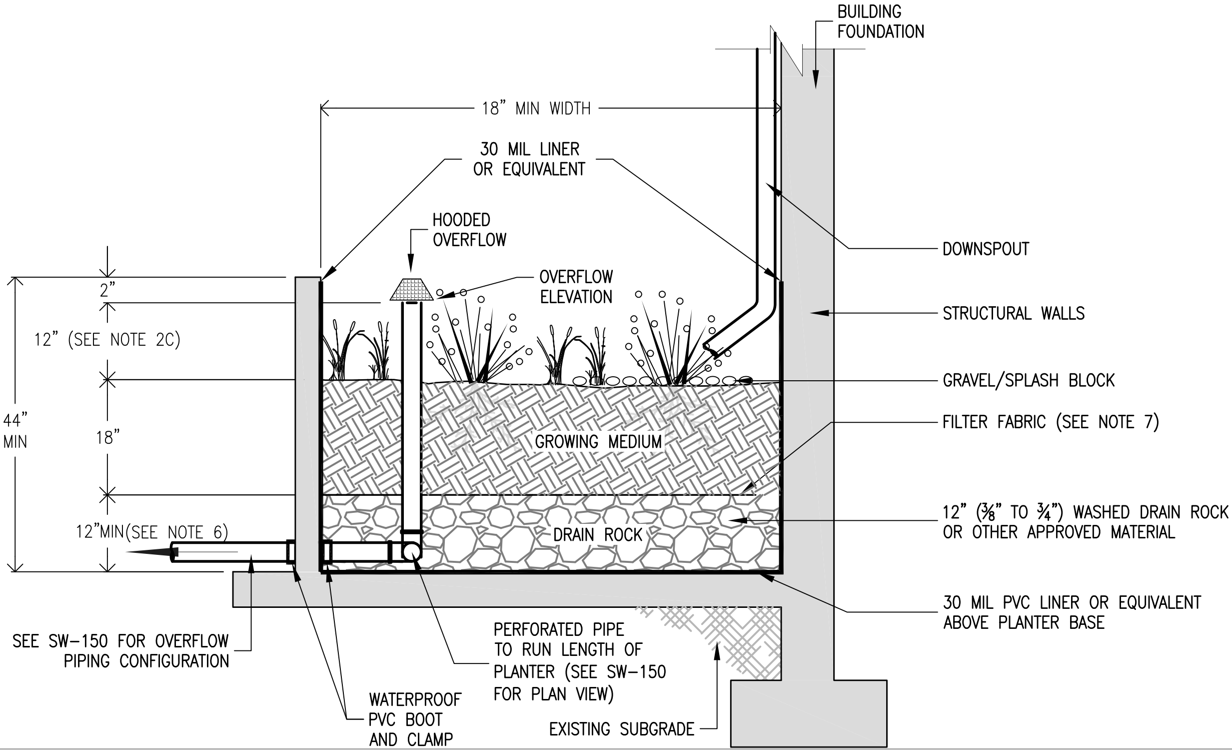
10. Waterproof liner: Shall be 30 mil PVC or equivalent for flow-through facilities.

11. Install washed pea gravel or river rock to transition from inlets and splash pad to growing medium.

12. Check dams: Shall be placed according to facility design. Refer to SW-340 for profile and spacing.

13. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Dimensions:
   a. Width of flow-through planter: 18" minimum.
   b. Width of infiltration planter: 30" minimum.
   c. Depth of planter (from top of growing medium to overflow elevation). Simplified: 12"; Presumptive: 6"- 18".
   d. Slope of planter: 0.5% or less.

3. Setbacks (from centerline of facility):
   a. Infiltration planters must be 10' from foundations and 5' from property lines.
   b. Flow-through planters must be less than 30" in height above surrounding area if within 5 feet of property line.

4. Overflow:
   a. Overflow required for Simplified Approach.
   b. Inlet elevation must allow for 2" of freeboard, minimum.
   c. Protect from debris and sediment with strainer or grate.

5. Piping: shall be ABS Sch.40, cast iron, or PVS Sch.40. 3" pipe required for up to 1,500 sq ft of impervious area, otherwise 4" min. Piping must have 1% grade and follow the Uniform Plumbing Code.

6. Drain rock:
   a. Size for infiltration planter: 1½" - ¾" washed
   b. Size for flow-through planter: ¾" washed
   c. Depth for Simplified: 12"
   d. Depth for Presumptive: 0-48", see calcs.

7. Separation between drain rock and growing medium: Use filter fabric (see SWMM Exhibit 2-4 Geotextile table) or a gravel lens (¾ - ¼ inch washed, crushed rock 2 to 3 inches deep).

8. Growing medium:
   a. 18" minimum
   b. See Appendix F.3 for specification or use sand/loam/compost 3-way mix.

9. Vegetation: Follow landscape plans otherwise refer to plant list in SWMM Appendix F. Minimum container size is 1 gallon. # of plantings per 100sf of facility area:
   a. Zone A (wet) 115 herbaceous plants, OR
   b. Zone A (wet) 100 herbaceous plants and 4 small shrubs.

10. Planter walls:
   a. Material shall be stone, brick, concrete, wood, or other durable material (no chemically treated wood).
   b. Concrete, brick, or stone walls shall be included on foundation plans.

11. Waterproof liner: Shall be 30 mil PVC or equivalent, for flow-through facilities.

12. Install washed pea gravel or river rock to transition from inlet or splash pad to growing medium.

13. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

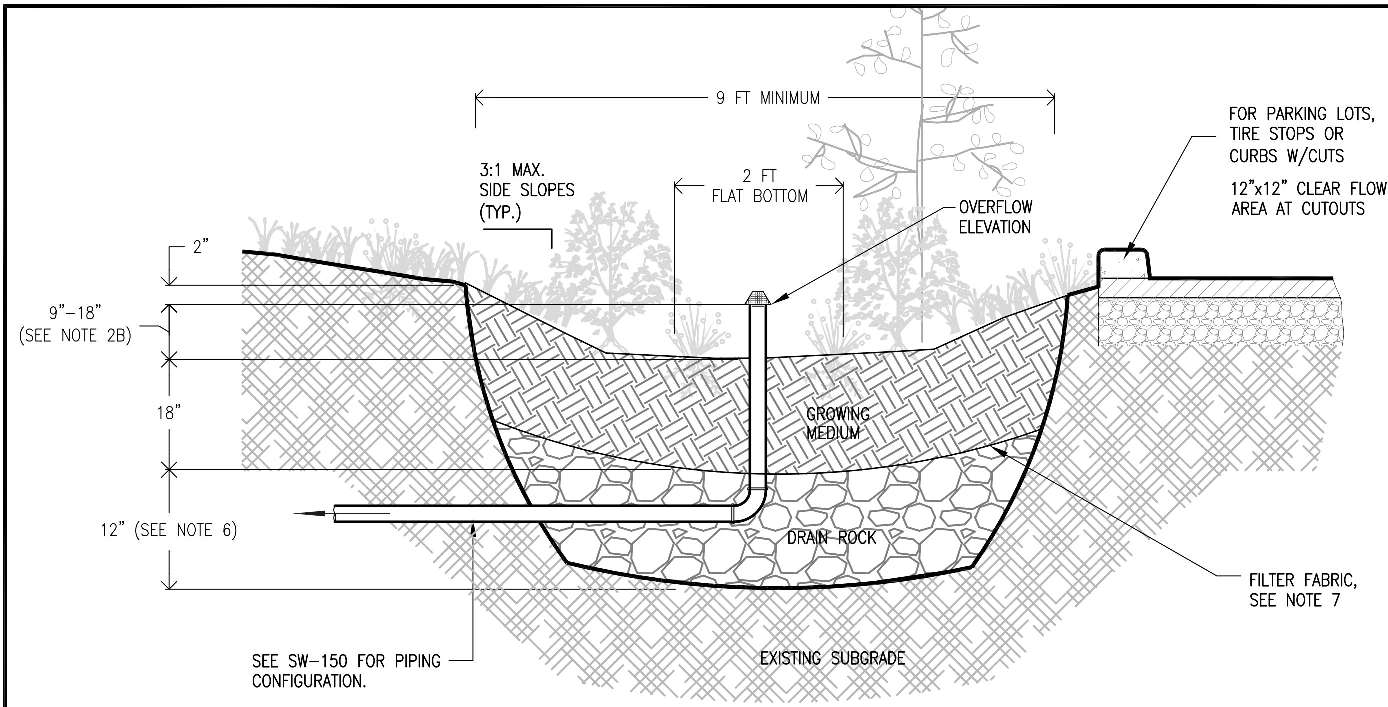
- Simplified / Presumptive Design Approach -

Planter

Bureau of Environmental Services

NUMBER

SW-130



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Dimensions:
   a. Width of basin: 9' minimum.
   b. Depth of basin (from top of growing medium to overflow elevation); Simplified: 12", Presumptive: 9"-18".
   c. Flat bottom width: 2' min.
   d. Side slopes of basin: 3:1 maximum.

3. Setbacks (from midpoint of facility):
   a. Infiltration basins must be 10' from foundations and 5' from property lines.
   b. Flow-through swales must be lined with connection to approved discharge point according to SWMM Section 1.3.

4. Overflow:
   a. Overflow required for Simplified Approach.
   b. Inlet elevation must allow for 2" of freeboard, minimum.
   c. Protect from debris and sediment with strainer or grate.

5. Piping: shall be ABS Sch.40, cast iron, or PVC Sch.40. 3" pipe required for up to 1,500 sq ft of impervious area, otherwise 4" min. Piping must have 1% grade and follow the Uniform Plumbing Code.

6. Drain rock:
   a. Size for infiltration basin: 1½" - ¾" washed
   b. Size for flow-through basin: ¾" washed
   c. Depth for Simplified: 12"
   d. Depth for Presumptive: 0-48", see calcs.

7. Separation between drain rock and growing medium:
   Use filter fabric (see SWMM Exhibit 2-5) or a gravel lens (¾ - ¼ inch washed, crushed rock 2 to 3 inches deep).

8. Growing medium:
   a. 18" minimum
   b. See Appendix F.3 for specification or use sand/loam/compost 3-way mix.

9. Vegetation: Follow landscape plans otherwise refer to plant list in SWMM Appendix F. Minimum container size is 1 gallon. # of plantings per 100sf of facility area):
   a. Zone A (wet): 115 herbaceous plants OR 100 herbaceous plants and 4 shrubs
   b. Zone B (moderate to dry): 1 tree AND 3 large shrubs AND 4 medium to small shrubs.

   The delineation between Zone A and B shall be either at the outlet elevation or the check dam elevation, whichever is lowest.

10. Install washed pea gravel or river rock to transition from inlets and splash pad to growing medium.

11. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

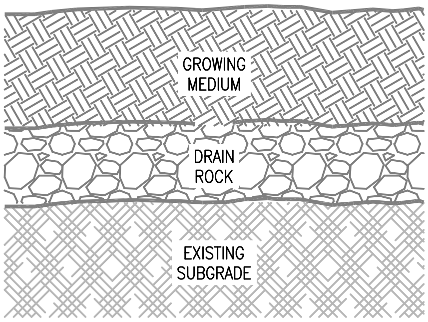
- Simplified / Presumptive Design Approach -

Basin

NUMBER

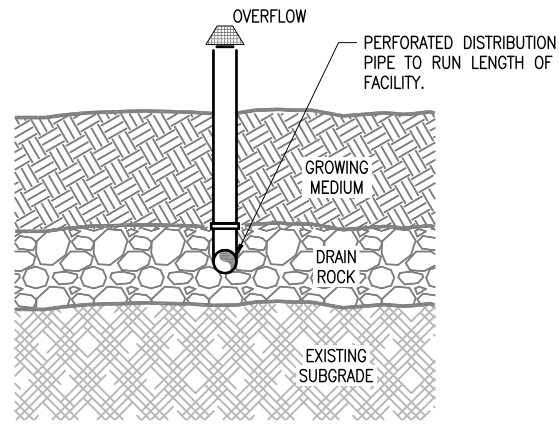
SW-140

Bureau of Environmental Services



INFILTRATION

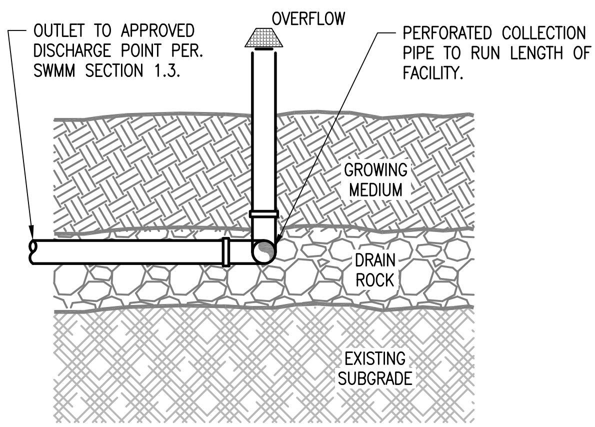
STORMWATER HIERARCHY CATEGORY 1



HYBRID

STORMWATER HIERARCHY CATEGORY 2

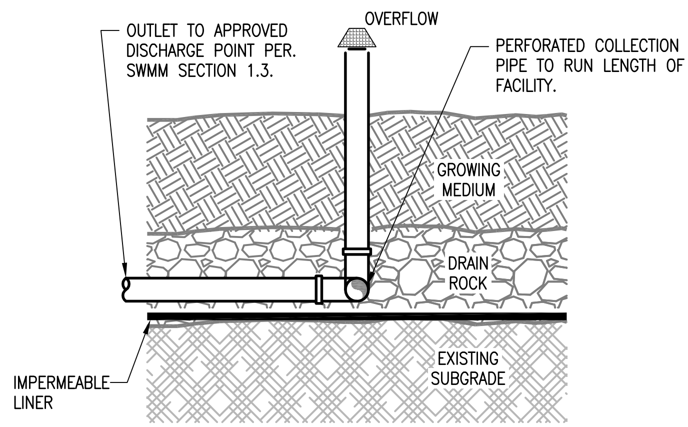
OVERFLOW DIRECTED TO DRAIN ROCK. (SEE SW–151 AND SW–152 FOR MORE INFORMATION)



PARTIAL INFILTRATION

STORMWATER HIERARCHY CATEGORY 3 or 4

OVERFLOW AND UNDERDRAIN REQUIRED.
SET UNDERDRAIN WITHIN DRAIN ROCK

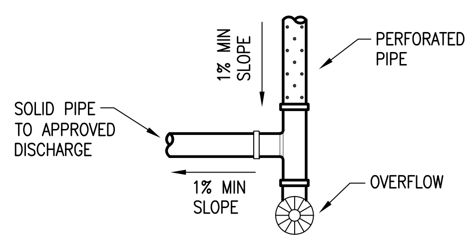


FLOW-THROUGH

STORMWATER HIERARCHY CATEGORY 3 or 4

OVERFLOW AND UNDERDRAIN REQUIRED.
SET UNDERDRAIN AT BASE OF DRAIN ROCK LINER.

NOTE:
HYBRID FACILITIES MUST BE REGISTERED AS A UIC DESIGNED UNDER THE PRESUMPTIVE APPROACH.



PLAN VIEW

PIPE W/ UNDERDRAIN & DISCHARGE POINT

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

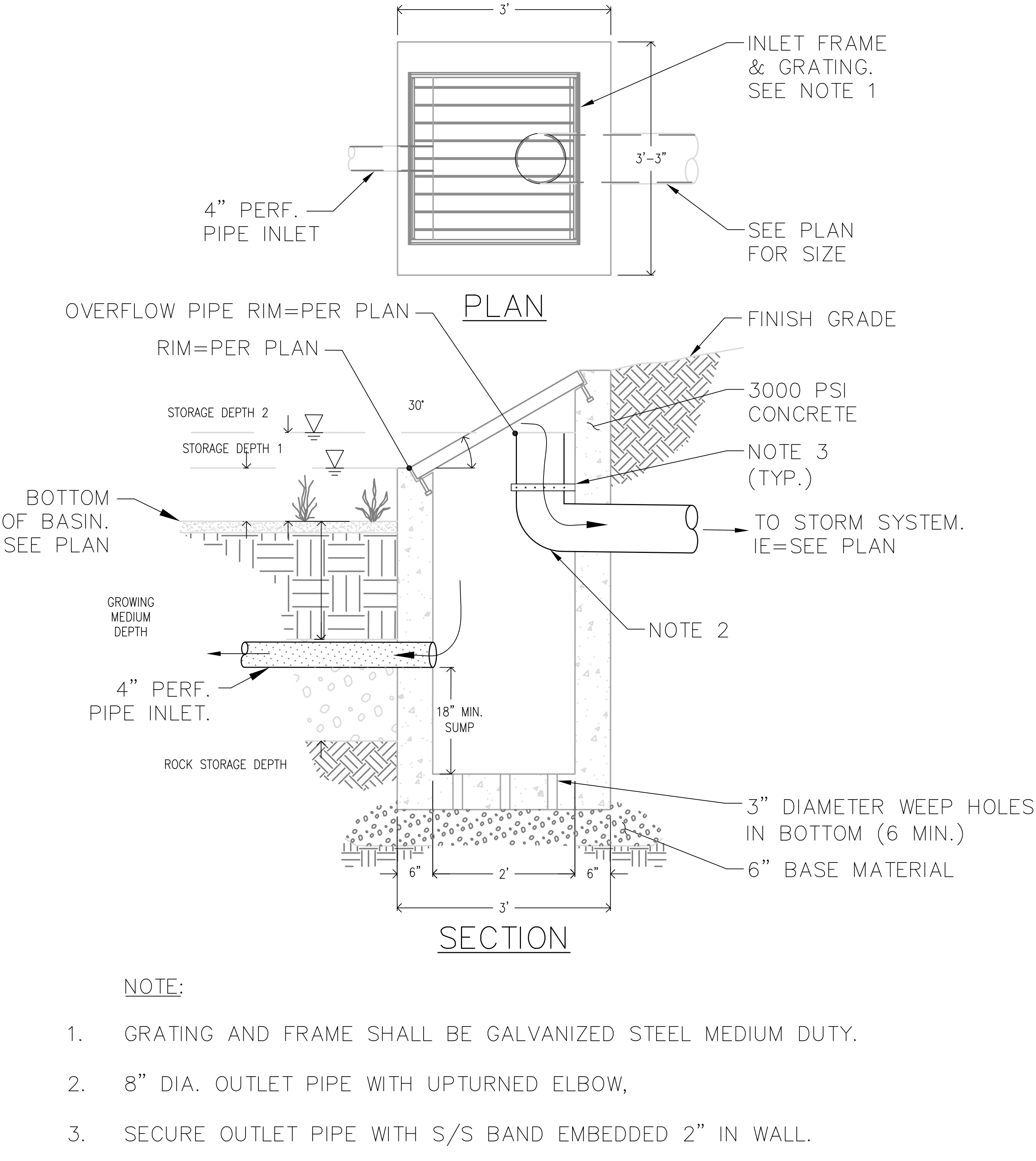
- Simplified / Presumptive Design Approach -

Facility Overflow Configurations

NUMBER

SW-150

Bureau of Environmental Services



NOTE:

1. GRATING AND FRAME SHALL BE GALVANIZED STEEL MEDIUM DUTY.
2. 8" DIA. OUTLET PIPE WITH UPTURNED ELBOW,
3. SECURE OUTLET PIPE WITH S/S BAND EMBEDDED 2" IN WALL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

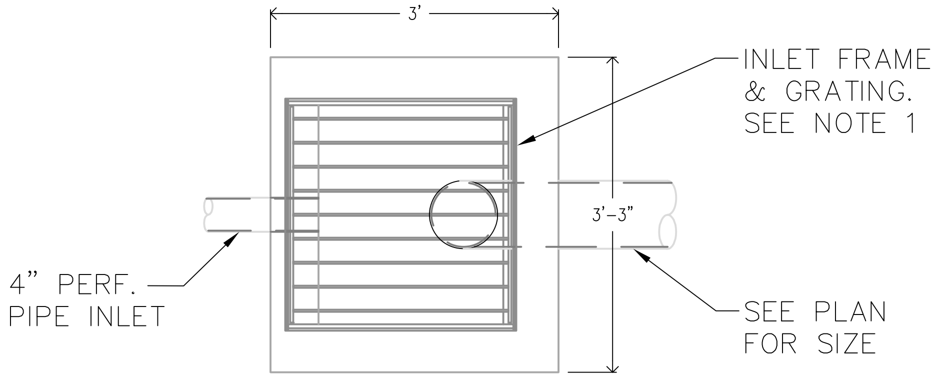
- Presumptive Design Approach -

Hybrid Configuration E

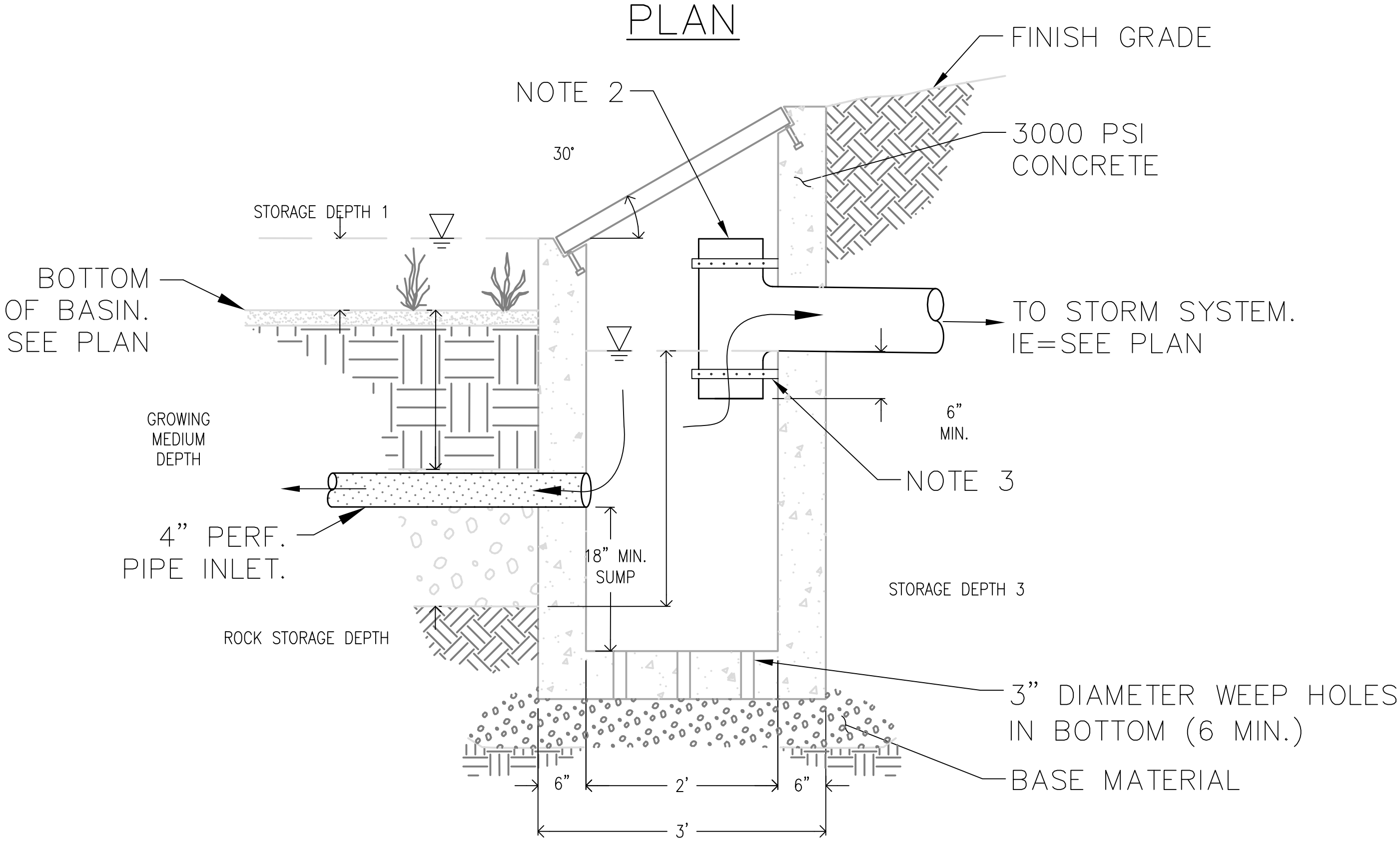
NUMBER

SW-151

Bureau of Environmental Services



PLAN



SECTION

NOTE:

1. GRATING AND FRAME SHALL BE GALVANIZED STEEL MEDIUM DUTY.

2. 8" DIA. OUTLET PIPE TEE. TEE IS OPEN ON TOP AND BOTTOM,

3. SECURE OUTLET PIPE WITH S/S BAND EMBEDDED 2" IN WALL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

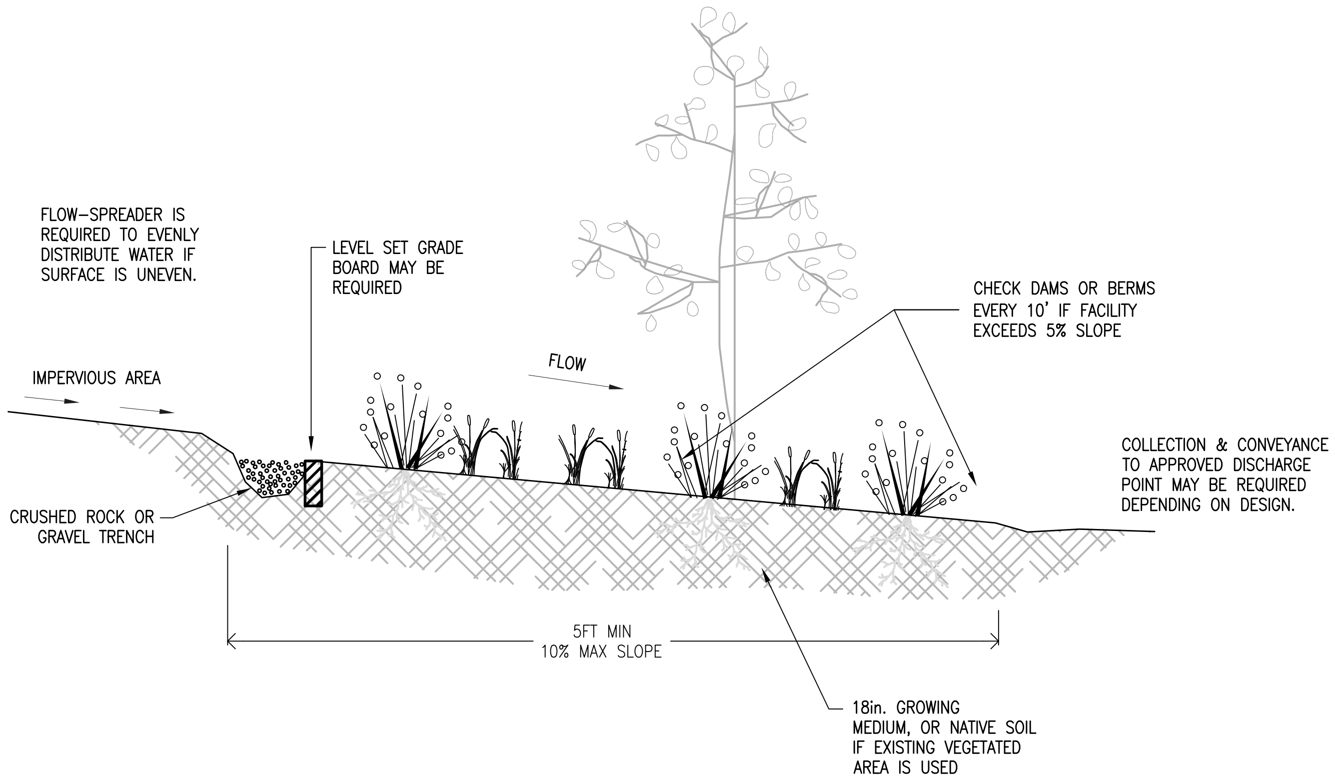
- Presumptive Design Approach -

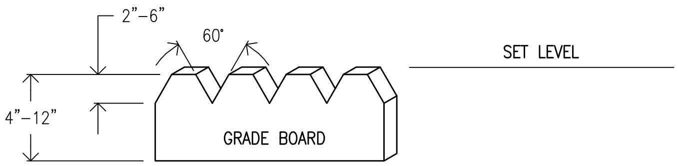
Hybrid Configuration F

Bureau of Environmental Services

NUMBER

SW-152





1. Provide protection from all vehicle traffic, equipment staging, as well as foot traffic for proposed infiltration areas prior to and during construction.

2. Dimensions:
   a. Flow line length: 5' minimum.
   b. Slopes: 0.5 - 10%

3. Setbacks (from beginning of facility):
   a. 5' from property line
   b. 10ft from buildings
   c. 50ft from wetlands, rivers, streams, and creeks where required.

4. Overflow: Collection from filter strip shall be specified on plans to approved discharge point according to SWMM Section 1.3.

5. Growing medium: Unless existing vegetated areas are used for the filter strip, growing medium shall be used within the top 18" (See Appendix F.3 for specifications or use sand / loam / compost 3-way mix).

6. Vegetation: The entire filter strip must have 100% coverage by native grasses, native wildflower blends, native ground covers, or any combination thereof.

7. Level Spreaders: A grade board or sand/gravel trench may be required to disperse the runoff evenly across the filter strip to prevent a point of discharge. The top of the level spreader must be horizontal and at an appropriate height to provide sheetflow directly to the soil without scour. Level spreaders shall not hold a permanent volume of runoff. Grade boards can be made of any material that will withstand weather and solar degradation. Trenches used as level spreaders can be filled with washed crushed rock, pea gravel, or sand

8. Check dams: shall be placed according to facility design otherwise:
   a. 12" in length
   b. Equal to the width of the filter
   c. 3 to 5" in height
   d. Every 10' where slope exceeds 5%.

9. Inspections: call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

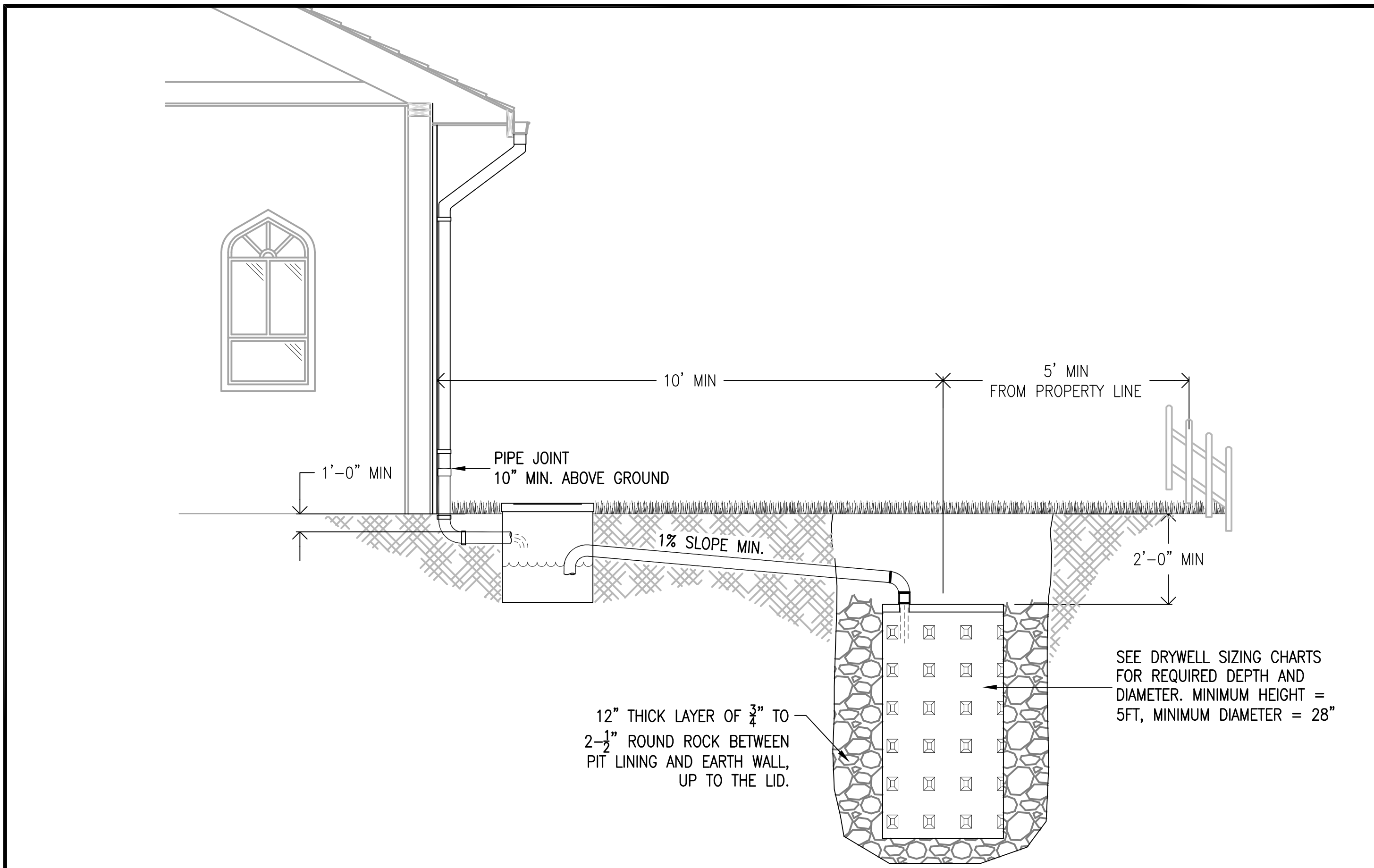
- Simplified / Presumptive / Performance Design Approach -

Filter Strip

NUMBER

SW-160

Bureau of Environmental Services



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Siting criteria: Gravelly sand, gravelly loamy sand, or other equally porous material must occur in a continuous 5' deep stratum within 12' of the ground surface.

3. Sizing: **Exhibit 2-36** is used to appropriately size the drywell(s) based on the amount of impervious area that each drywell is designed to manage. This chart shall be used as guidance, is based on field experience, and should be used as minimums only.

4. Drywell shall not be installed where base of facility has less than 10' of separation to water table.

5. Top of drywell must be below lowest finished floor.

6. Setbacks (from center of facility):
   a. 10' from foundations
   b. 5' from property lines
   c. 20' from cesspools.

7. Piping shall be ABS SCH40, cast iron, or PVC SCH40. 3" pipe must be used for up to 1500sf of impervious area, otherwise 4" minimum. Piping must have 1% grade and must follow current Uniform Plumbing Code.

Exhibit 2-36: Drywell Sizing Table

Once approval has been given by BDS for onsite infiltration of stormwater, the following chart shall be used to select the number and size of drywells. Gray boxes are acceptable.

IMPERVIOUS	28" Diameter				48" Diameter			
Area (sq-ft)	Drywell Depth				Drywell Depth			
	5'	10'	15'	20'	5'	10'	15'	20'
1000								
2000								
3000								
4000								
5000								
6000								
7000								
8000								
9000								
10000								

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

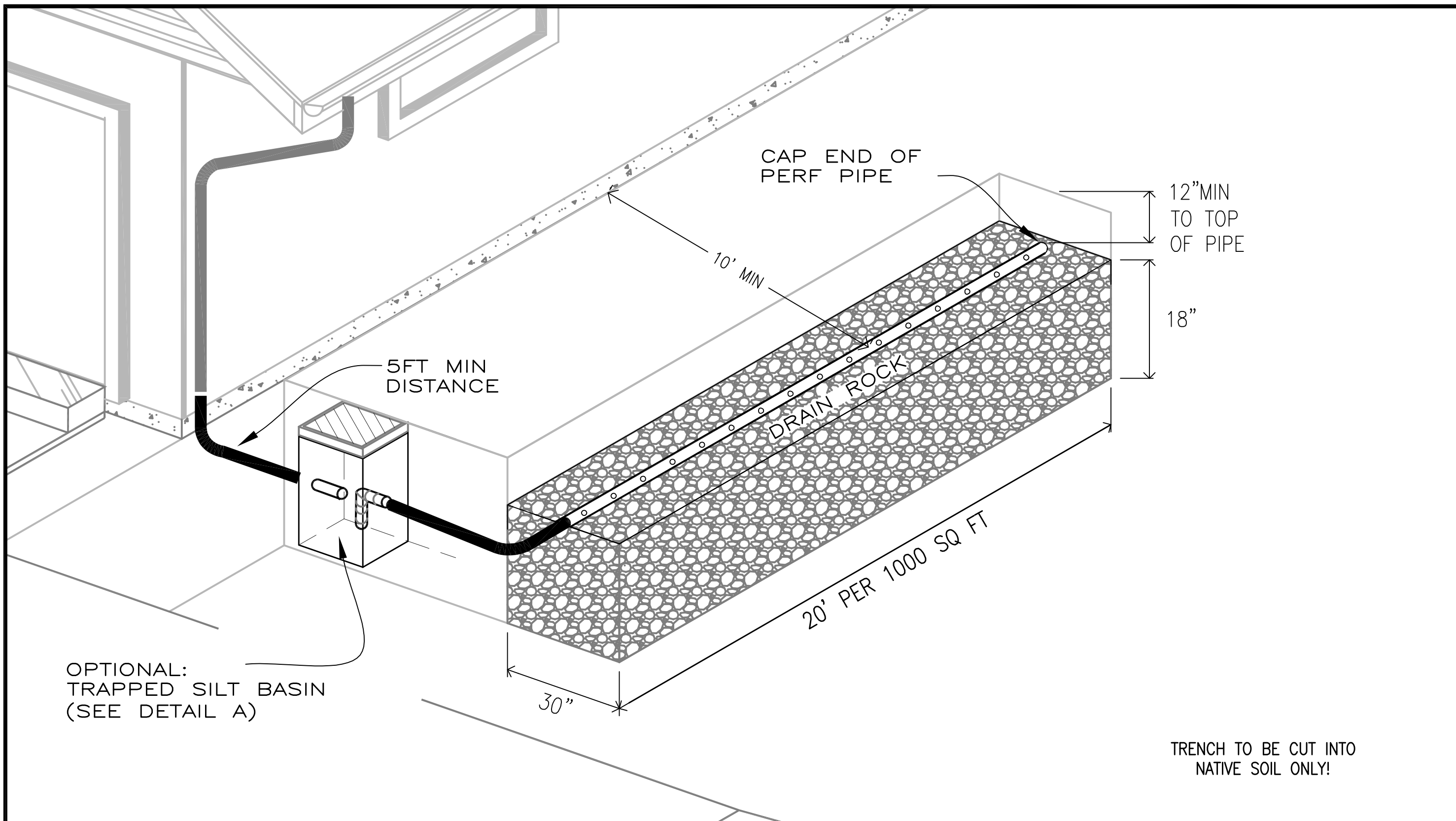
- Simplified / Presumptive Design Approach -

Drywell

NUMBER

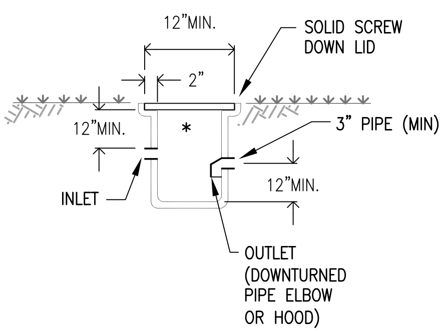
SW-170

Bureau of Environmental Services



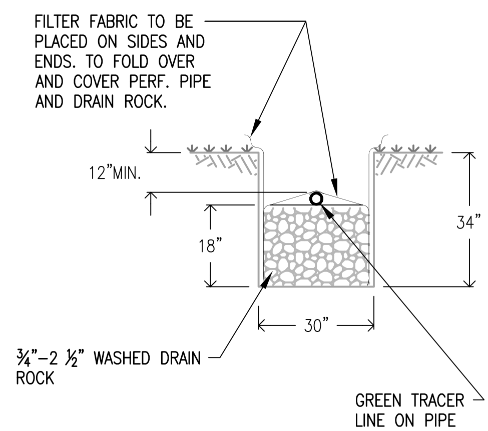
TRENCH TO BE CUT INTO NATIVE SOIL ONLY!

DETAIL A: OPTIONAL TRAPPED SILT BASIN DETAIL



* THE BOTTOM OF THE INLET PIPE MUST NOT BE LOWER THAN THE TOP OF THE OUTLET PIPE.

DETAIL B: SOAKAGE TRENCH CONSTRUCTION



LINE TRENCH SIDES WITH FILTER FABRIC AS SHOWN, ADD 18" OF DRAIN ROCK. PLACE PERF. PIPE AND COVER ALL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Simplified / Presumptive Design Approach -

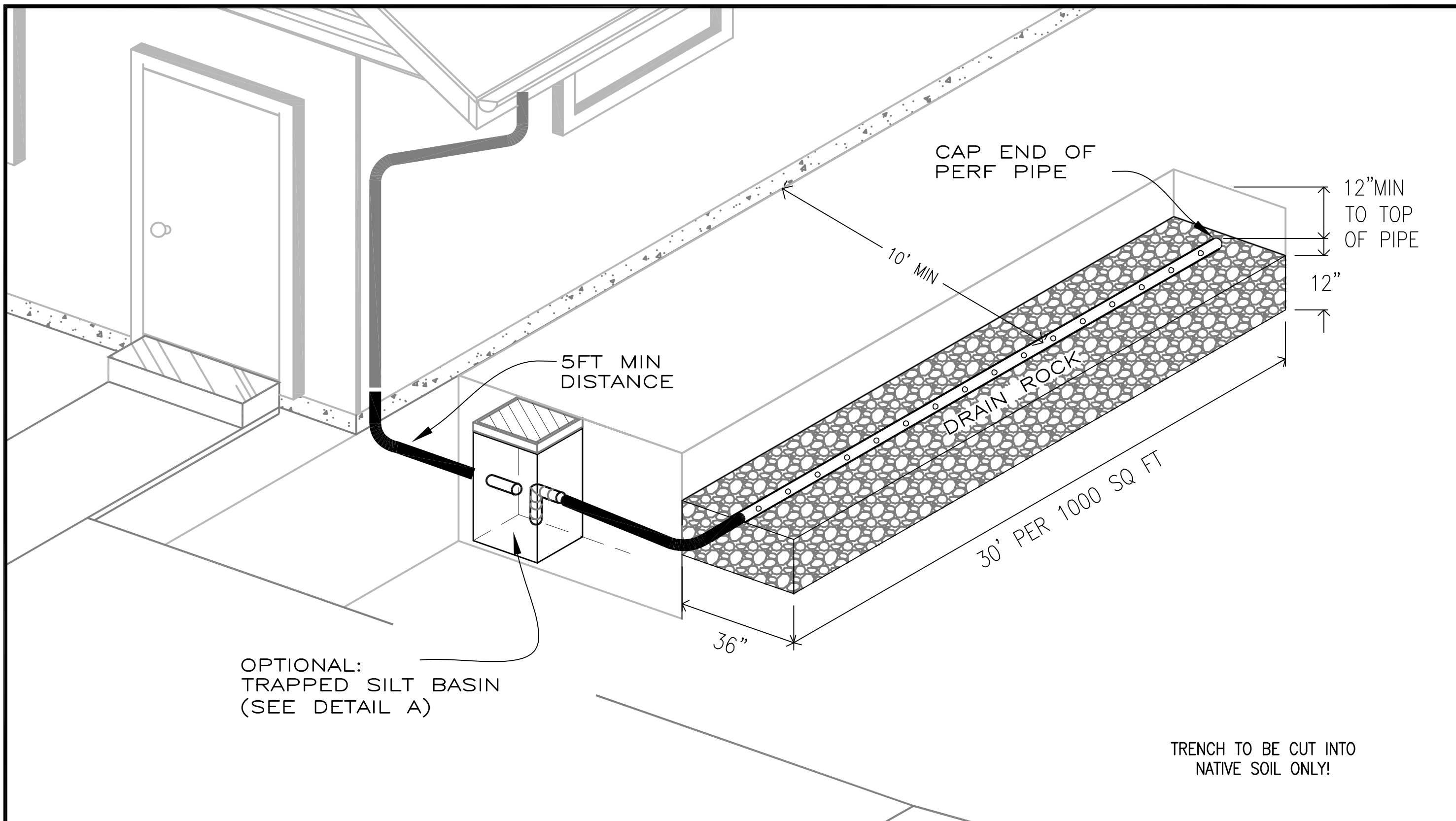
Soakage Trench

East Side

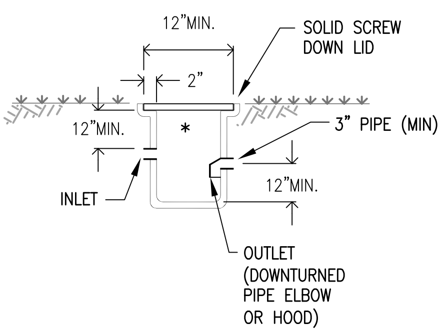
Bureau of Environmental Services

NUMBER

SW-180

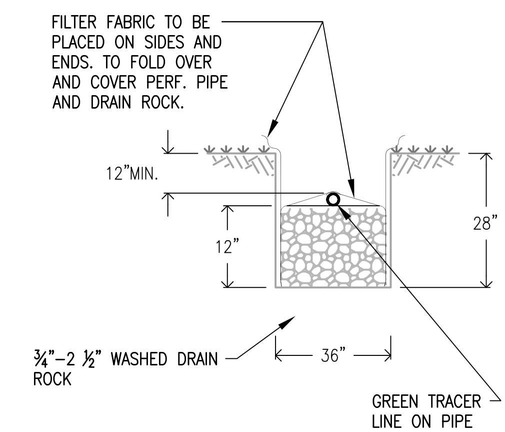


DETAIL A: OPTIONAL TRAPPED SILT BASIN DETAIL



* THE BOTTOM OF THE INLET PIPE MUST NOT BE LOWER THAN THE TOP OF THE OUTLET PIPE.

DETAIL B: SOAKAGE TRENCH CONSTRUCTION



LINE TRENCH SIDES WITH FILTER FABRIC AS SHOWN, ADD 18" OF DRAIN ROCK. PLACE PERF. PIPE AND COVER ALL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Simplified / Presumptive Design Approach -

Soakage Trench

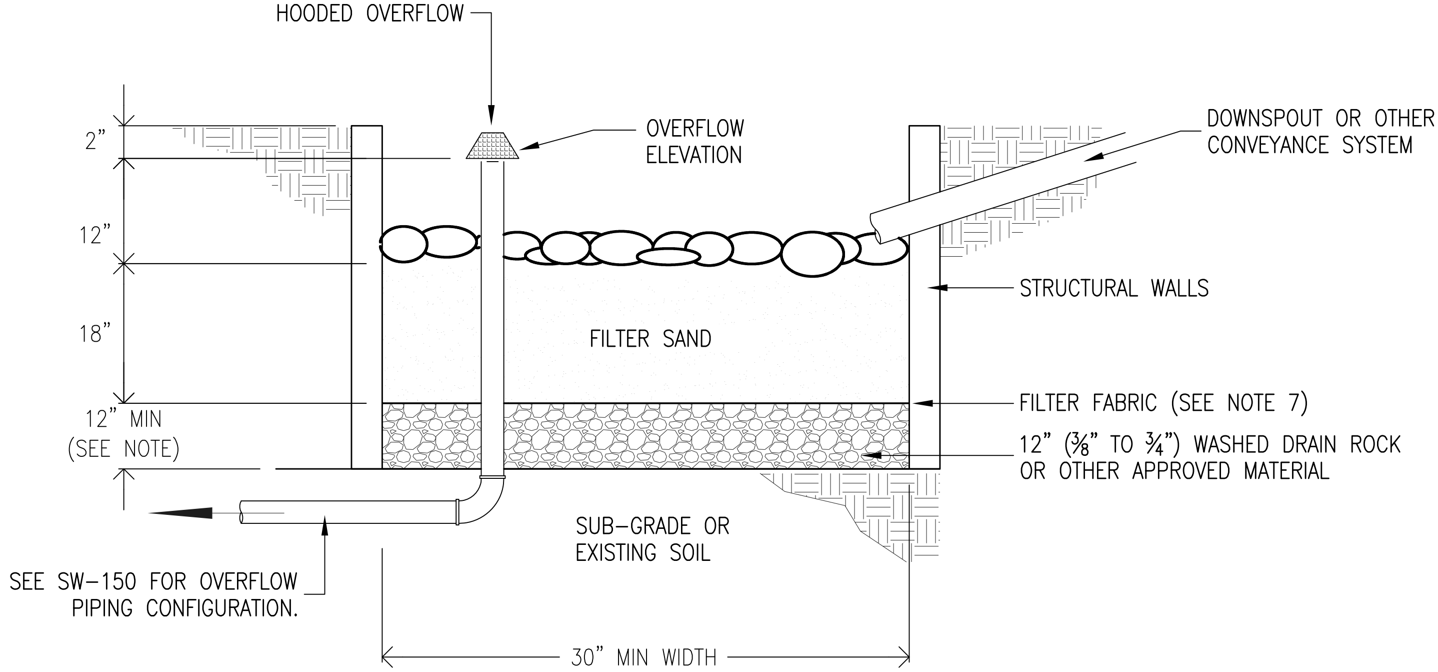
West Side

Bureau of Environmental Services

NUMBER

SW-181

Appendix G.2 Table of Contents



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Dimensions:
   a. Width of sand filter: 18” minimum.
   b. Depth of sand filter (from top of sand to overflow elevation). Simplified: 12”; Presumptive: 6”- 18”.
   c. Slope of sand filter: 0.5% or less.

3. Setbacks (from centerline of facility):
   a. Infiltration sand filters must be 10' from foundations and 5' from property lines.
   b. Flow-through sand filters must be less than 30” in height above surrounding area if within 5 feet of property line.

4. Overflow (where required):
   a. Overflow required for Simplified Approach.
   b. Inlet elevation must allow for 2” of freeboard, minimum.
   c. Protect from debris, sand, and sediment with strainer or grate.

5. Piping: shall be ABS Sch.40, cast iron, or PVS Sch.40. 3” pipe required for up to 1,500 sq ft of impervious area, otherwise 4” min. Piping must have 1% grade and follow the Uniform Plumbing Code.

6. Drain rock (minimum):
   a. Infiltration sand filter: 12” of 1½” - ¾” washed.
   b. Flow-through sand filter: 8” of ¾” washed.

7. Separation between drain rock and sand:
   Use filter fabric (see SWMM Section 2.3.1 Geotextile table) or a gravel lens (¾ - ¼ inch washed, crushed rock 2 to 3 inches deep).

8. Filter sand:
   a. 18” minimum.
   b. See sand spec in SWMM Exhibit 2-4.

9. Sand filter walls:
   a. Material shall be stone, brick, concrete, wood, or other durable material (no chemically treated wood).
   b. Concrete, brick, or stone walls shall be included on foundation plans.

10. Waterproof liner: Shall be 30 mil PVC or equivalent, for flow-through facilities.

11. Install washed pea gravel or river rock to transition from inlet or splash pad to growing medium.

12. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

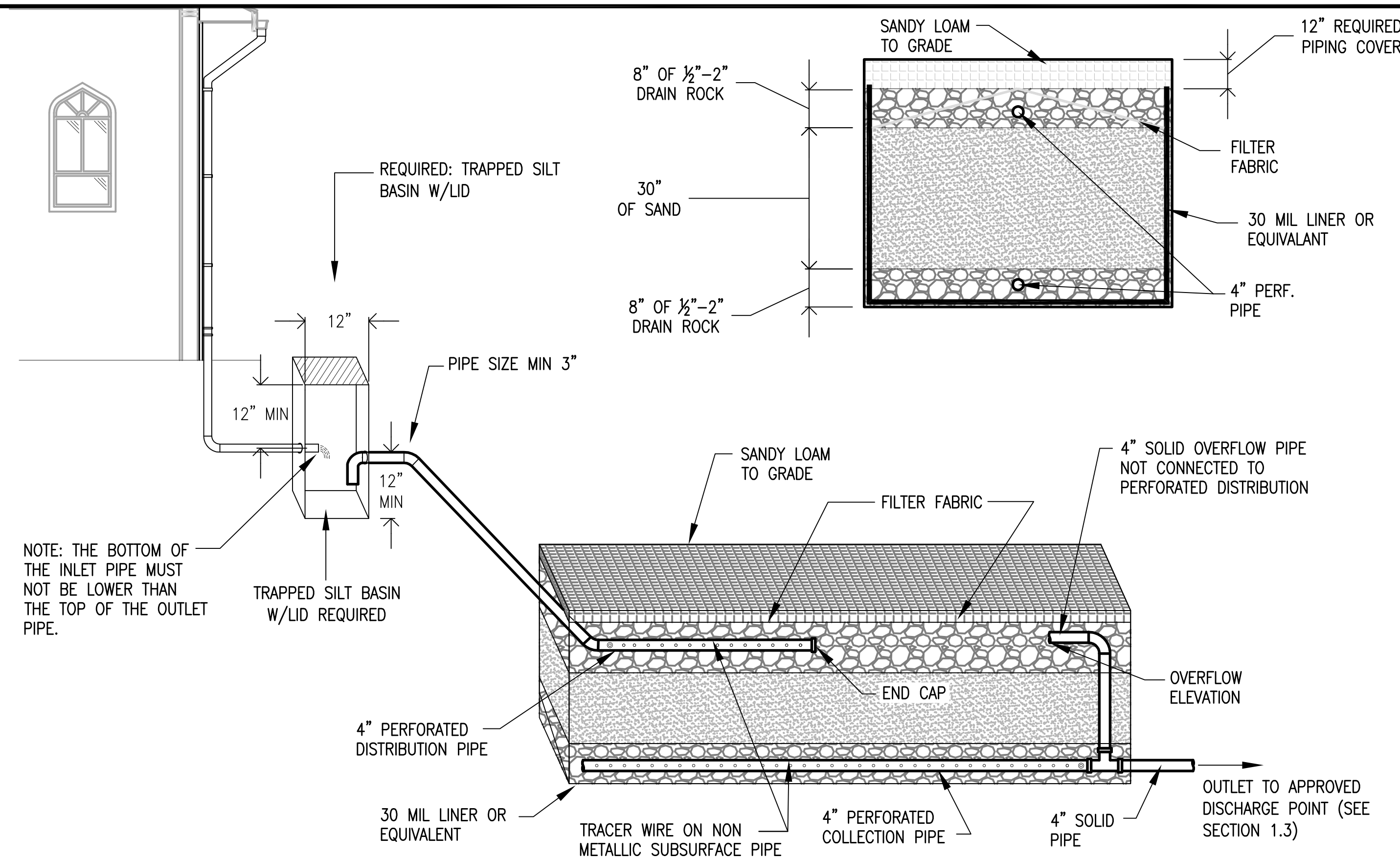
Sand Filter

Infiltration

NUMBER

SW-220

Bureau of Environmental Services



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to and during construction.

2. Dimensions:
   a. Height of subsurface sandfilter: 46" from base.
   b. Depth of excavation: 58" Min. (to accommodate 12" of cover).

3. Setbacks (from centerline of facility):
   a. Infiltration facilities must be 10' from foundations and 5' from property lines.
   b. Flow-through facilities may be within 10' of foundation and within 5' of property line if properly lined.

4. Trapped silt basin required prior to inlet to subsurface sand filter.

5. Overflow: perforated collection pipe within top gravel layer connected to approved discharge point according to Section 1.3

6. Piping shall be ABS SCH40, cast iron, or PVC SCH40. 3" pipe must be used for up to 1500sf of impervious area, otherwise 4" minimum. Piping must have 1% grade and must follow current Uniform Plumbing Code.
   a. Underdrain piping system shall consist of minimum 4" diameter collector manifold with perforated lateral branch lines.
   b. Underdrain laterals shall be placed with minimum 1% positive gravity drainage to the collector manifold.
   c. The collector manifold shall have a minimum 1% grade toward the discharge joint.
   d. Lateral spacing of collection or distribution pipes shall not exceed 10'.
   e. All laterals and collector manifolds shall have cleanouts installed, accessible from the surface without removing or disturbing filter media.
   f. Outlet to approved discharge point shall be protected from soil, gravel, or sand displacement with filter fabric or equivalent.

7. Drain rock and sand depth:
   a. 8" of ¾" washed drain rock as base.
   b. 30" of washed sand (See sand spec in SWMM Section 2.3.3).
   c. 8" top layer of ¾" washed drain rock over sand.

8. Separation between drain rock and sand:
   Use filter fabric (see SWMM Exhibit 2-4 Geotextile table) or a gravel lens (¾ - ¼ inch washed, crushed rock 2 to 3 inches deep).

9. Waterproof liner: Shall be 30 mil PVC or equivalent for flow-through facilities.

10. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, for appropriate inspections.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

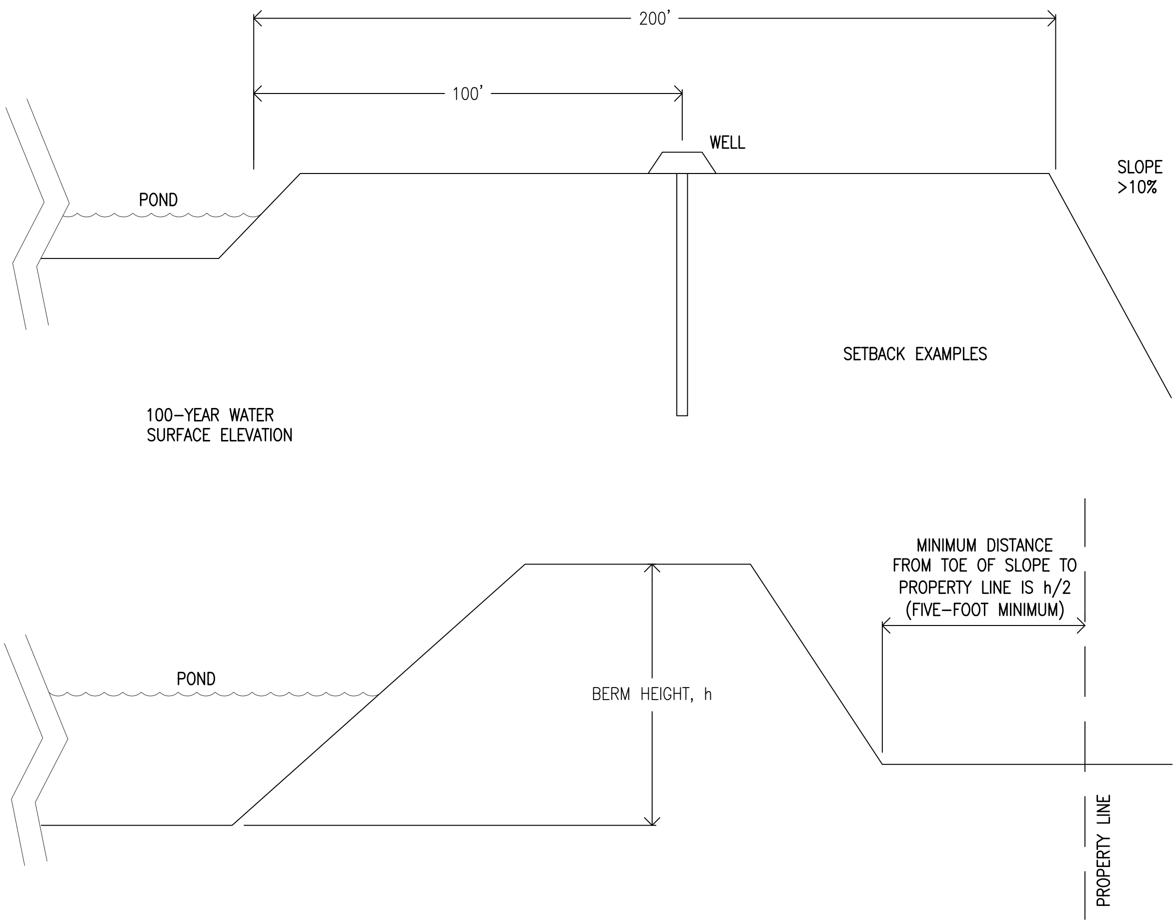
- Performance Approach -

Subsurface Sand Filter

NUMBER

SW-221

Bureau of Environmental Services



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

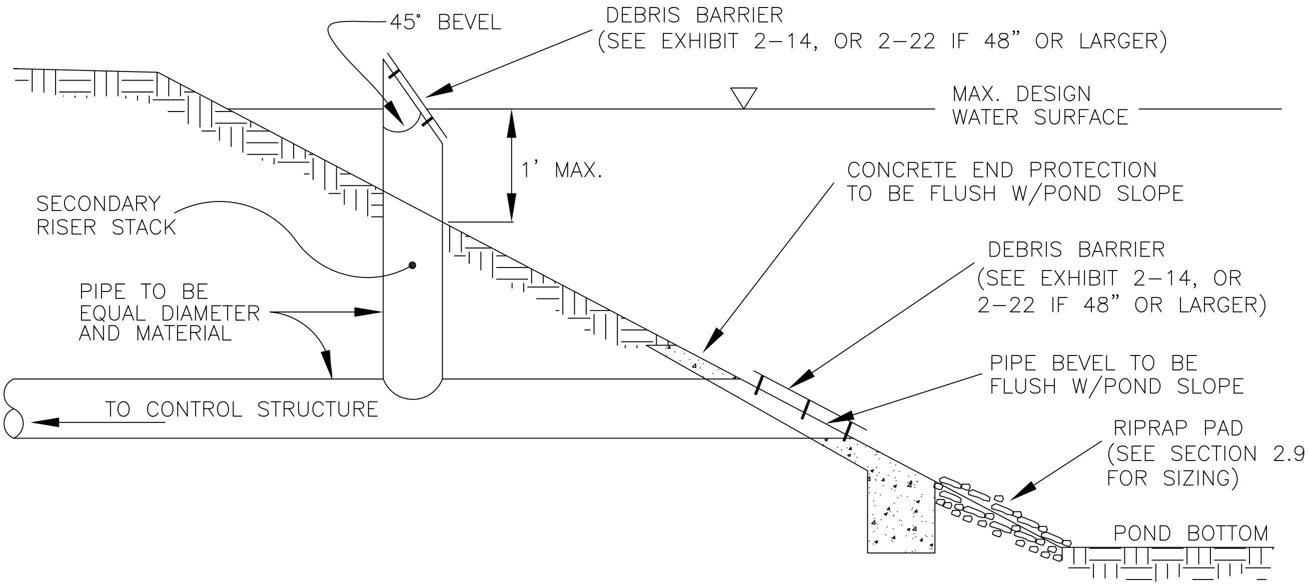
Pond

Setback Details

Bureau of Environmental Services

NUMBER

SW-230



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

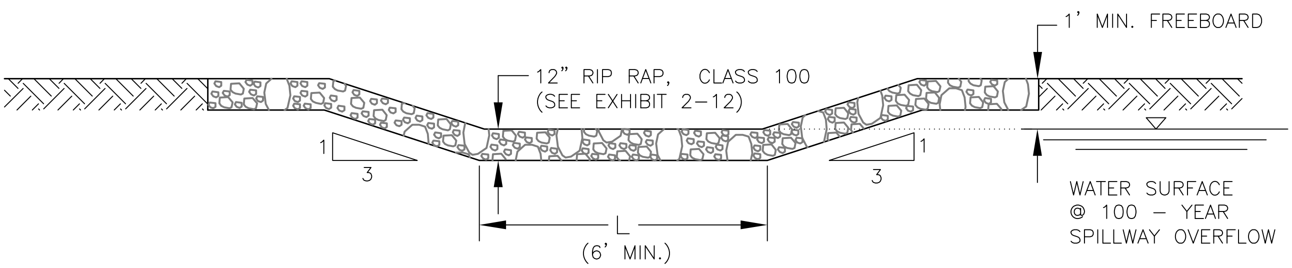
Pond

Secondary Riser Stack

Bureau of Environmental Services

NUMBER

SW-231



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

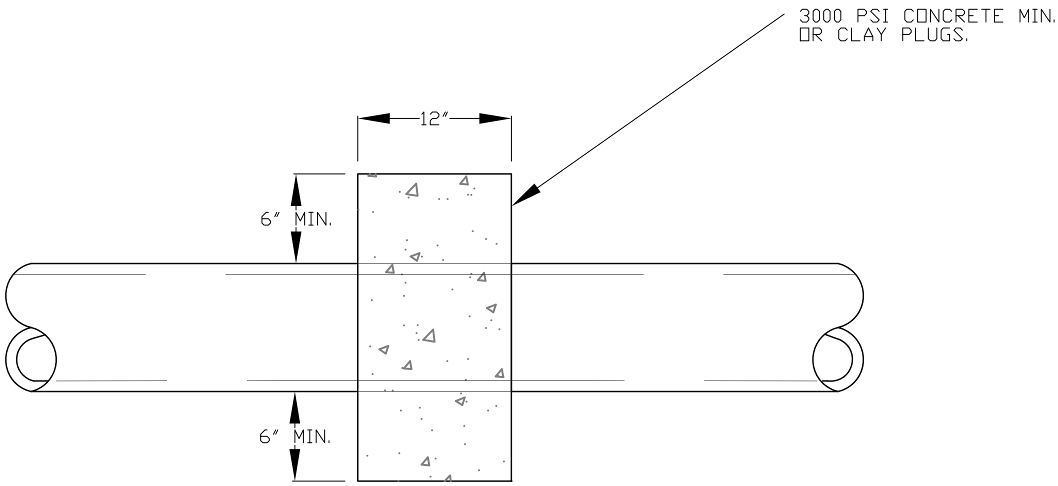
Pond

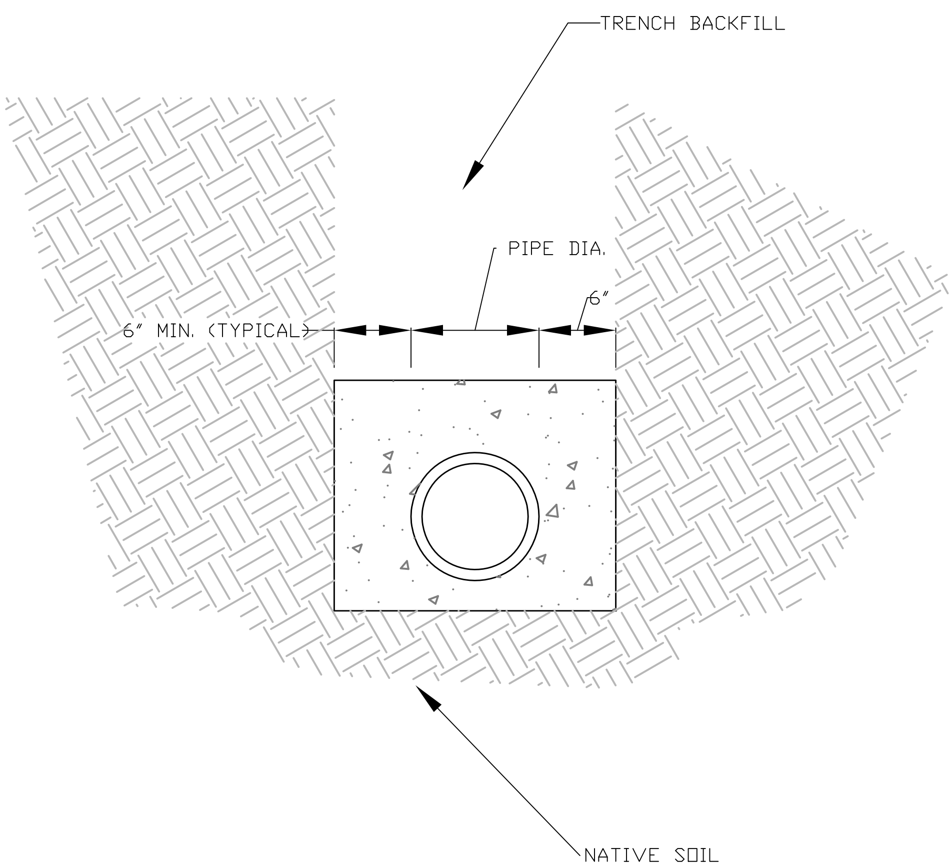
Emergency Overflow Spillway Weir

Bureau of Environmental Services

NUMBER

SW-232





- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

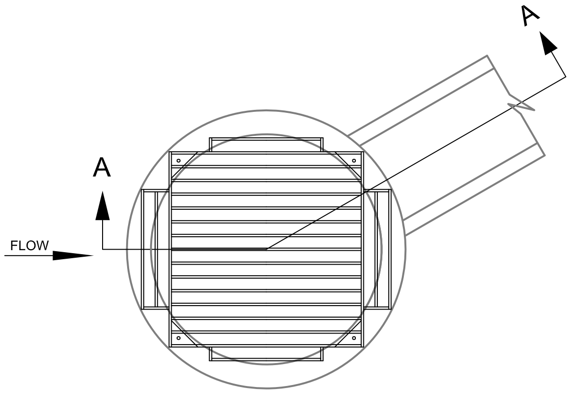
Pond

Inlet/Outlet Anti-Seepage Collar

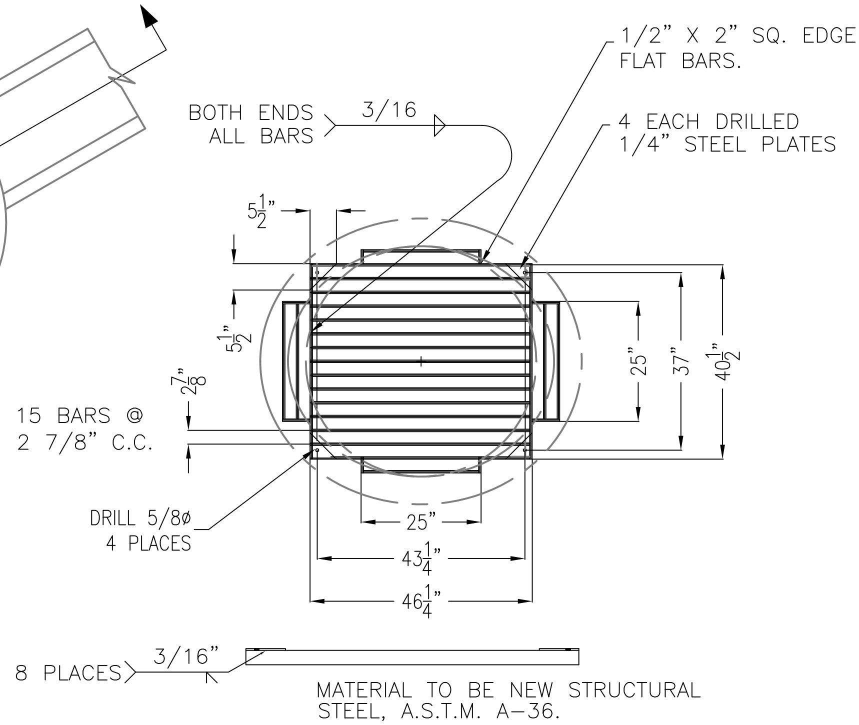
NUMBER

SW-233

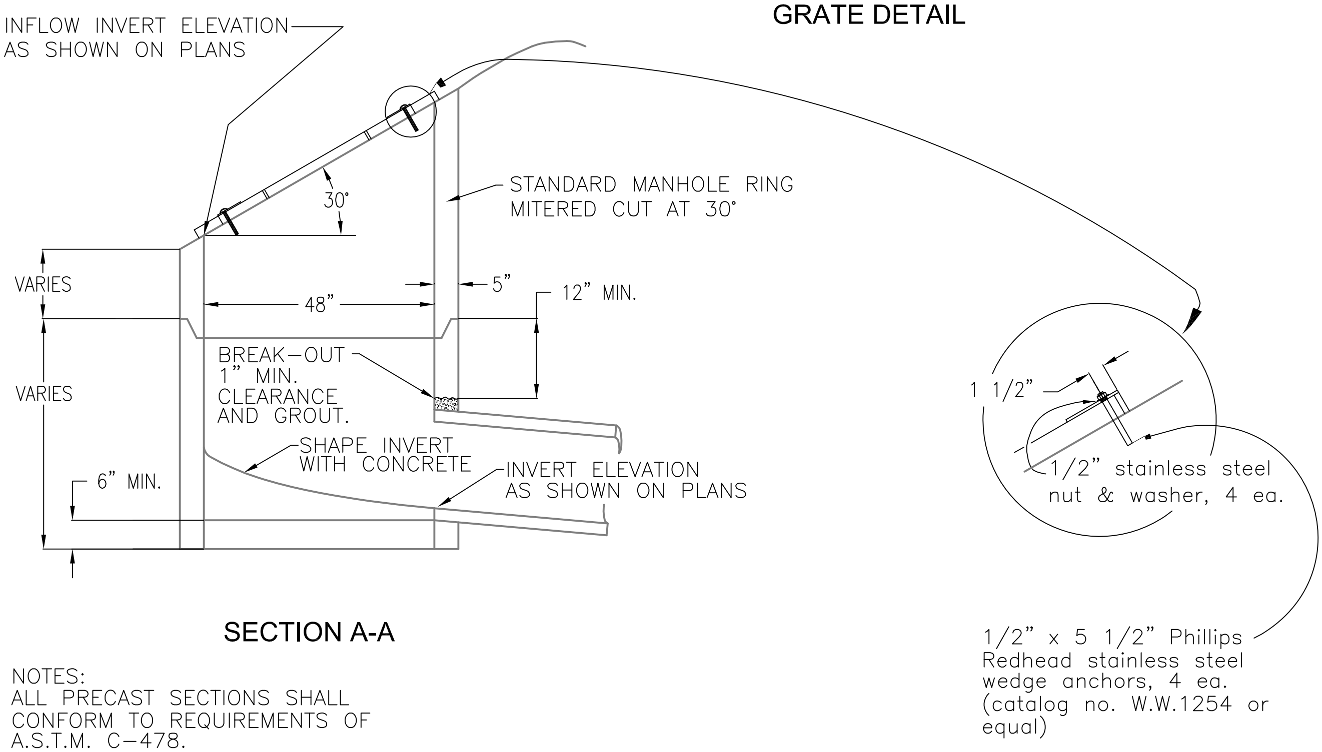
Bureau of Environmental Services



PLAN VIEW



GRATE DETAIL



SECTION A-A

NOTES:
ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF A.S.T.M. C-478.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

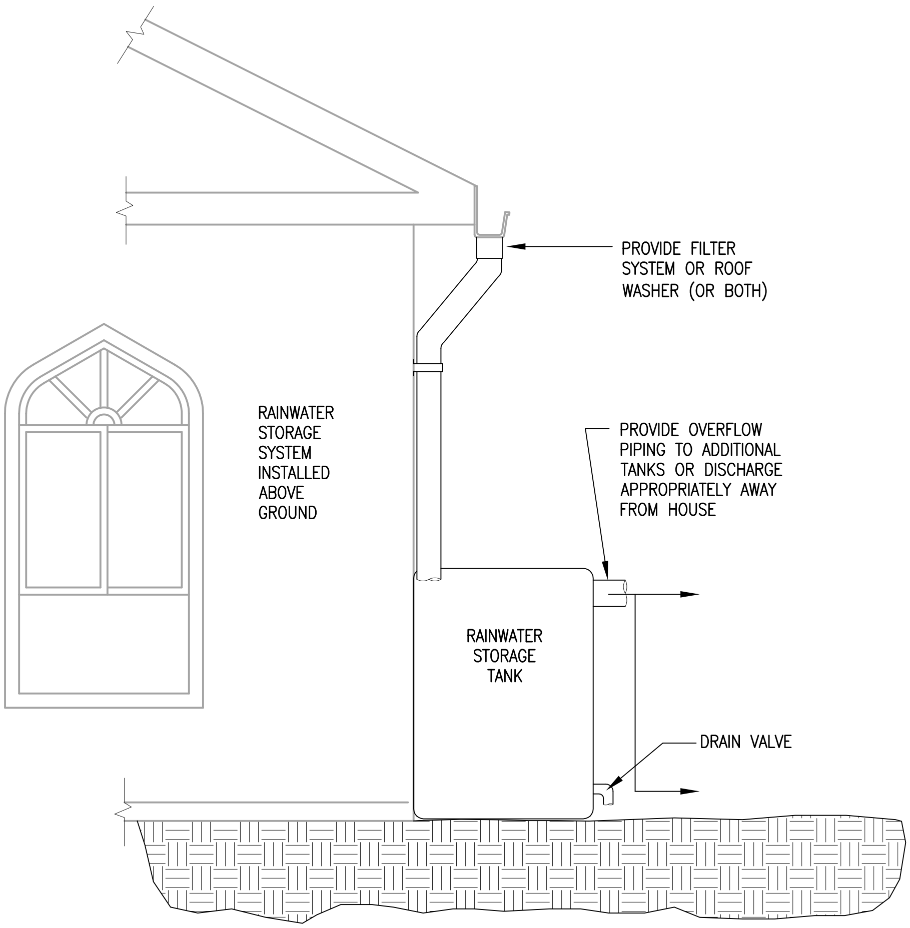
Pond

Inflow Riser Manhole w/ Grate Cover

NUMBER

SW-234

Bureau of Environmental Services



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STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

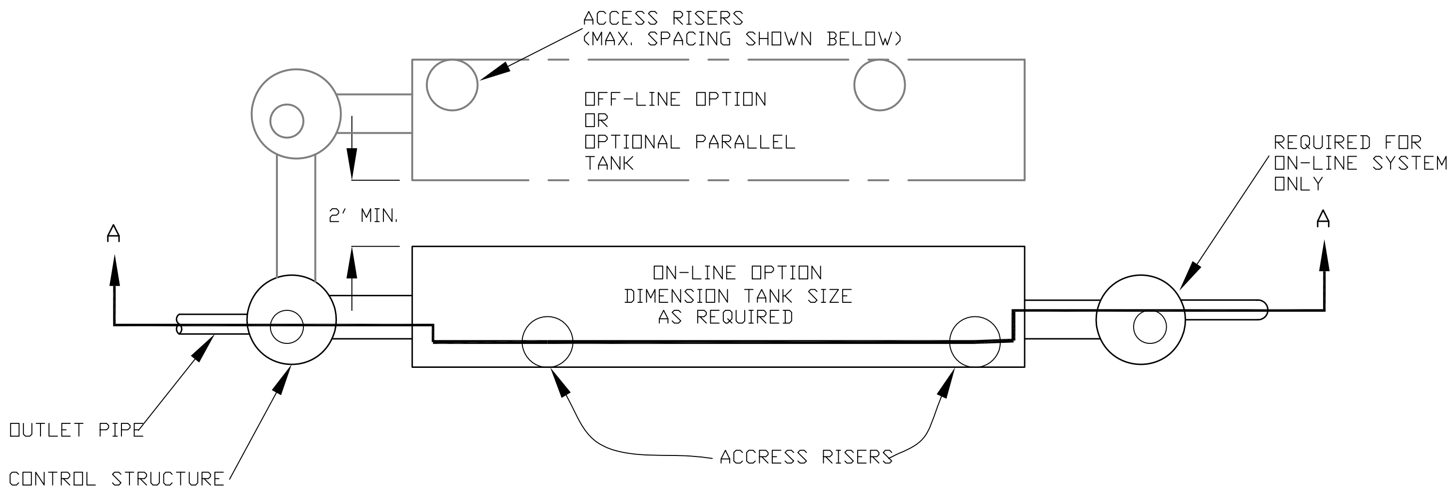
- Performance Design Approach -

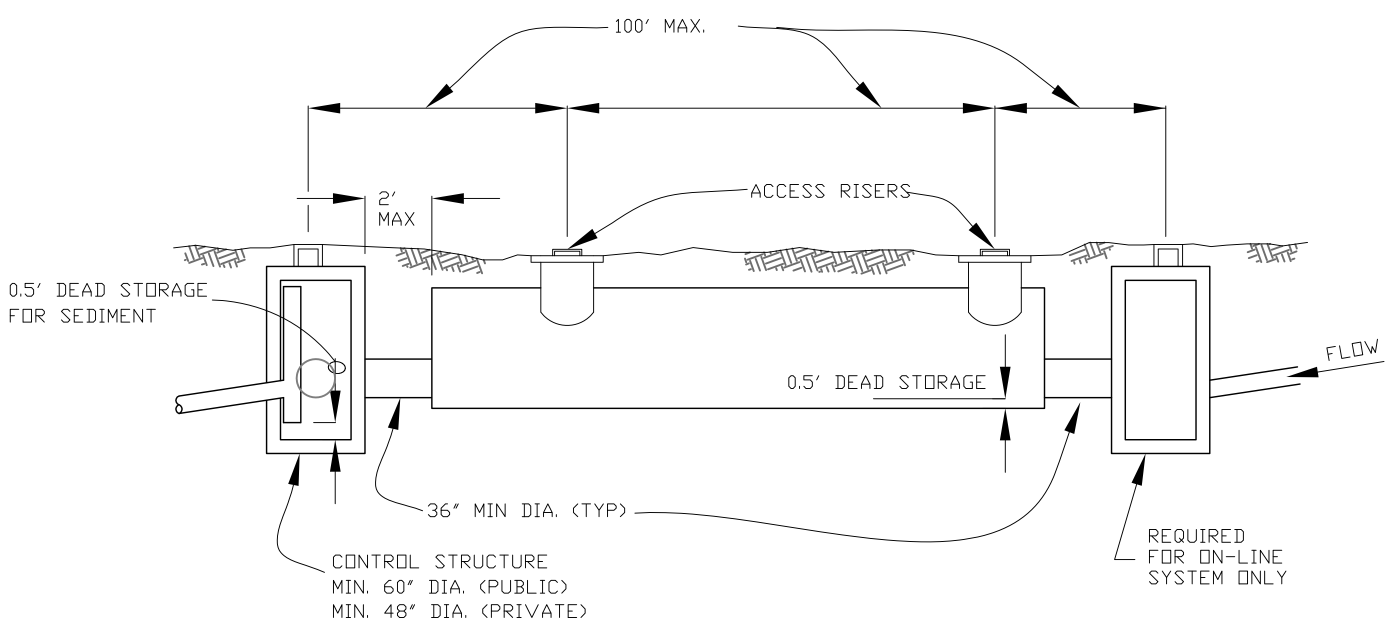
Rainwater Harvesting

Bureau of Environmental Services

NUMBER

SW-250





- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

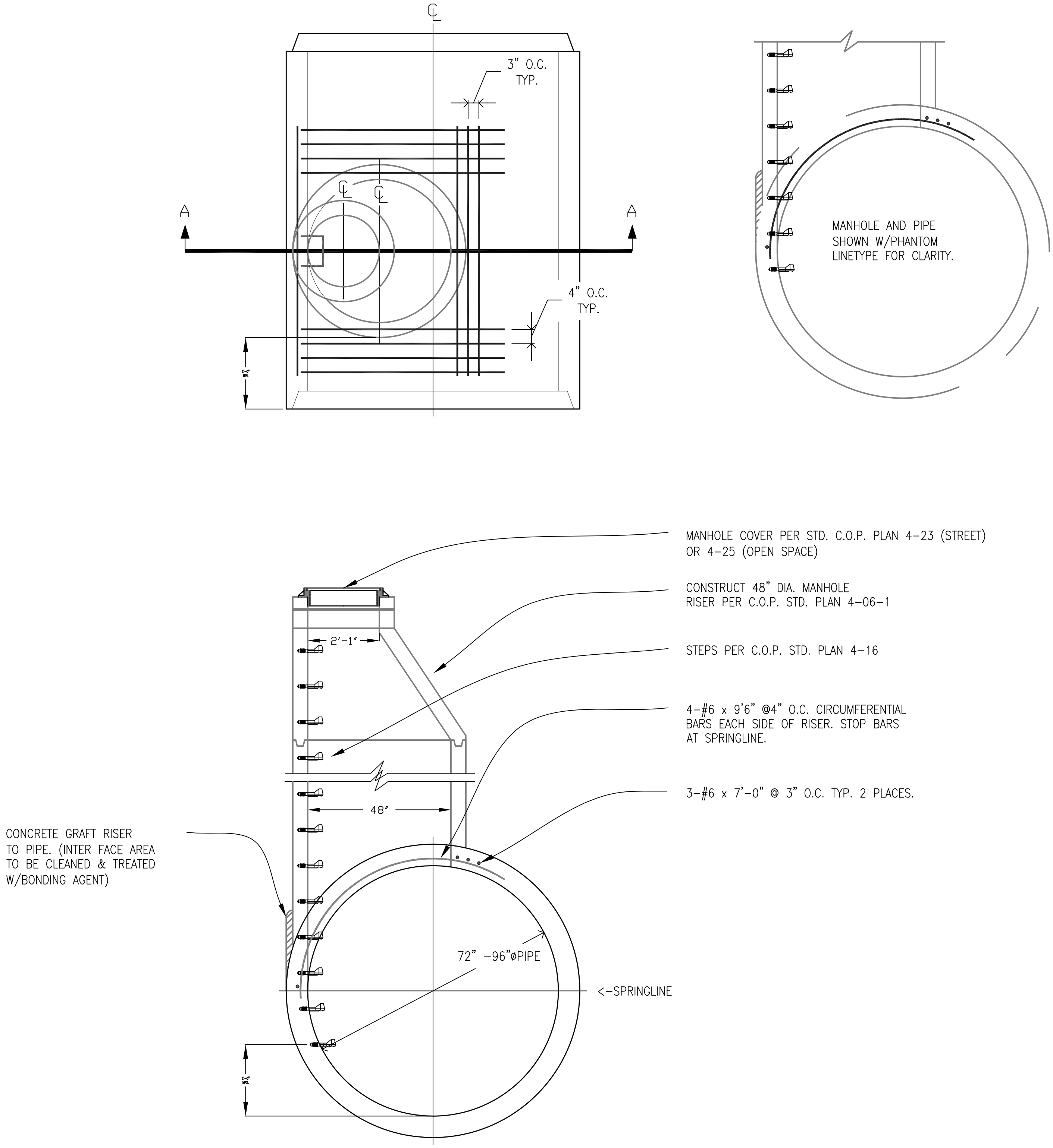
- Performance Approach -

Detention Tank

NUMBER

SW-260

Bureau of Environmental Services



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STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

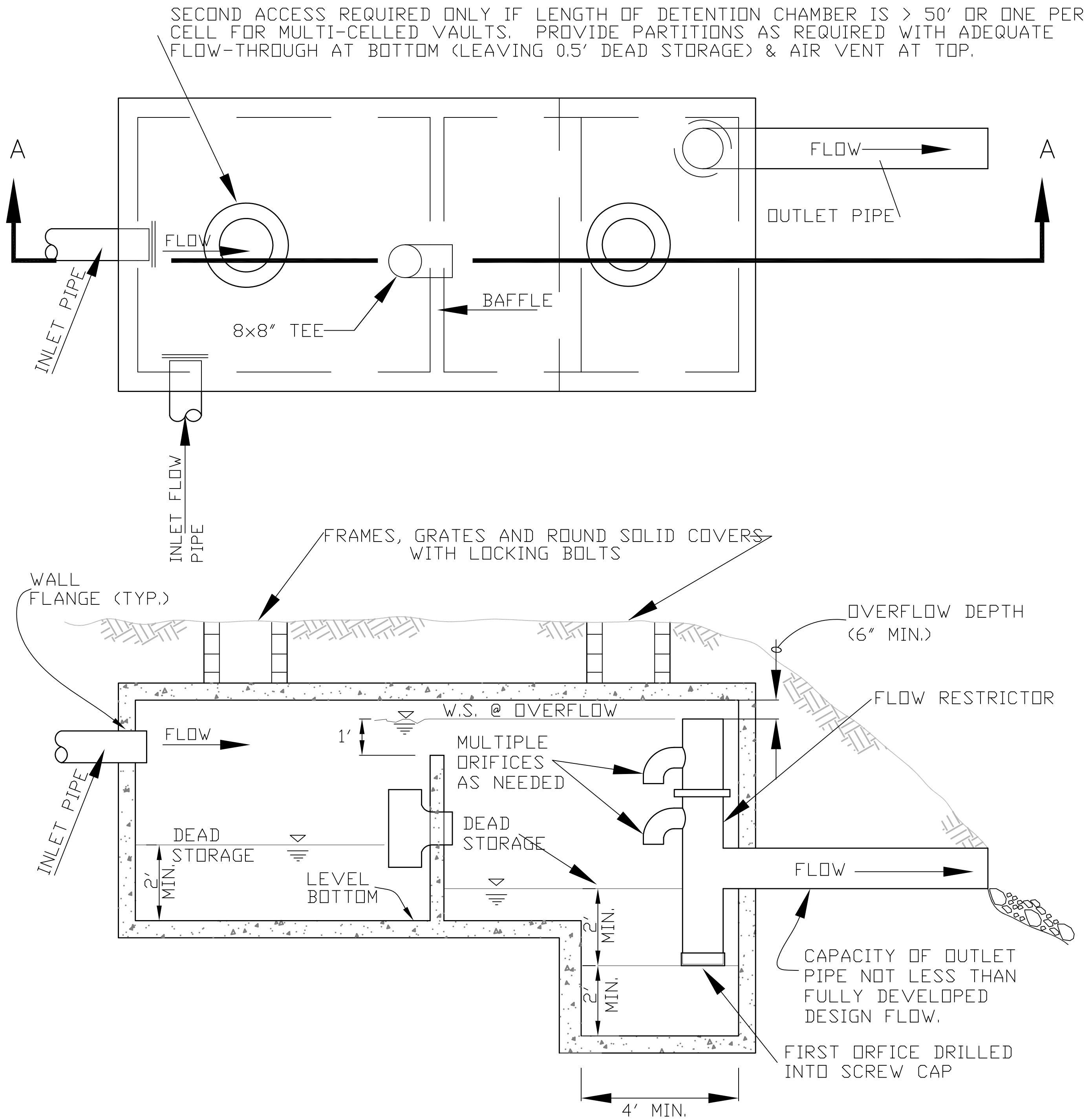
- Performance Approach -

Access Riser

NUMBER

SW-261

Bureau of Environmental Services



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

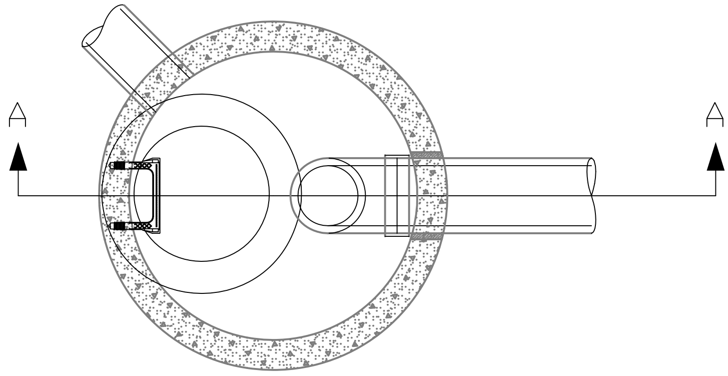
- Performance Approach -

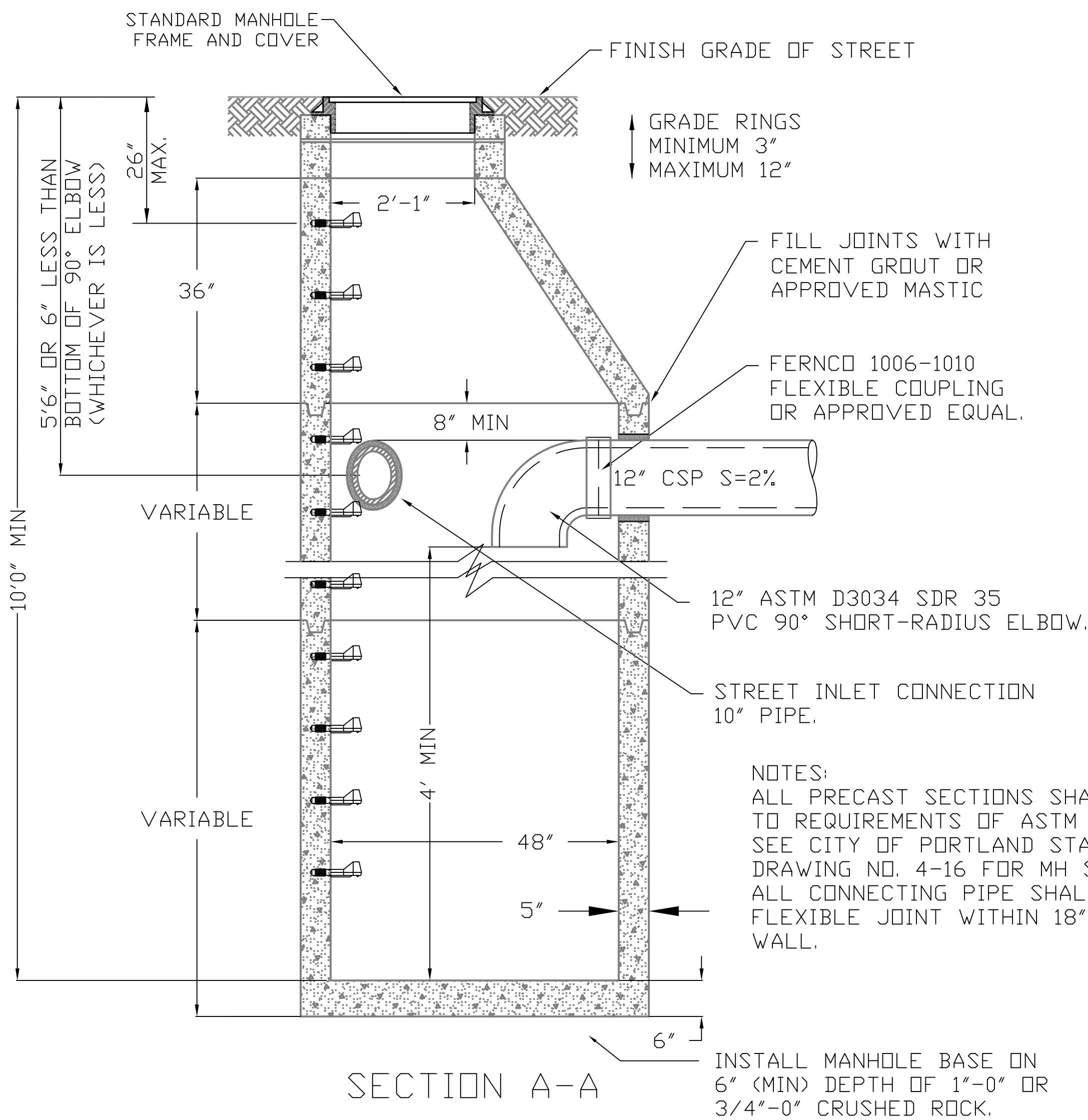
Detention Vault

NUMBER

SW-262

Bureau of Environmental Services





NOTES:
ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF ASTM C-478.
SEE CITY OF PORTLAND STANDARD DRAWING NO. 4-16 FOR MH STEP DETAIL.
ALL CONNECTING PIPE SHALL HAVE A FLEXIBLE JOINT WITHIN 18" OF MANHOLE WALL.

SECTION A-A

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

Orifice Location Tee Riser

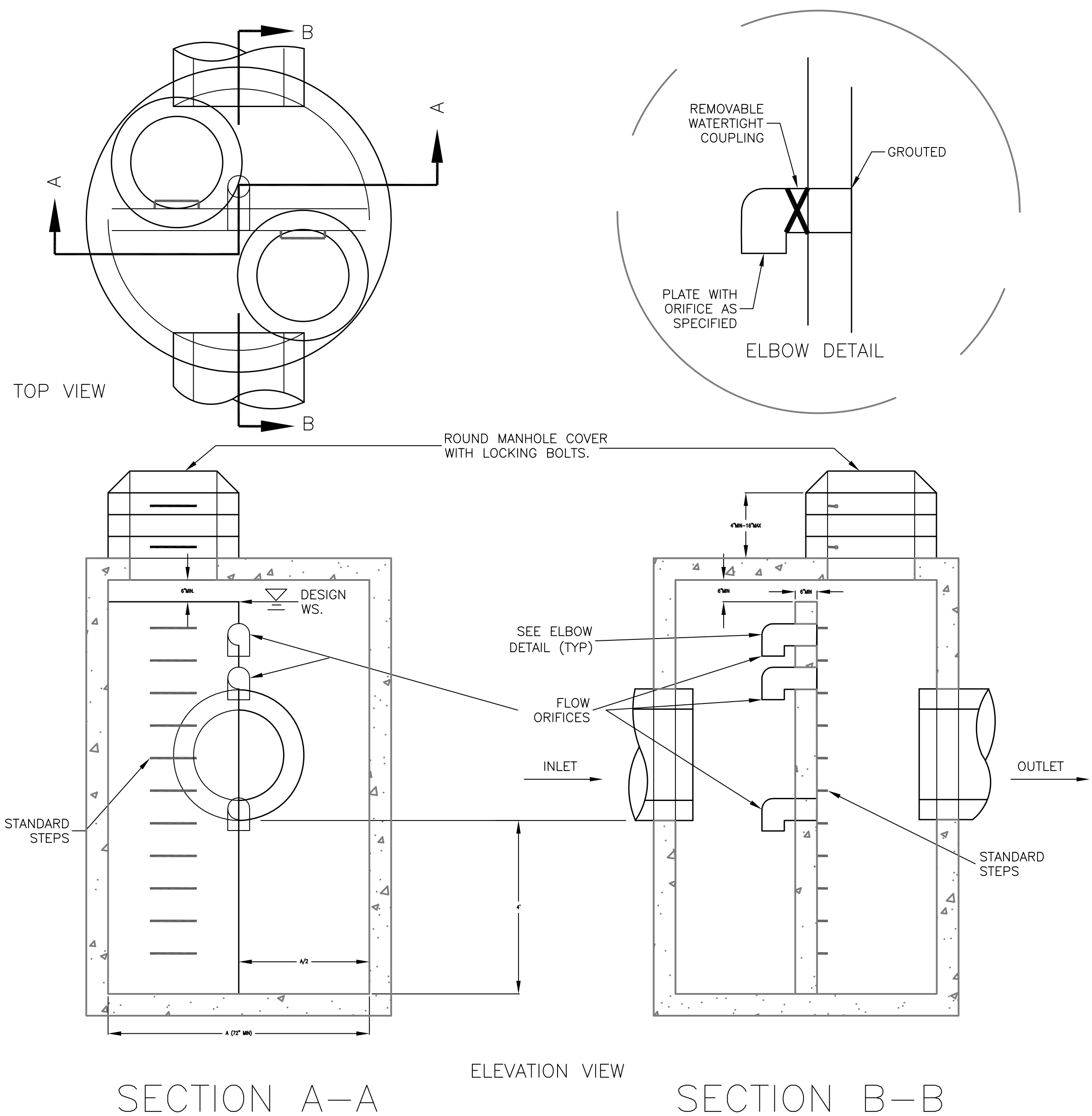
NUMBER

SW-263

Bureau of Environmental Services

NOTES

1. EXCEPT AS SHOWN OR NOTED, UNIT SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGE PRE CAST CONCRETE MANHOLES. SEE C.O.P. STANDARD PLAN No. 4-08-1. 72", 84" & 96" DIAMETER.
2. FOR DETAILS SHOWING GRADE RINGS, STEPS, AND TOP SLABS, ALSO SEE STANDARD PLAN No. 4-08-1.
3. SEE PROJECT PLANS FOR SIZE AND LOCATION OF ORIFICES.
4. PIPE SIZES, SLOPES AND ALL ELEVATIONS AS SHOWN IN THE PLANS.
5. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
6. PRE CAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
7. ORIFICE PLATES TO BE 1/4" THICK MIN. HDPE OR APPROVED EQUAL AND ATTACHED WITH 1/2" STAINLESS STEEL BOLTS.



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

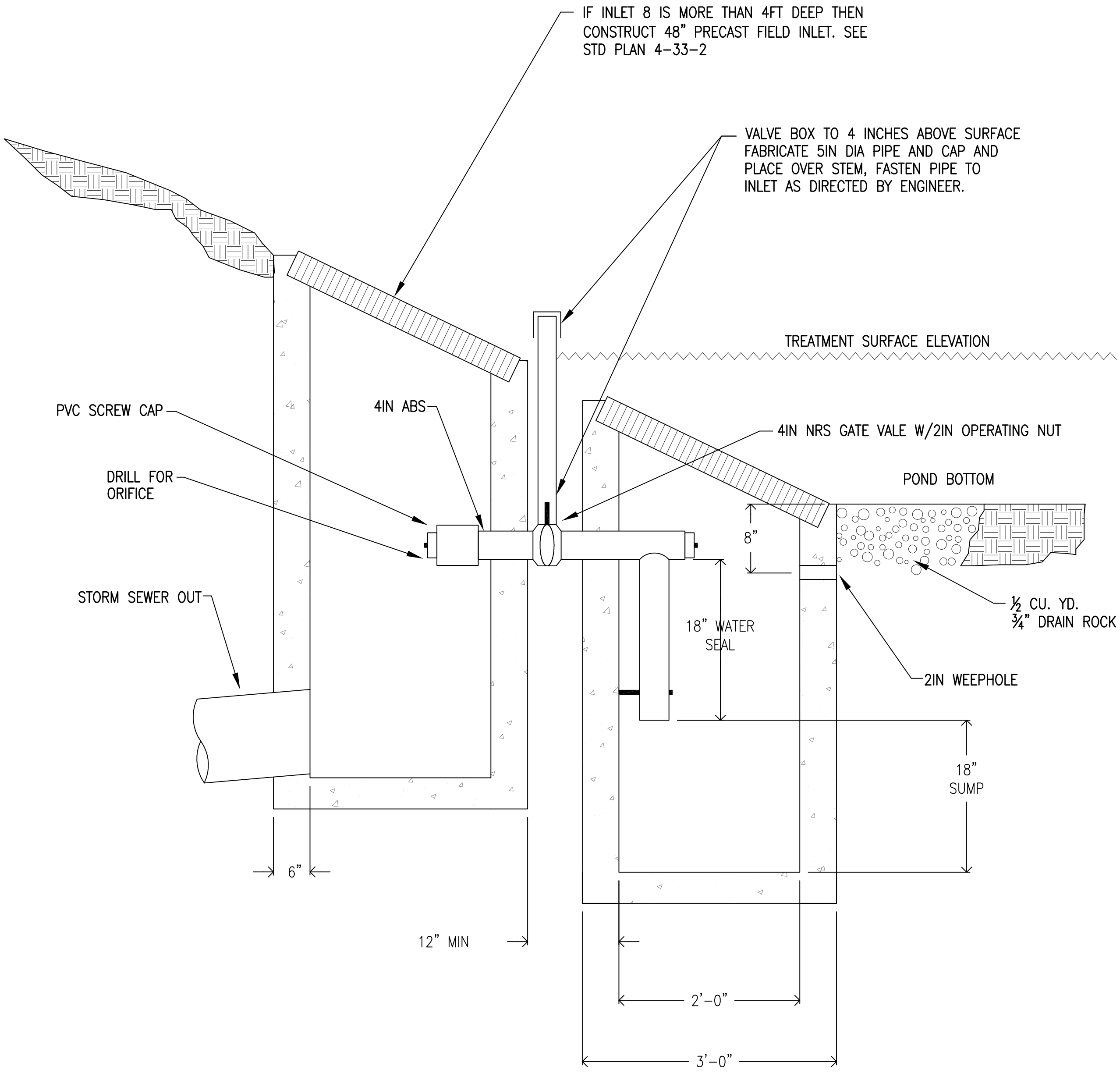
- Performance Approach -

Orifice Location Baffle Riser

NUMBER

SW-264

Bureau of Environmental Services



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Performance Approach -

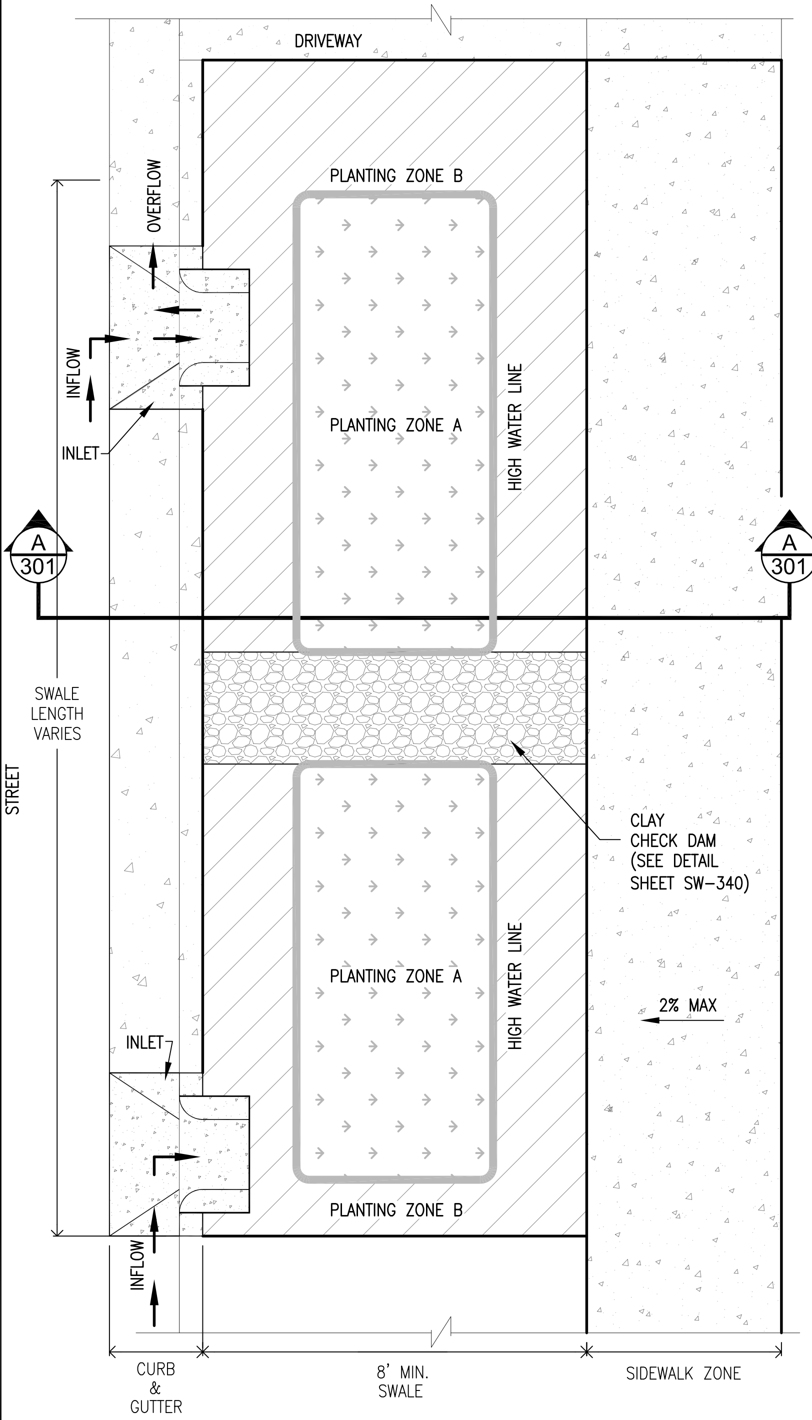
Orifice Structure

NUMBER

SW-265

Bureau of Environmental Services

Appendix G.3 Table of Contents



PLAN

FOR SECTIONS REFER TO SW-301

NOTES:

1. See City of Portland 2007 Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of swale: 8' minimum from inside curbs. Depth of swale: 6" minimum from inlet at gutter elevation to bottom of swale (see SW-301).
3. Longitudinal slope of swale: matches road. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for swales designed to include discharge.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. See sheets SW-330, 331, and 332 for inlet details.
8. Check dams required: See sheet SW-340 for details.
9. See Appendix F.3 for Growing Medium requirements.
10. Special requirements for water lines, meters, and fire hydrants: See sheet SW-302 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Roadway Drawing RD700 with thickened 12" gutter. Use 1'-6" wide gutter, typical.
13. Install washed pea gravel or river rock to transition from splash pad to topsoil.
14. See Landscape Templates SW-410 through SW-412 and Plant List in SWMM Appendix F.4.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Office of Transportation, Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:

PDOT (503) 823-7884
BES (503) 823-7651
PWB (503) 823-7368
Urban Forestry (503) 823-4025

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

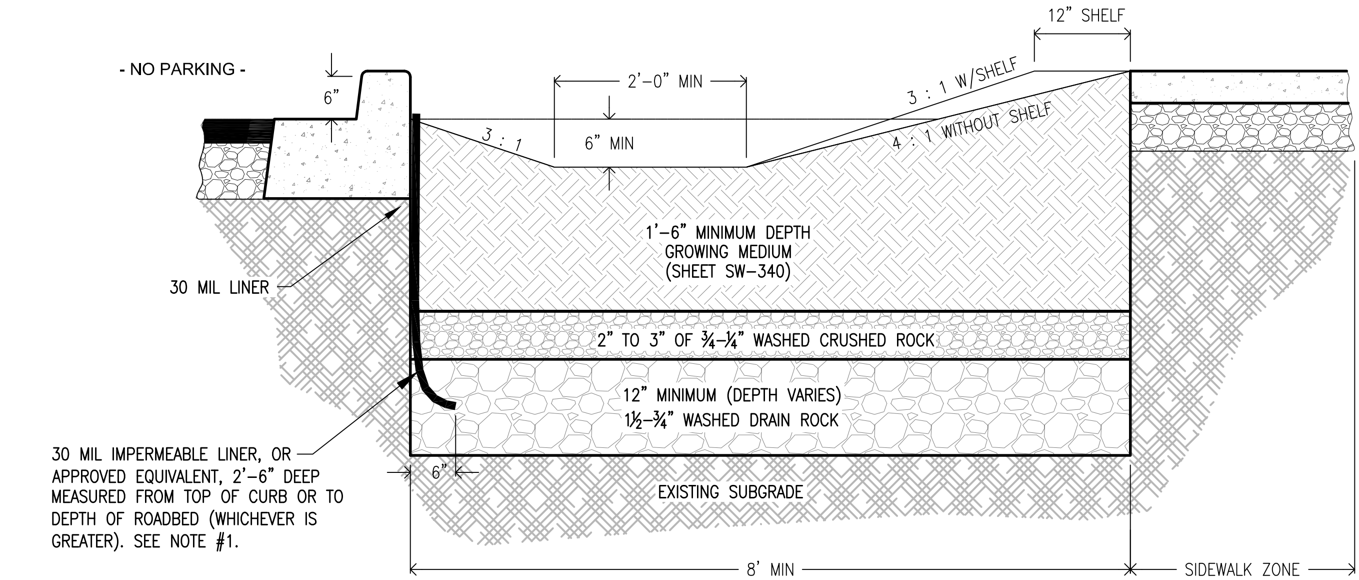
- Green Streets -

Swale Plan

NUMBER

SW-300

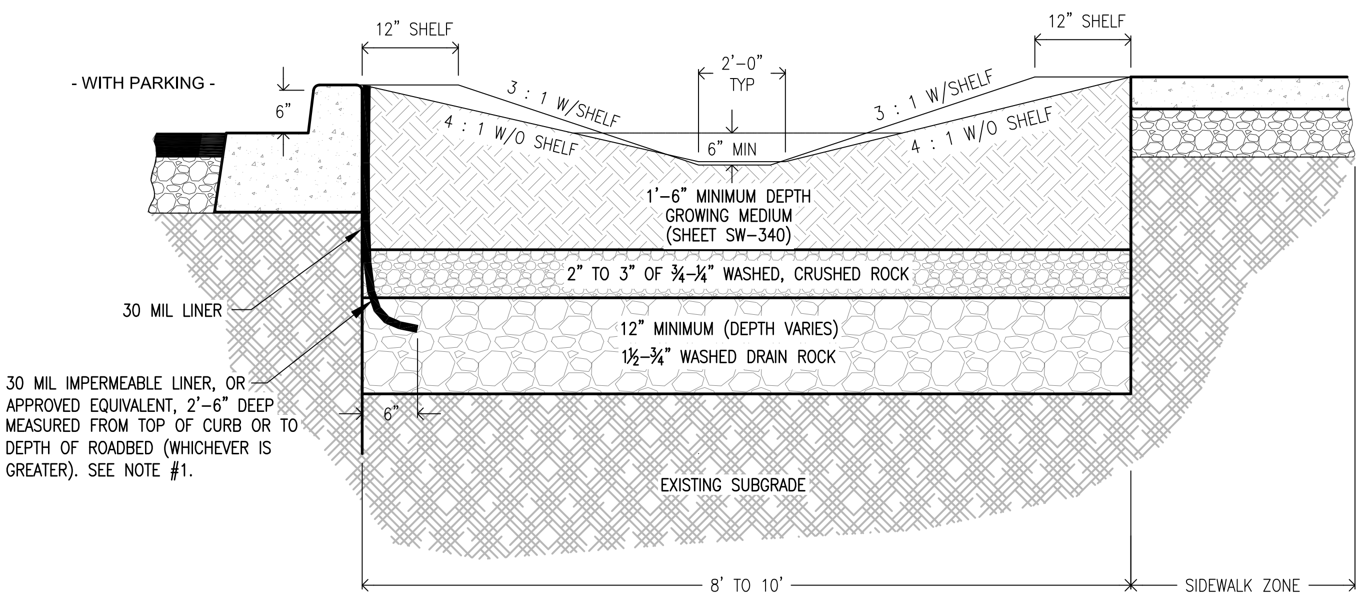
Bureau of Environmental Services



SECTION A-A
SWALE WITHOUT PARKING

NOTE:

1. Liner required when face of new curb is < 2ft from adjacent water line or on neighborhood collectors and higher street classifications. Liner may be required on local streets with transit routes, higher traffic volumes, or when facility is adjacent to travel lane, at the discretion of the City Engineer.



SECTION A-A
SWALE WITH PARKING

FOR PLAN VIEW
REFER TO SW-300

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

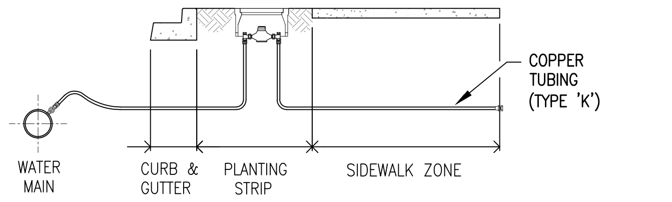
Swale Sections

With and without Parking

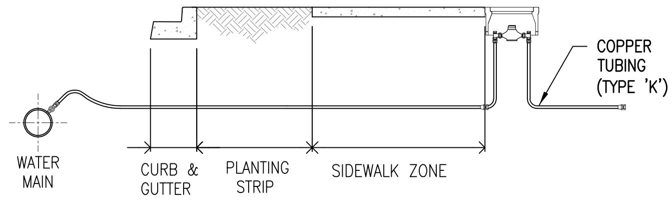
NUMBER

SW-301

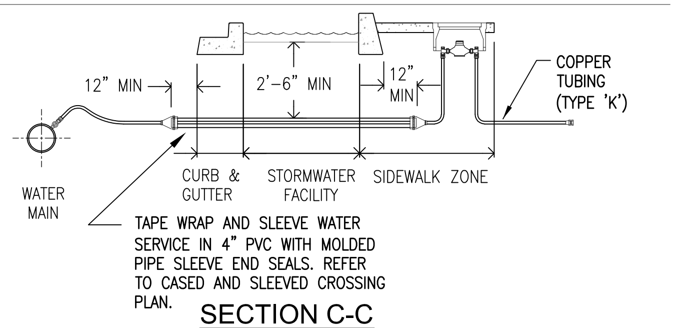
Bureau of Environmental Services



SECTION A-A



SECTION B-B



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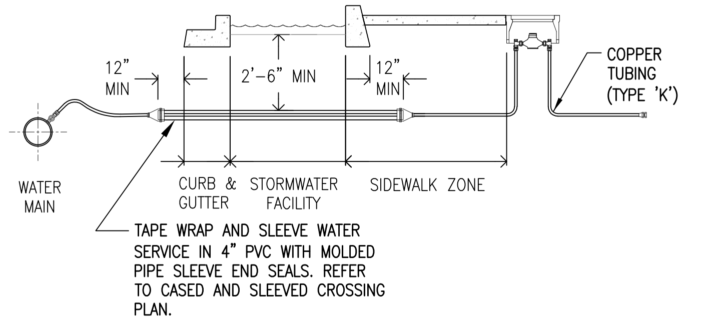

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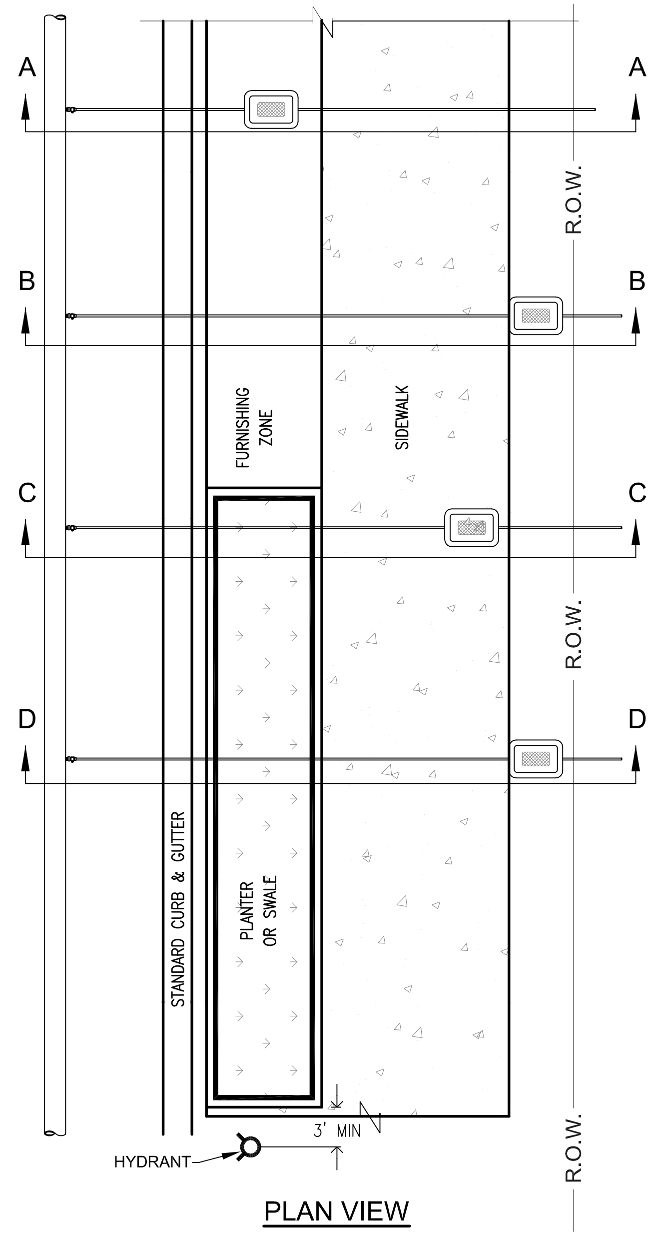


PLAN VIEW

NOTES:

1. Refer to fire hydrant installation plan. Hydrants must have min 3' clearance from the edge of stormwater facility.

2. Standard meter location is A or D. Option B or D can be used only if the meter box is fully within the Right-of-Way. Option C can only be used where the meter box cannot be placed behind the sidewalk, within the Right-of-Way.

3. Refer to small service installation plan. For larger services or other appurtenances, contact PWB development services @ 503 823-7368. Water service line must be 2'-6" min below lowest point of ground surface of stormwater facility, typical.

4. If watermain is under or behind proposed curb the watermain must be relocated, unless otherwise approved by PWB.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

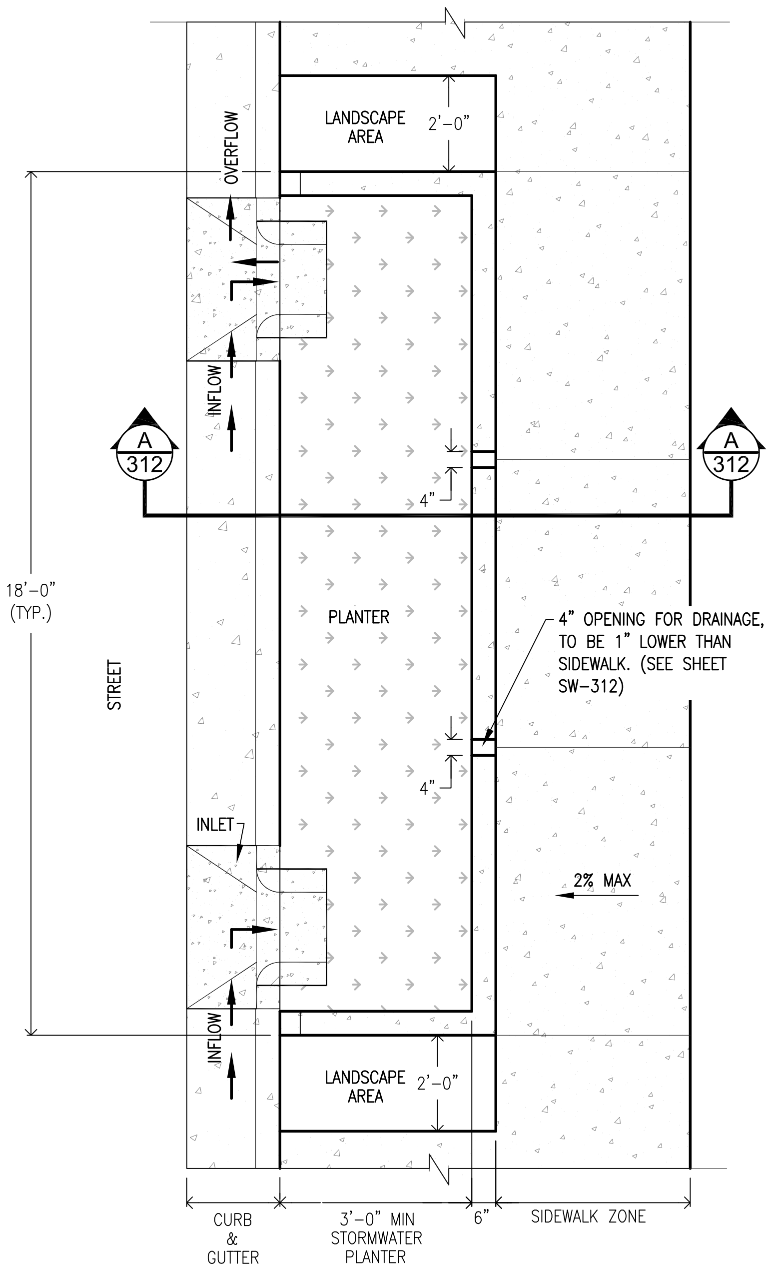
Swale

Meter & Hydrant Locations

Bureau of Environmental Services

NUMBER

SW-302



FOR SECTIONS REFER TO SW-312

PLANTER PLAN

NOTES:

1. See 2007 City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of planter: 3' minimum from inside curbs Length of planter based on engineering calculations: 18' typical, 12' minimum. Depth of planter:12" max from top of street curb to top of soil.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for planters designed to include discharge.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. See sheets SW-330, 331, and 332 for inlet details.
8. Check dams may be required: See sheet SW-340 for details.
9. See Appendix F.3 for Growing Medium requirements.
10. Special requirements for water lines, meters, and fire hydrants: See sheet SW-310 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Roadway Drawing RD700 with thickened 12" gutter. Use 1'-6" wide gutter.
14. Install washed pea gravel or river rock to transition from splash pad to topsoil.
15. See Landscape Templates SW-410 through SW-412 and Plant List in SWMM Appendix F.4.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Office of Transportation, Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:

PDOT (503) 823-7884 | BES (503) 823-7651
PWB (503) 823-7368 | Urban Forestry (503) 823-4025

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

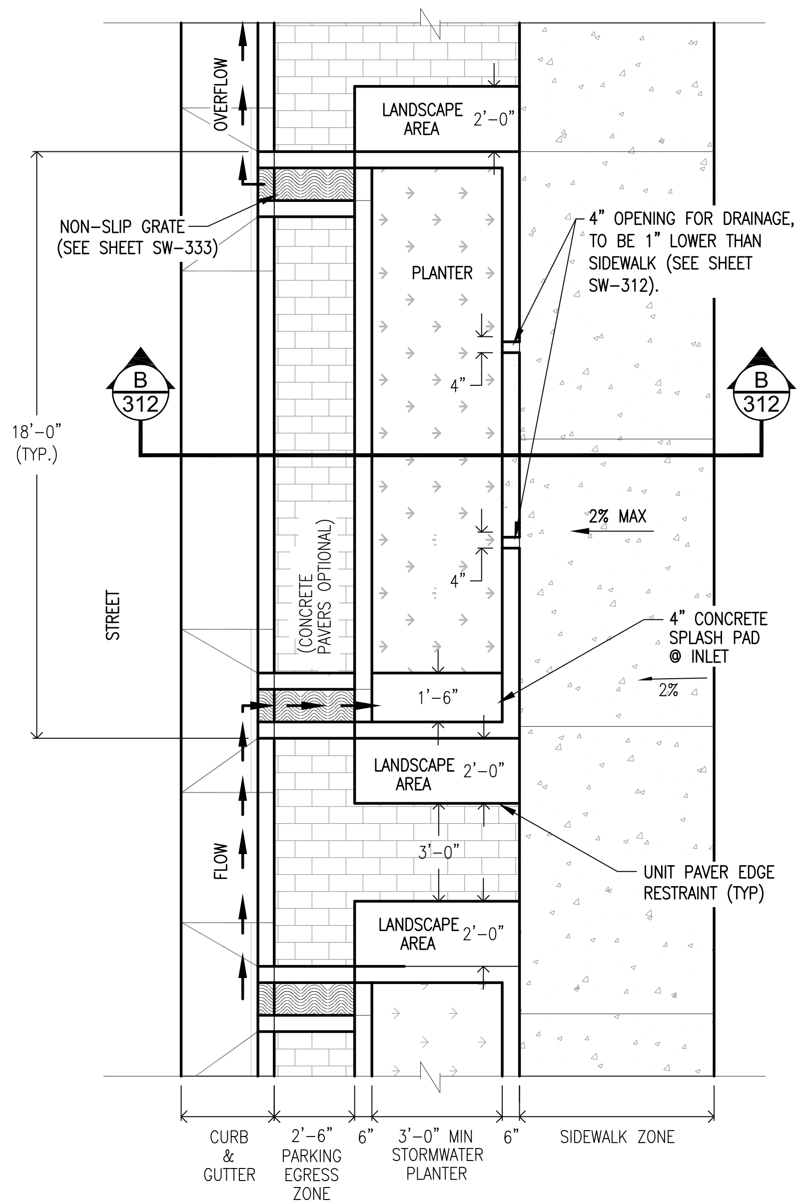
Planter Plan

Without Parking

Bureau of Environmental Services

NUMBER

SW-310



FOR SECTIONS REFER TO SW–312

PLANTER PLAN

- DRAWING NOT TO SCALE -

NOTES:

1. See 2007 City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of planter: 3' minimum from inside curbs. Length of planter based on engineering calculations: 18' typical, 12' minimum. Depth of planter: 12" max from top of street curb to top of soil.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for planters designed to include discharge.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. See sheets SW-330, 331, and 332 for inlet details.
8. Check dams may be required: See sheet SW-340for details.
9. Special soil and planting requirements: See sheets SW-340 and SW-400 for details.
10. Special requirements for water lines, meters, and fire hydrants: See sheet SW-313 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Roadway Drawing RD700 with thickened 12" gutter. Use 1'-6" wide gutter.
13. Install washed pea gravel or river rock to transition from splash pad to topsoil.
14. See GreenStreet Planting details SW-420 through SW-422.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

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For more information contact:

PDOT (503) 823-7884 | BES (503) 823-7651
PWB (503) 823-7368 | Urban Forestry (503) 823-4025

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

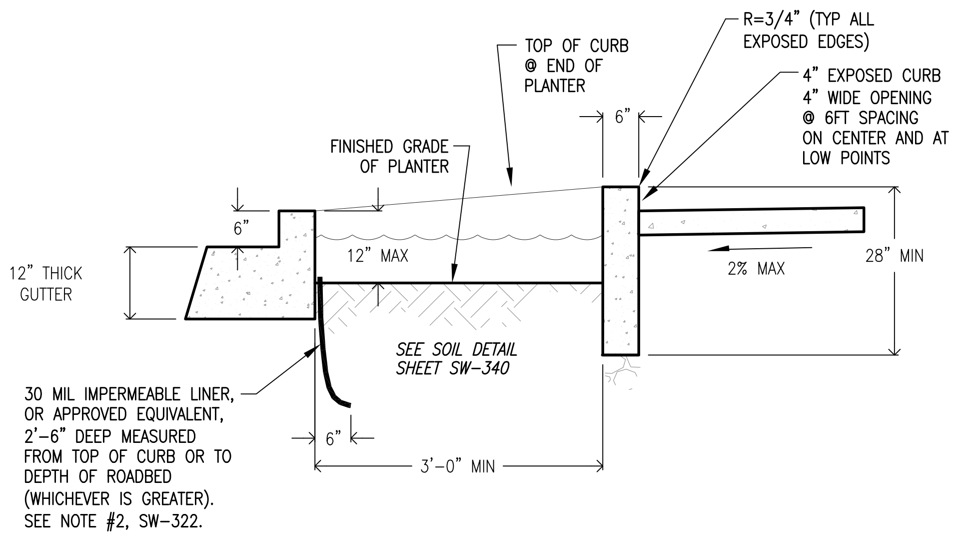
Planter Plan

With Parking

NUMBER

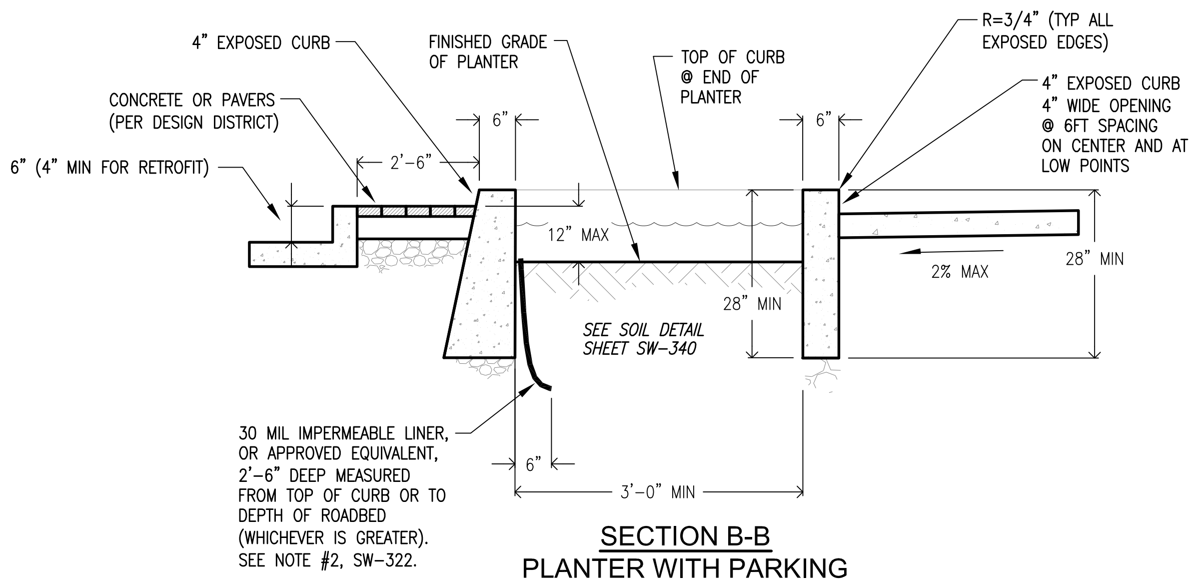
SW-311

Bureau of Environmental Services



SECTION A-A
PLANTER WITHOUT PARKING

FOR PLAN REFER
TO SW-310



SECTION B-B
PLANTER WITH PARKING

FOR PLAN REFER
TO SW-311

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

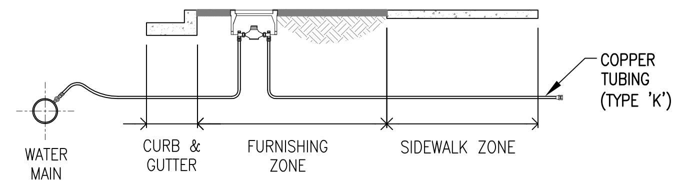
- Green Streets -

Planter Sections

NUMBER

SW-312

Bureau of Environmental Services



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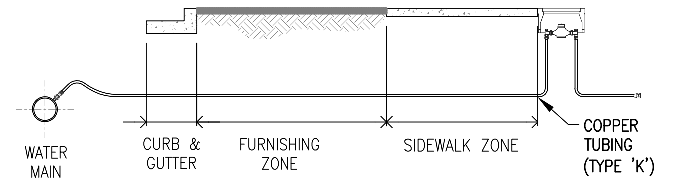

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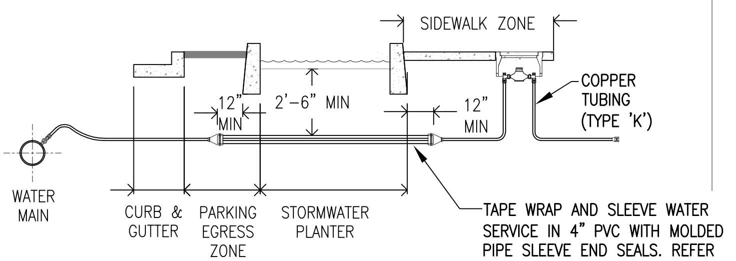

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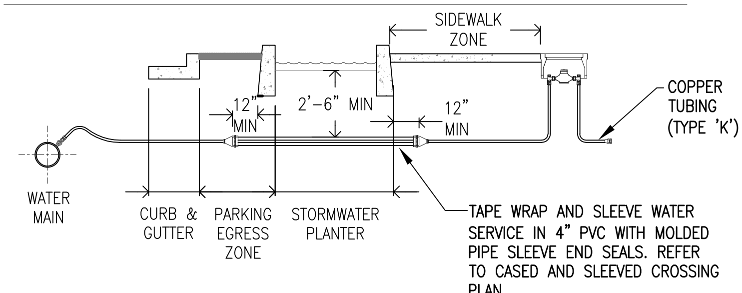

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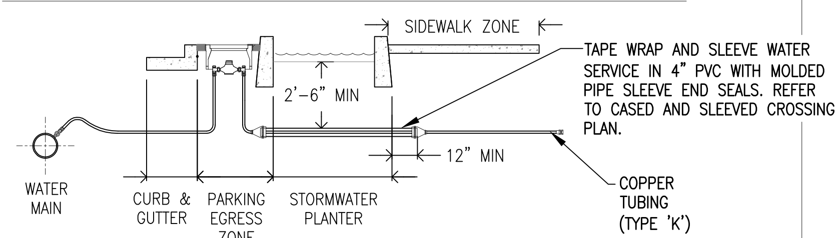
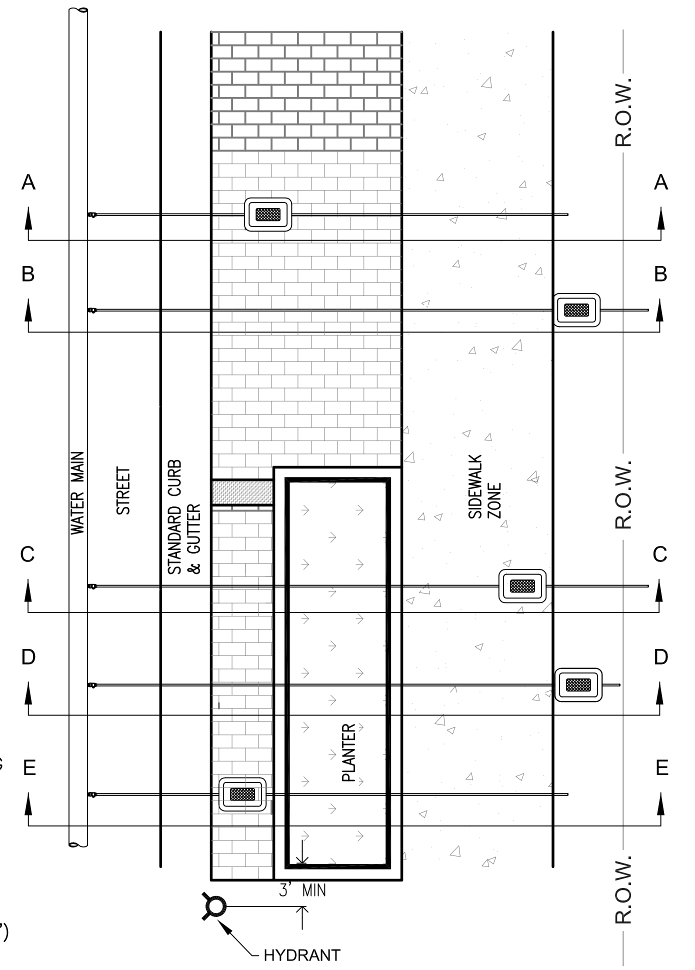


SECTION E-E



NOTES:

1. Refer to fire hydrant installation plan. Hydrants must have min 3' clearance from the edge of a stormwater facility.

2. Standard meter location is A or D. Option B or D can be used only if the meter box is fully within the Right-of-Way. Option C can only be used if furnishing zone is available and the meter box cannot be placed behind the sidewalk within the Right-of-Way.

3. Refer to small service installation plan. For larger services or other appurtenances, contact PWB development services @ 503 823-7368. Water service line must be 2'-6" min below lowest point of ground surface of stormwater facility, typical.

4. If watermain is under or behind proposed curb the watermain must be relocated, unless otherwise approved by PWB.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

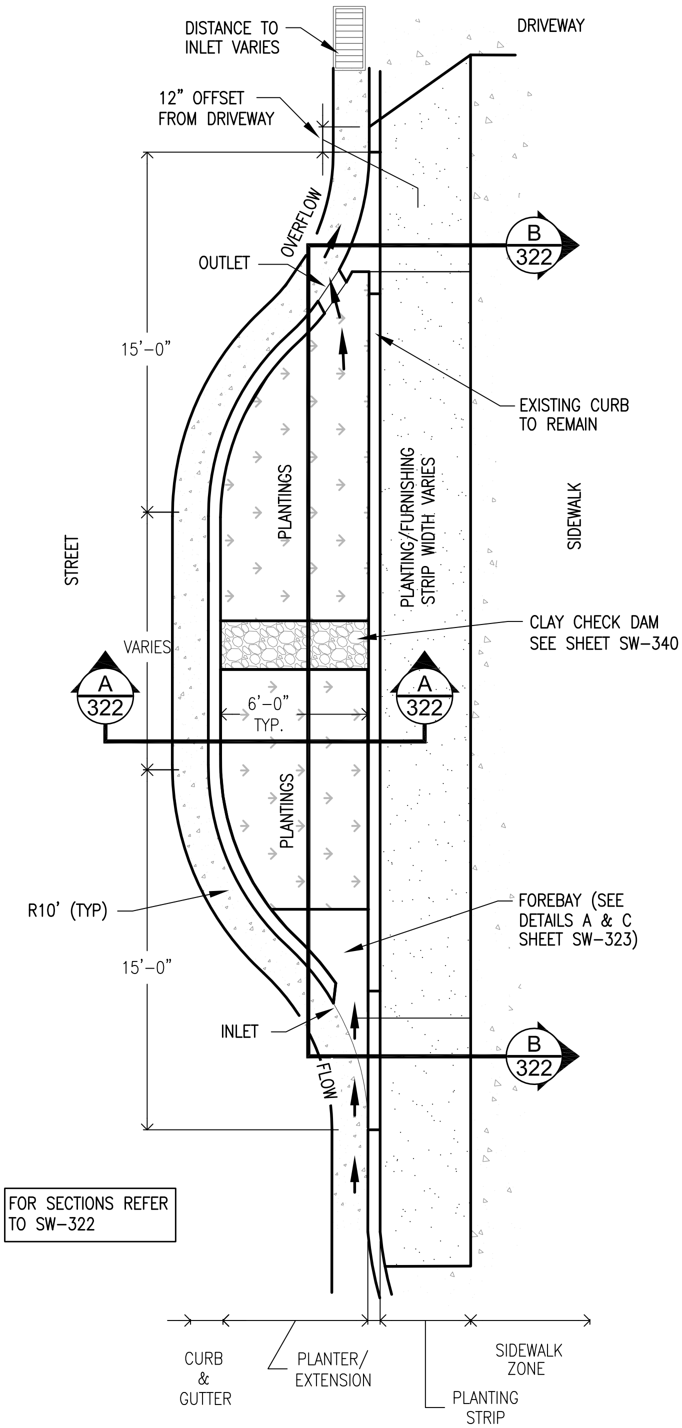
Planter

Meter & Hydrant Locations

Bureau of Environmental Services

NUMBER

SW-313



CURB EXTENSION PLAN

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of curb extension: 6' typical from inside curbs. Depth of curb extension: 6" min. from inlet at gutter elevation to bottom of facility. Actual width to be determined by City Engineer.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for facilities designed to include discharge.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. See sheets SW-330, 331, and 332 for inlet details.
8. Check dams required: See sheet SW-340 for details.
9. See Appendix F.3 for Growing Medium requirements.
10. Special requirements for water lines, meters, and fire hydrants: See sheet SW-324 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Roadway Drawing RD700 with thickened 12" gutter. Use 1'-6" wide gutter.
13. Where feasible, width of stormwater facility may extend into existing planting strip (in which case existing curb would be removed).
14. See Landscape Templates SW-410 through SW-412 and Plant List in SWMM Appendix F.4.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

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For more information contact:

PDOT (503) 823-7884 | BES (503) 823-7651
PWB (503) 823-7368 | Urban Forestry (503) 823-4025

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

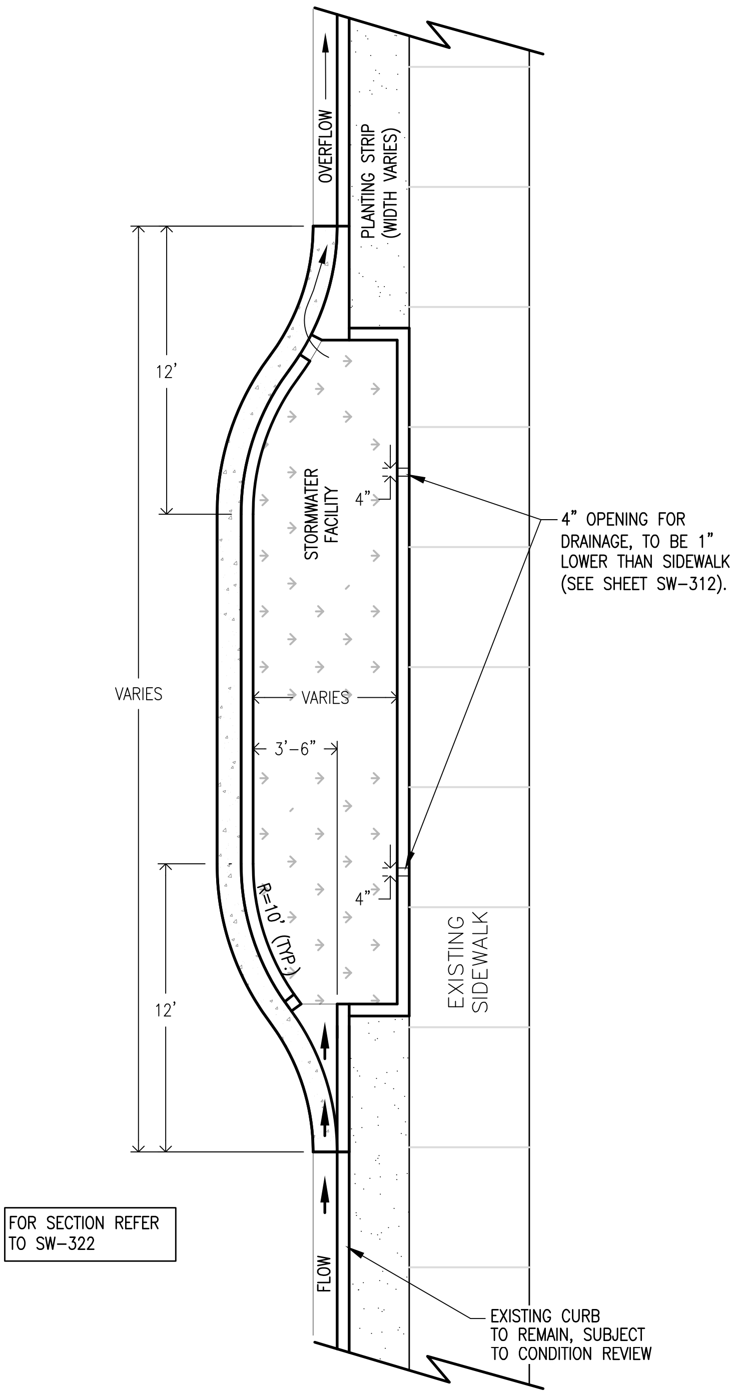
Curb Extension

In-Street Plan

NUMBER

SW-320

Bureau of Environmental Services



CURB EXTENSION PLAN

NOTES:

1. See City of Portland Standard Construction Specifications Section 00415 - Vegetated Stormwater Facilities.
2. Width of curb extension: 6' typical from inside curbs. Depth of curb extension: 6" min. from inlet at gutter elevation to bottom of facility. Actual width to be determined by City Engineer.
3. Longitudinal slope of planter matches road: flat as possible, 3% maximum. Longitudinal and cross slope of soil within planter: none, flat as possible. (Typical cross slope of road 2-6%, cross slope of gutter 8%.)
4. Special requirements may be necessary on steep slopes & for facilities designed to include discharge.
5. Include beginning and ending station elevations for each facility. Provide the top and bottom elevation of facility at each station specified. Include elevations at every inlet and outlet.
6. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
7. Inlets and outlets required: See sheets SW-330, 331, and 332 for details.
8. Check dams required: See sheet SW-340 for details.
9. Special soil and planting requirements: See sheets SW-340 and SW-400 for details.
10. Special requirements for water lines, meters, and fire hydrants: See sheet SW-324 for details.
11. Depending on location, utility lines may need to be sleeved.
12. Curb and Gutter: ODOT Standard Roadway Drawing RD700 with thickened 12" gutter. Use 1'-6" wide gutter.
13. Where feasible, width of stormwater facility may extend into existing planting strip (in which case existing curb would be removed).
14. See GreenStreet Planting details SW-430 through SW-432.

IMPORTANT: Utility conflicts and existing conditions can create major design variables. Locate utilities and survey existing conditions prior to beginning design work.

The Portland Office of Transportation, Portland Water Bureau (PWB), and Bureau of Environmental Services (BES) are responsible for the review and approval of Stormwater Swales in the public right of way. Stormwater facilities in *Well Field Protection Areas* may require special containment measures.

For more information contact:

PDOT (503) 823-7884 | BES (503) 823-7651
PWB (503) 823-7368 | Urban Forestry (503) 823-4025

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

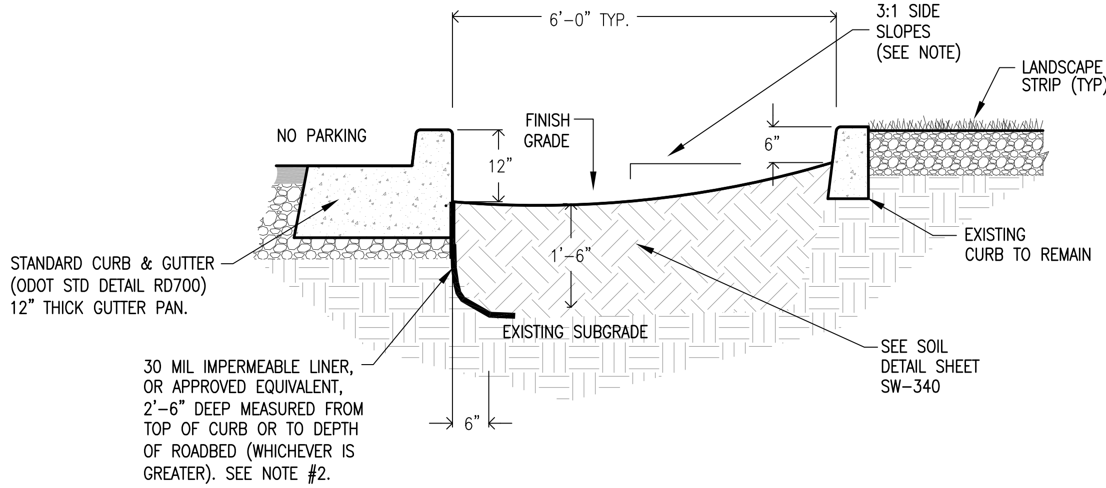
Curb Extension

In-Planter Plan

NUMBER

SW-321

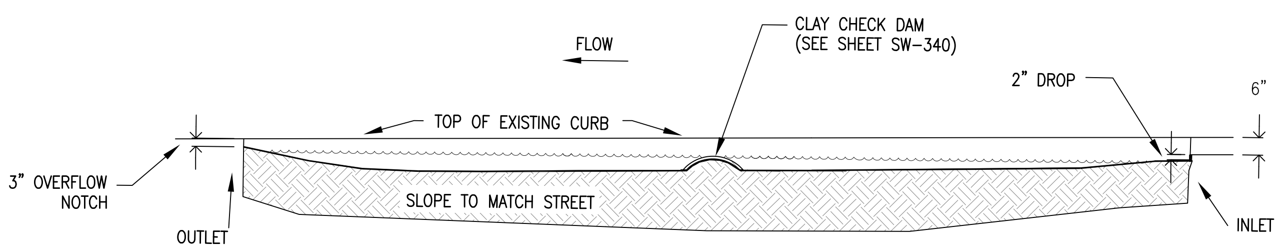
Bureau of Environmental Services



SECTION A-A
CURB EXTENSION SECTION

NOTE:

1. If stormwater curb extension is constructed next to an existing sidewalk, soil elevation must be brought to top of curb and slope away from curb at a 4:1 slope.
2. Liner required when face of new curb is < 2ft from adjacent water line or on neighborhood collectors and higher street classifications. Liner may be required on local streets with transit routes, higher traffic volumes, or when facility is adjacent to travel lane, at the discretion of the City Engineer.



SECTION B-B
CURB EXTENSION PROFILE

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

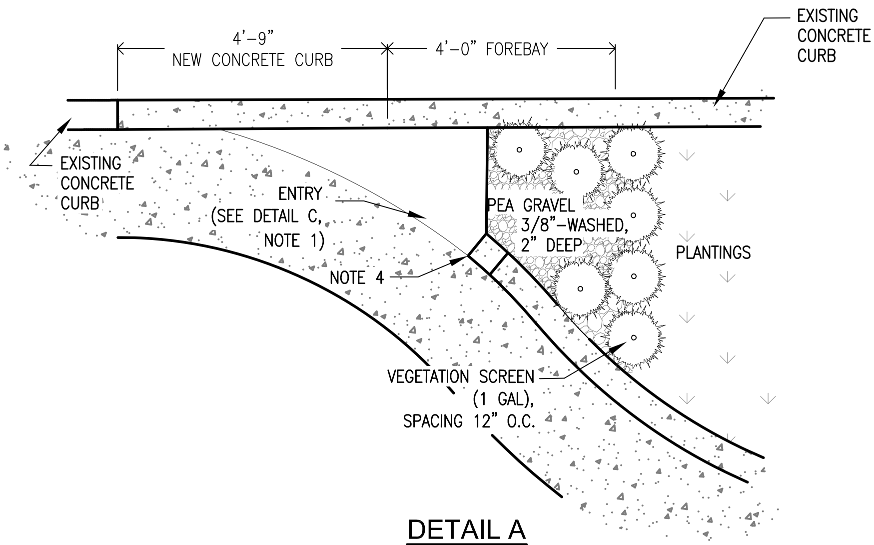
- Green Streets -

Curb Extension Sections

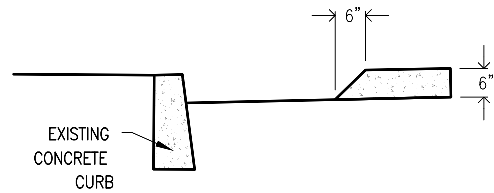
Bureau of Environmental Services

NUMBER

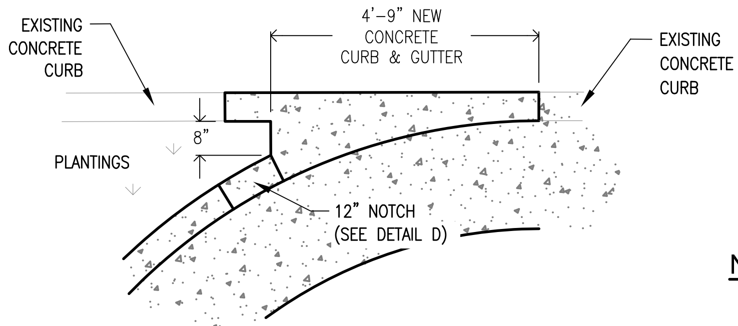
SW-322



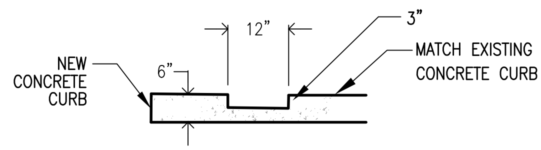
DETAIL A
FOREBAY



DETAIL C
MODIFIED INLET



DETAIL B
OUTLET CURB PLAN



DETAIL D
MODIFIED OUTLET

NOTES:

1. Detail A: Pea gravel forebay for use with stormwater curb extensions only. Pea gravel forebay replaces standard concrete splash pad.

2. Detail C: To prevent ponding, position inlet closer to existing curb if the street cross-slope is >2%. Additional inlets can be added if necessary (preferably immediately downstream of each check dam to minimize potential backflow). Additional inlets are not recommended for streets sloped <1%.

3. Details B, C & D: For use on local service streets only.

4. Inlet may be modified to maximize flow entry to stormwater facility.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

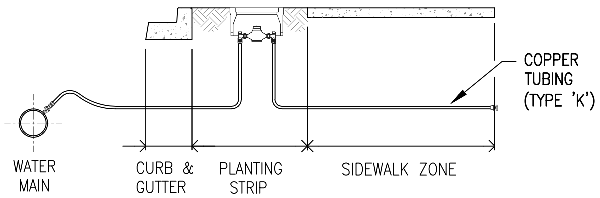
Curb Extension

Inlet / Outlet Details

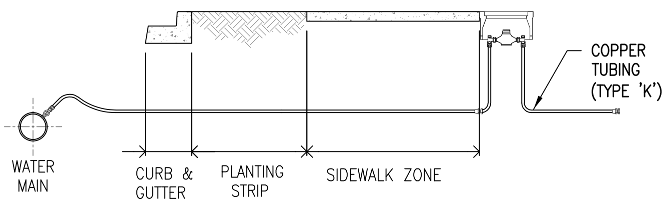
Bureau of Environmental Services

NUMBER

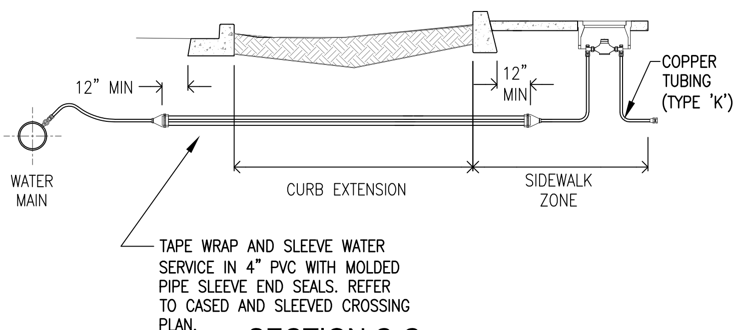
SW-323



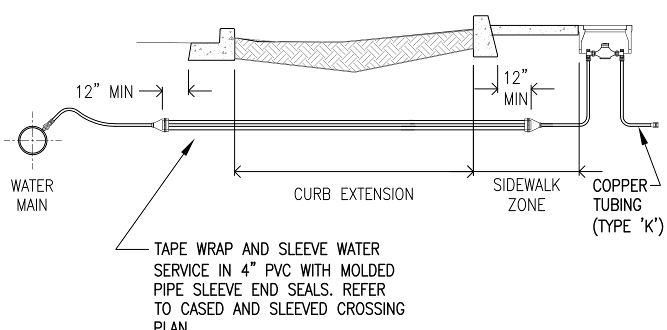
SECTION A-A



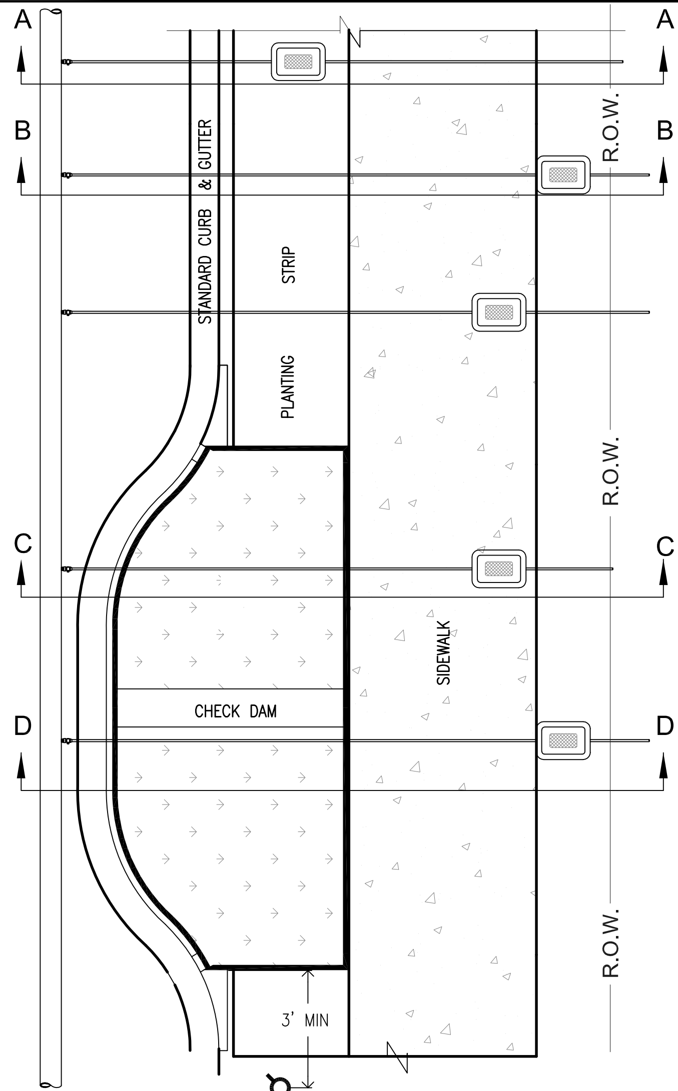
SECTION B-B



SECTION C-C



SECTION D-D



PLAN VIEW

NOTES:

1. Refer to fire hydrant installation plan. Fire hydrants must have min 3' clearance from the edge of a stormwater facility.

2. Standard meter location is A or D. Option B or D can be used only if the meter box is fully within the Right-of-Way. Option C can only be used where the meter box cannot be placed behind the sidewalk within the Right-of-Way.

3. Refer to small service installation plan. For larger services or other appurtenances, contact PWB development services @ 503 823-7368. Water service line must be 2'-6" min below lowest point of ground surface of stormwater facility, typical.

NOTES (cont):

4. If watermain is under or behind proposed curb, the watermain must be relocated unless otherwise approved by PWB.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

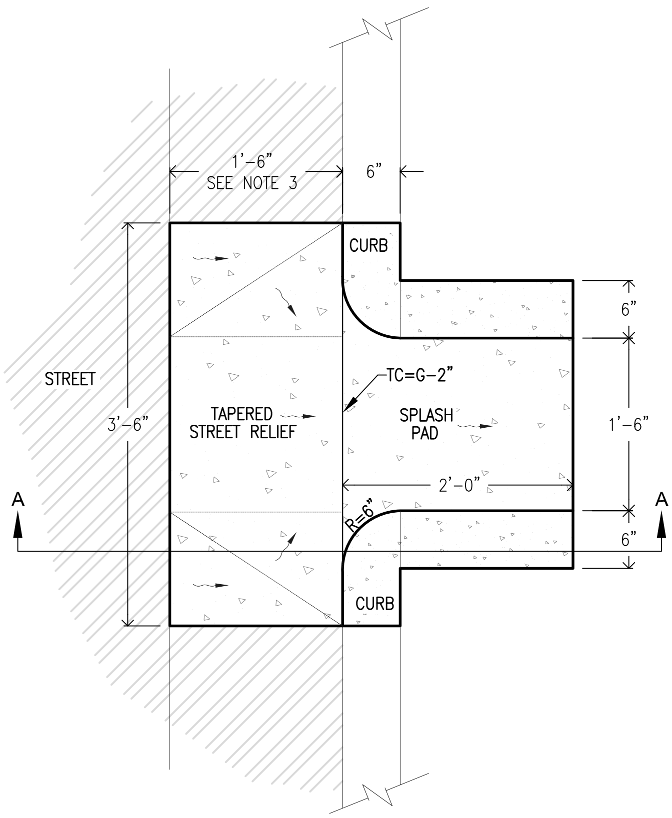
Curb Extension

Meter & Hydrant Locations

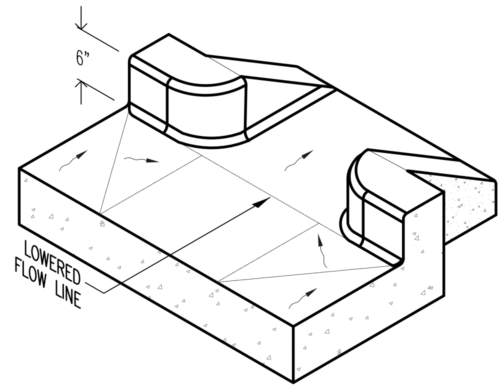
Bureau of Environmental Services

NUMBER

SW-324



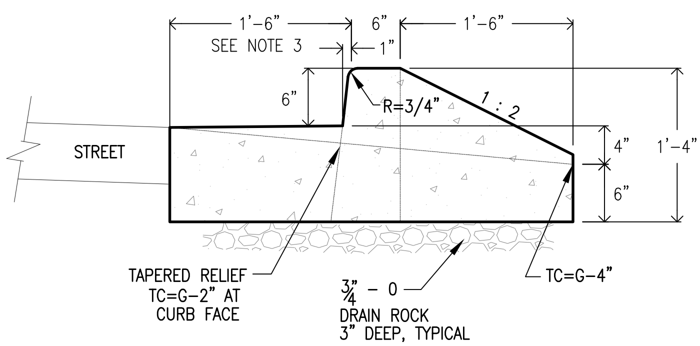
PLAN



ISOMETRIC

NOTES:

1. Concrete splash pad necessary where water enters and/or exits facility.
2. For stormwater facilities, install washed pea gravel or river rock to transition from splash pad to topsoil.
3. Reference ODOT Standard Drawing RD 700. Use 1'-6" wide gutter, typical.



TC = TOP OF CONCRETE
G = GUTTER

SECTION A-A

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

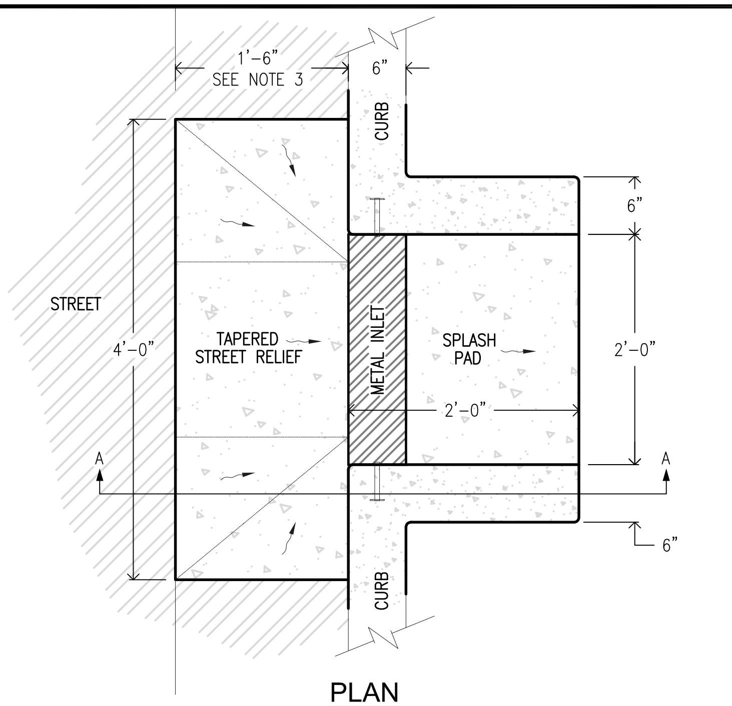
Concrete Inlet, Type SW

For Local Service Streets

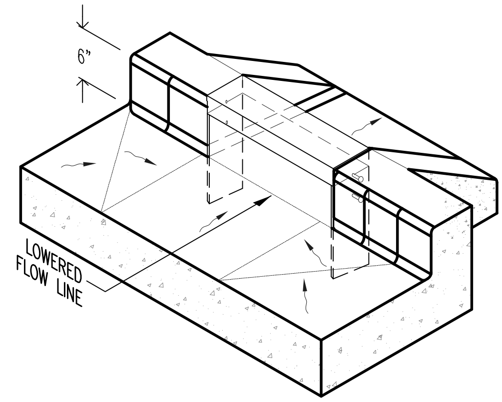
Bureau of Environmental Services

NUMBER

SW-330



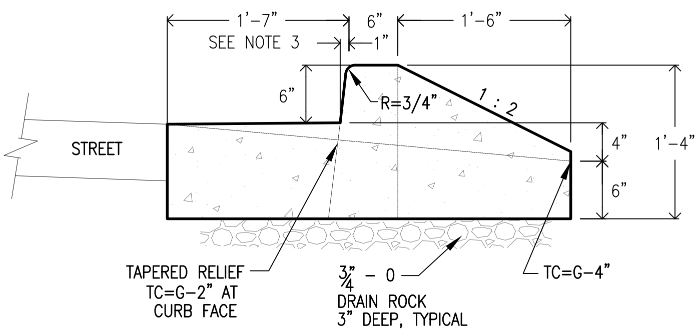
PLAN



ISOMETRIC

NOTES:

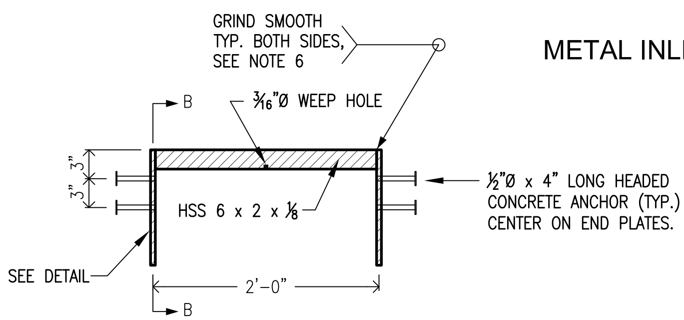
1. Headed concrete anchors shall meet the requirements of ASTM A-108.
2. HSS 6 x 2 x 1/8 shall meet the requirements of ASTM A-500 Grade B.
3. End Plates shall meet the requirements of ASTM A-36.
4. Entire assembly shall be Hot-Dip Galvanized in accordance with ASTM A-123.
5. Design vertical wheel load is 8.5kips (1/2 of tandem axle weight specified in FHWA-HOP-06-105).
6. Single Bevel Groove Weld.



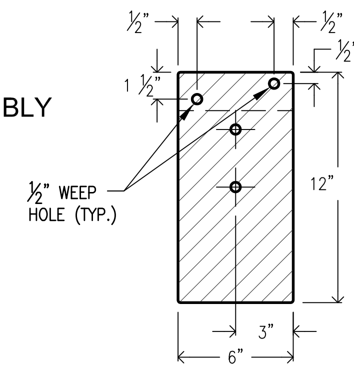
TC = TOP OF CONCRETE
G = GUTTER

SECTION A-A

METAL INLET ASSEMBLY



ELEVATION



SECTION B-B
END PLATE DETAIL

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

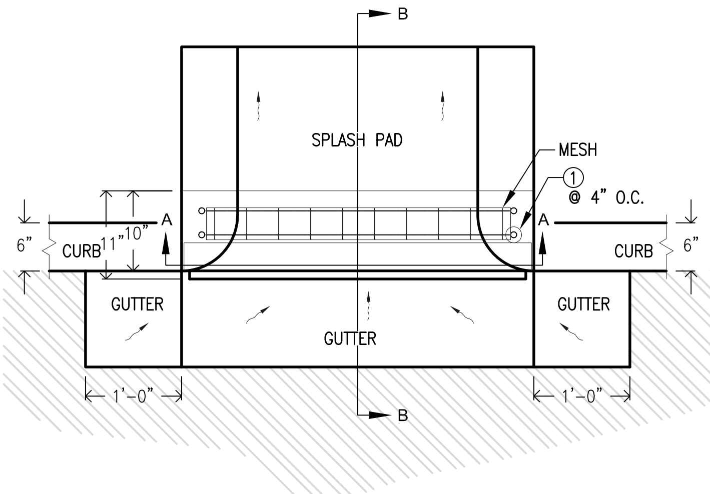
Metal Inlet, Type PB

For Neighborhood Collectors and Above

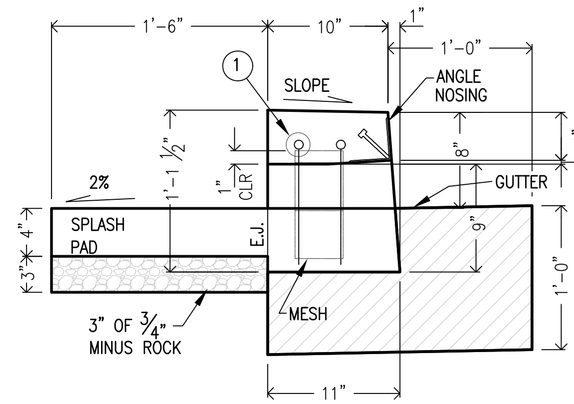
Bureau of Environmental Services

NUMBER

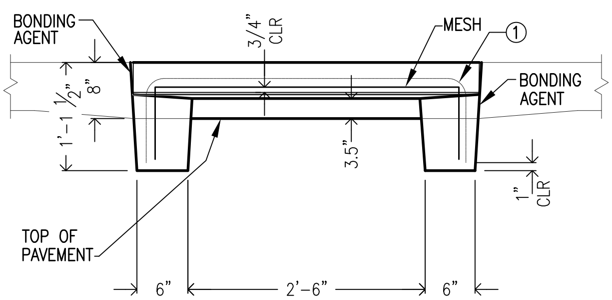
SW-331



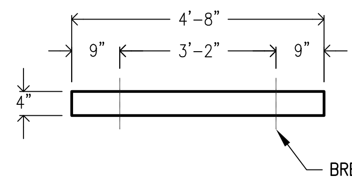
PLAN



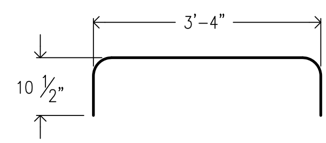
SECTION B-B



SECTION A-A



DETAIL MESH



DETAIL 1

E.J. = EXPANSION JOINT
CLR. = CLEAR
O.C. = ON CENTER

STRUCTURAL NOTES:

1. Concrete: 28 Day Strength f'c = 5,500 PSI.
2. Rebar: ASTM A-615 Grade 60.
3. Mesh: ASTM A-185 Grade 65.
4. Design: ACI-318 Building Code, ASTM C-857 "Min structural design loading for underground precast concrete utility structures".
5. Loads: H-20 truck wheel w/ 30% impact.

BILL OF MATERIAL

PART	DESCRIPTION	QTY.	SIZE	TOTAL WT. LBS.
	ANGLE NOSING	1	3.5"x3.5"x3'-7" GALV.	
MESH	W2.9/W2.9 4x4	1	SEE DETAIL MESH	2 SF
1	#6 GR 60	2	SEE DETAIL 1	15

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

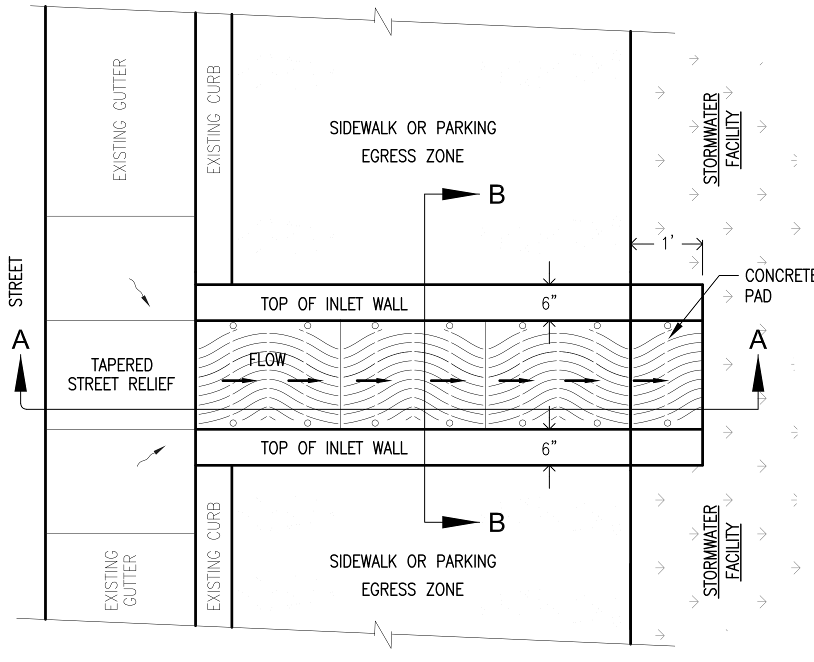
Concrete Inlet, Type PB

For Neighborhood Collectors and Above

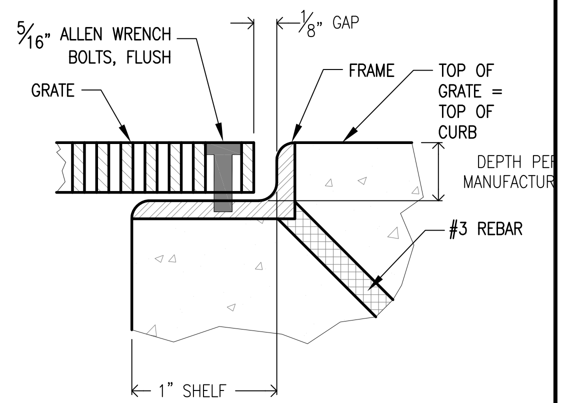
Bureau of Environmental Services

NUMBER

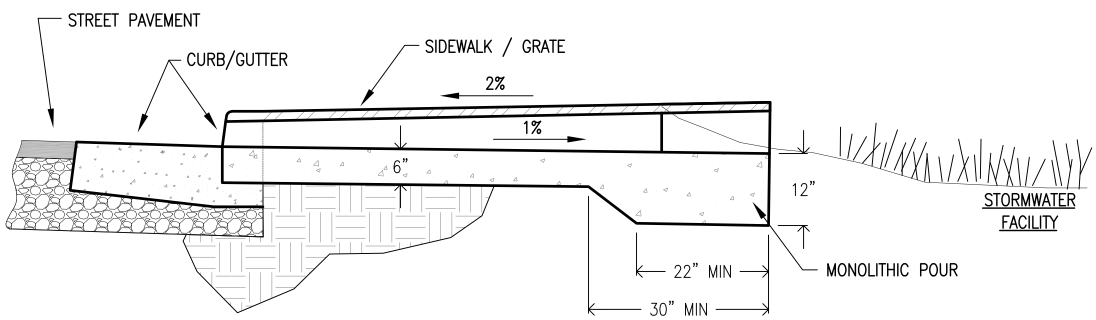
SW-332



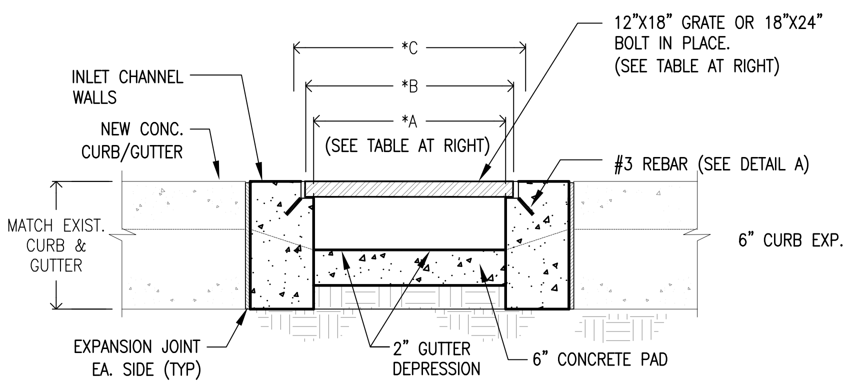
PLAN VIEW



DETAIL A



SECTION A-A



SECTION B-B

*TRENCH GRATING

A TRENCH WIDTH	B GRATE WIDTH	C FRAME WIDTH
10"	11 7/8"	12 1/8"
16"	17 7/8"	18 1/8"

NOTE: MAXIMUM GRATE HOLE WIDTH (OPEN) 1/4 INCH. GRATE SIZE 12"X18" OR 18"X24". CAST IRON URBAN ACCESSORIES TRENCH GRATE AND FRAME. TITLE WAVE MODEL OR EQUAL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

Concrete Inlet

Type Channel & Grate

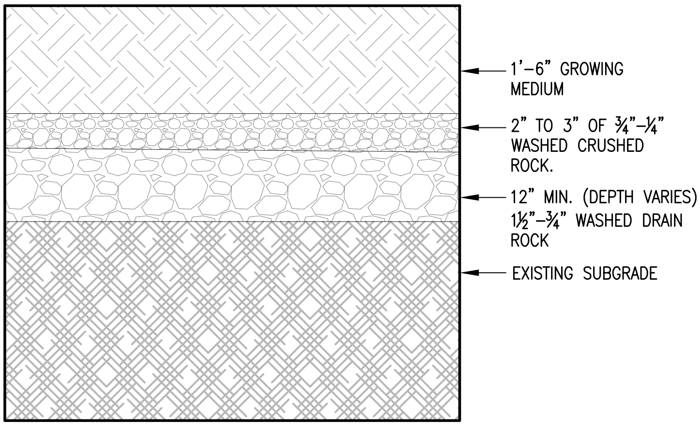
Bureau of Environmental Services

NUMBER

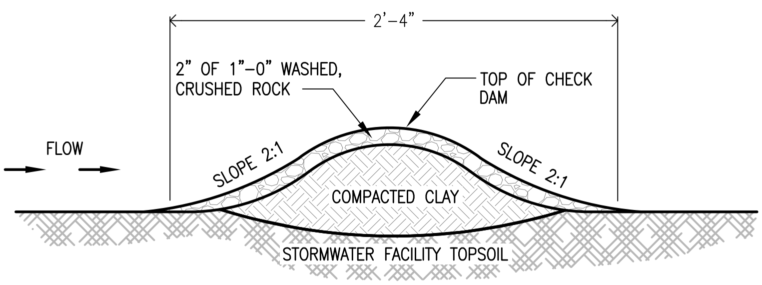
SW-333

NOTE:

SEE APPENDIX F.3 FOR GROWING MEDIUM SPECIFICATIONS FOR VEGETATED STORMWATER FACILITIES.



SOIL PROFILE



CHECK DAM

CHECK DAM SPACING			
Facility Length	Longitudinal Street Slope	# of Check Dams *	Additional Inlets **
30	<=1%	0	None
	>1%	1	None
31 - 50	<=1%	1	None
	>1%	2	1
51 - 70	<=1%	2	1
	>1%	3	2
71-90	<=1%	3	2
	>1%	4	3
91 +	<=1%	4	3
	>1%	5	4

TABLE 1

CHECK DAM NOTES:

1. Check Dams to be evenly spaced between inlet and outlet. Additional requirements maybe necessary on steep slopes.
2. Additional inlets to be placed directly downstream of check dams.
3. Top of Check Dam to be 1" below gutter elevation at inlet (at curb line) but not greater than 2" below top of curb.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Streets -

Growing Medium Profile and Check Dam

NUMBER

SW-340

Bureau of Environmental Services

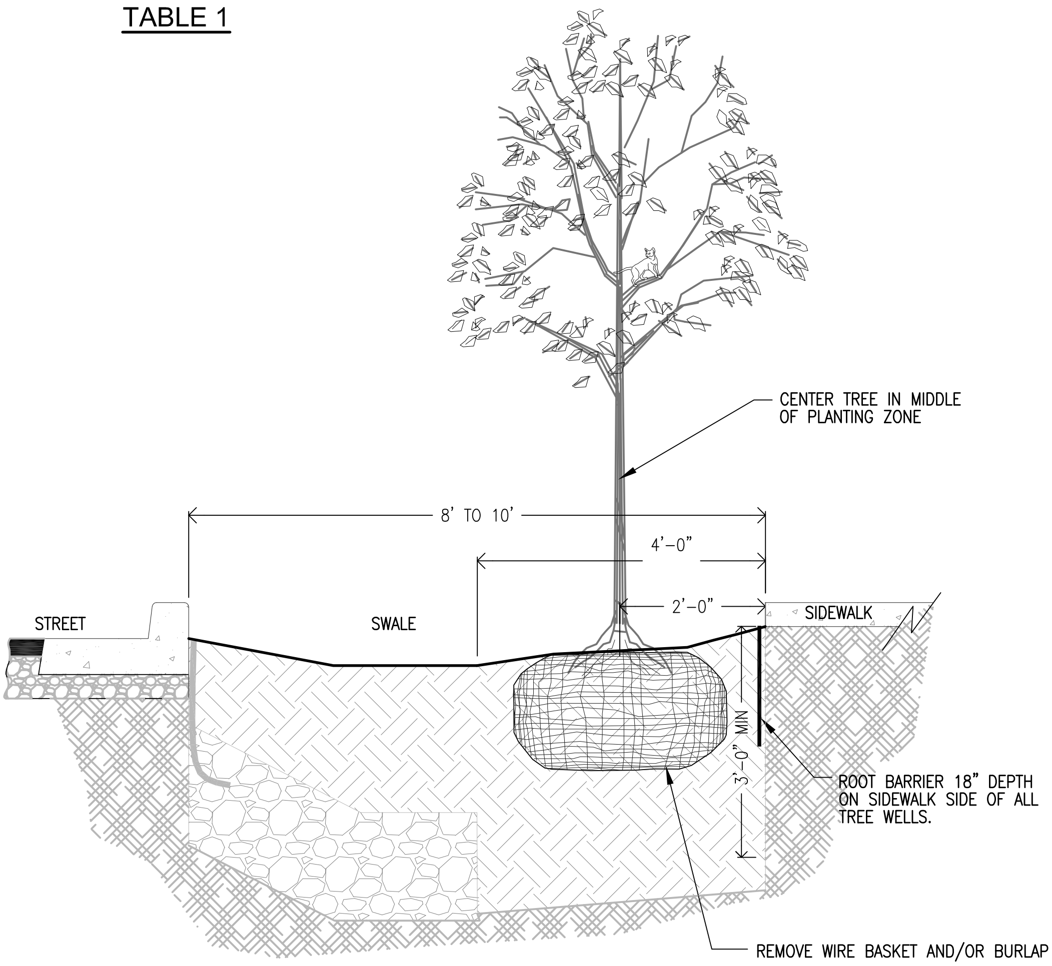
Appendix G.4 Table of Contents

RECOMMENDED STREET TREES	
Botanical Name	Common Name
WITH power lines	
Carpinus caroliniana	American Hornbeam
Fraxinus pennsylvanica 'Johnson'	Leprechaun Ash
Gleditsia triacanthos 'Impcole'	Imperial Honeylocust
Koelreuteria paniculata	Goldenrain Tree
Prunus virginiana "Canada Red'	Canada Red Chokecherry
WITHOUT power lines	
Nyssa sylvatica	Black tupelo
Celtis occidentalis	Hackberry
Quesrcus shumardii	Shumard Oak
Betula jacquemontii	Jacquemontii Birch
Acer campestre 'Evelyn'	Queen Elizabeth Hedge Maple
Gleditsia triacanthos 'Skycole'	Skyline Honeylocust

TABLE 1

NOTES:

1. Contact Urban Forester for tree installation assistance, if necessary.
2. Remove wire and burlap from root ball prior to backfilling.
3. Set top of root ball a minimum of 1" above topsoil surface.
4. Distance between trees varies: 20'-30' on center.
5. Minimum clearance of 10' between trees and water facilities or meets Root Barrier plan.



STREET TREE IN SWALE

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

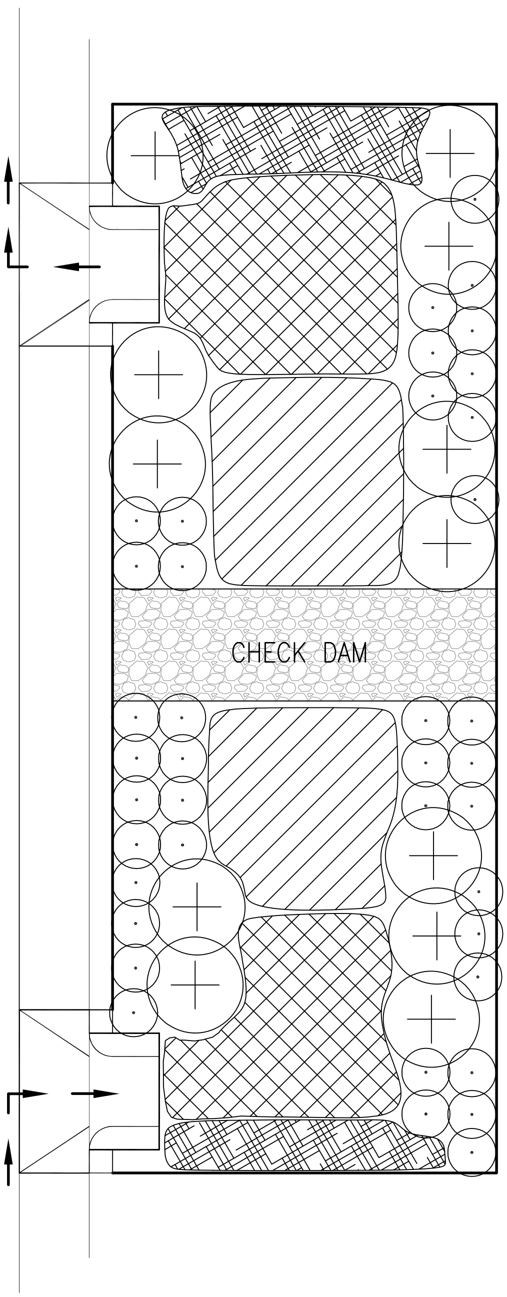
- Green Street Landscape Information -

Street Tree Details

Bureau of Environmental Services

NUMBER

SW-400



PLANT LEGEND

SYMBOL	*BOTANIC NAME* COMMON NAME	
	CAREX COMANS NEW ZEALAND HAIR SEDGE	
	HELICTOTRICHON SEMPERVIRENS BLUE OAT GRASS	
	JUNCUS PATENS SPREADING RUSH	
	MAHONIA REPENS CREEPING OREGON GRAPE	w/ OPTIONAL IRIS BULBS
	SPIRAEA DENSIFLORA SUB-ALPINE SPIRAEA	

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

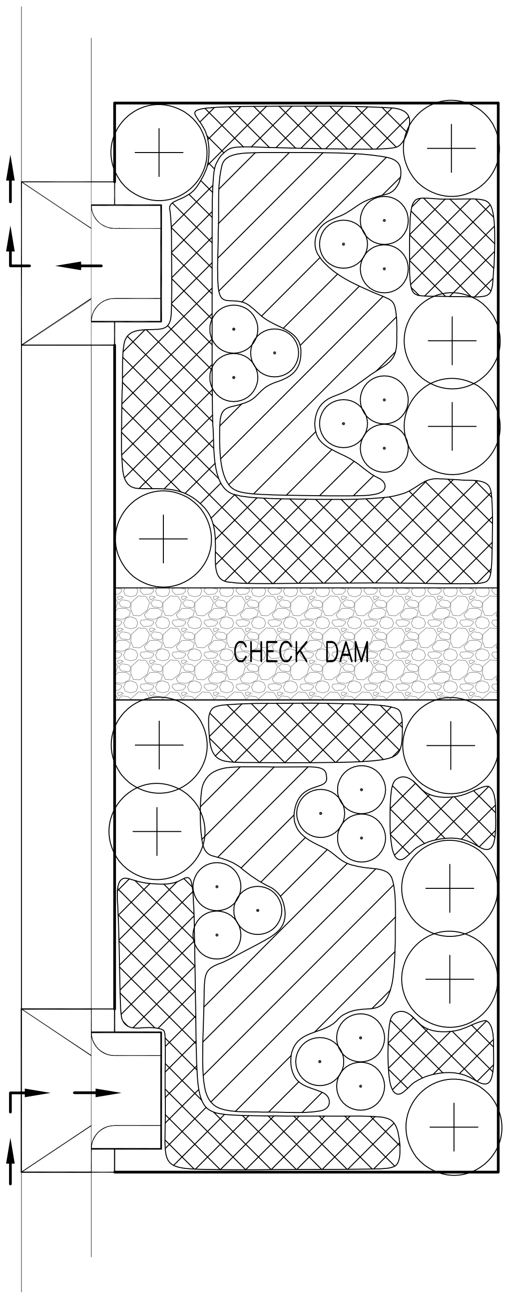
Infiltration Swale

Example Landscape Template

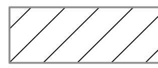
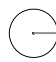
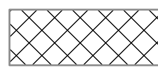
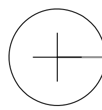
Bureau of Environmental Services

NUMBER

SW-410



PLANT LEGEND

SYMBOL	BOTANIC NAME / COMMON NAME	
	*CAREX TESTACEA* ORANGE SEDGE	w/ OPTIONAL CAMAS BULBS
	*DESCHAMPSIA CESPITOSA* TUFTED HAIR GRASS	
	*FRAGARIA CHILOENSIS* COASTAL STRAWBERRY	
	*SPIRAEA BETULIFOLIA* BIRCHLEAF SPIRAEA	

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

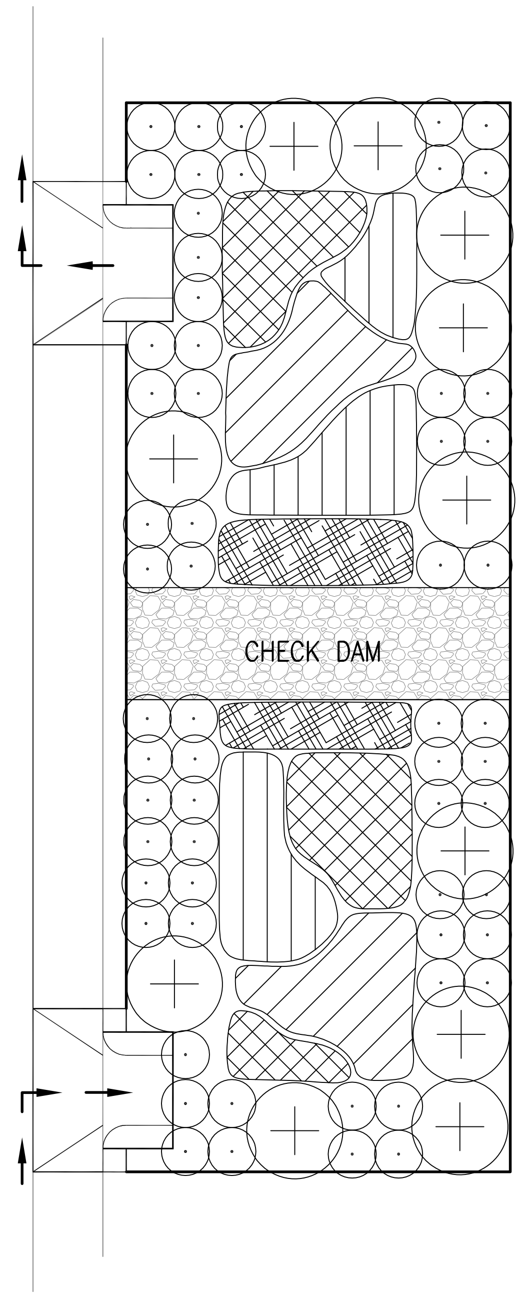
Infiltration Swale

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-411



PLANT LEGEND

SYMBOL	*BOTANIC NAME* / COMMON NAME
	CAREX OBNUPTA / SLOUGH SEDGE
	CAREX TESTACEA / ORANGE SEDGE
	DESCHAMPSIA CESPITOSA / TUFTED HAIR GRASS
	JUNCUS PATENS / SPREADING RUSH
	ARCOSTAPYLOS UVA-URSI / KINNICKINNICK
	POLYSTICHUM MUNITIM / SWORD FERN

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

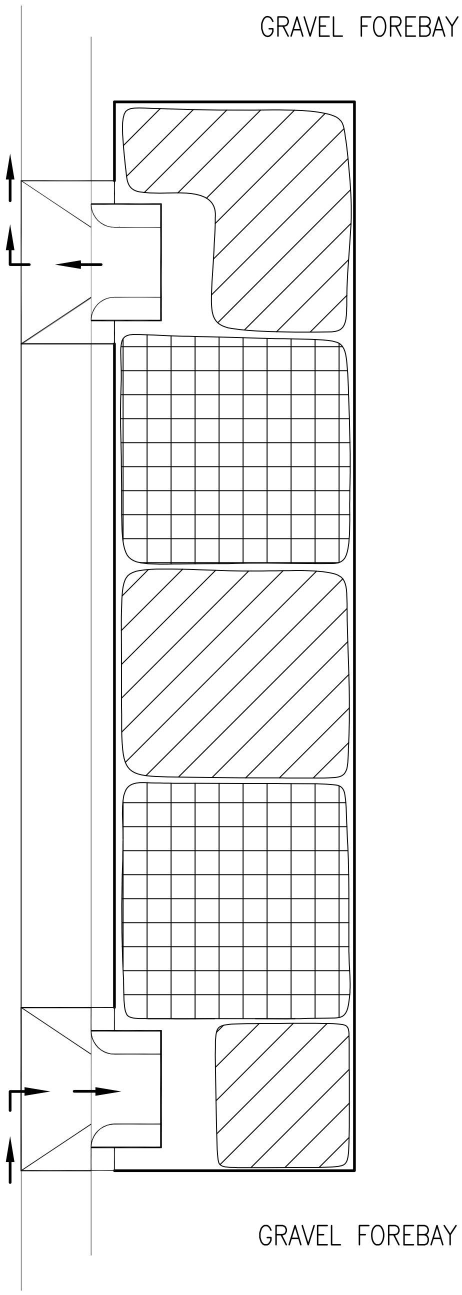
Infiltration Swale

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-412



PLANT LEGEND

SYMBOL	BOTANIC NAME / COMMON NAME	
(diagonal hatch)	*CAREX TESTACEA* ORANGE SEDGE	
(grid hatch)	*JUNCUS PATENS* SPREADING RUSH	w/ OPTIONAL CAMAS BULBS

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

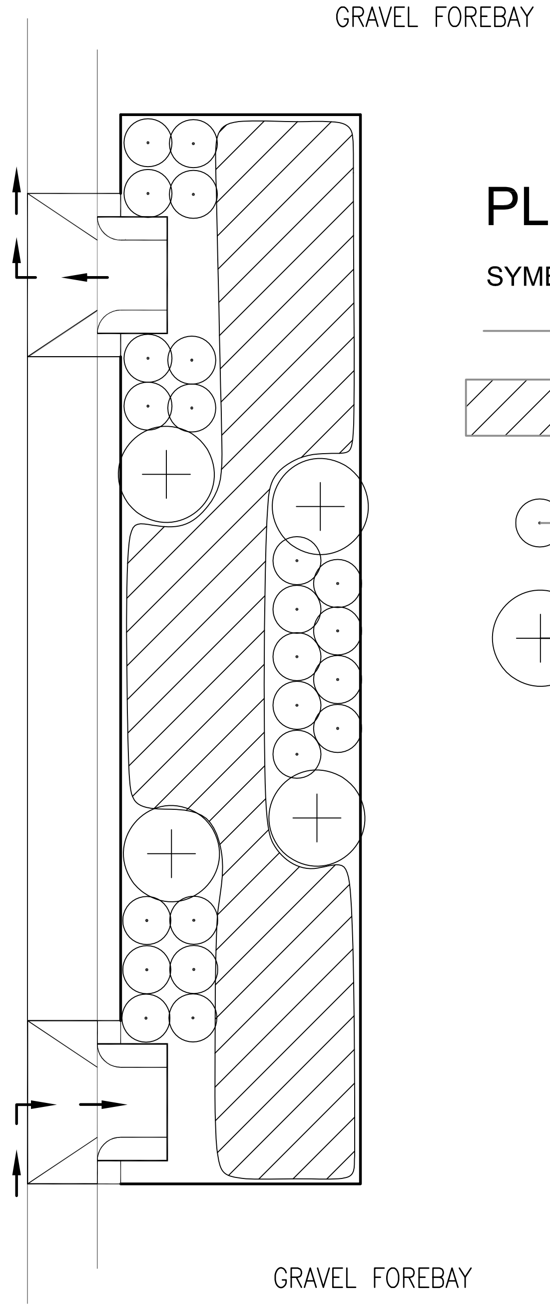
Infiltration Planter

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-420



PLANT LEGEND

SYMBOL	BOTANIC NAME COMMON NAME
	CAREX OBNUPTA SLOUGH SEDGE
	DESCHAMPSIA CESPITOSA TUFTED HAIR GRASS
	CORNUS SERICEA 'KELSEYII' KELSEY DOGWOOD

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

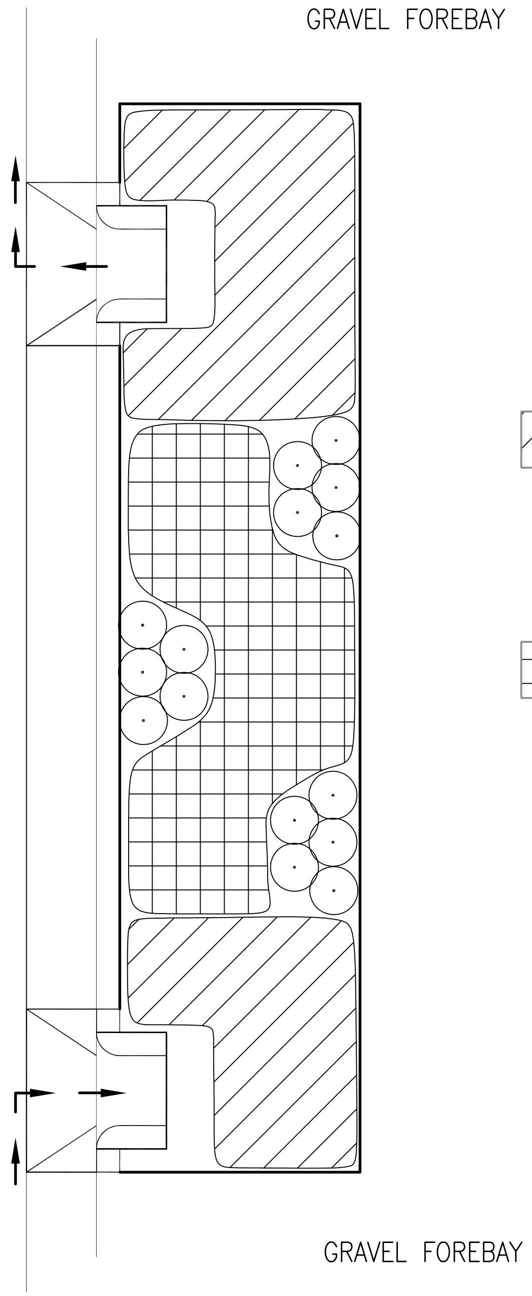
Infiltration Planter

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-421



PLANT LEGEND

SYMBOL	*BOTANIC NAME* / COMMON NAME
	CAREX OBNUPTA / SLOUGH SEDGE
	DESCHAMPSIA CESPITOSA / TUFTED HAIR GRASS
	JUNCUS PATENS / SPREADING RUSH

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

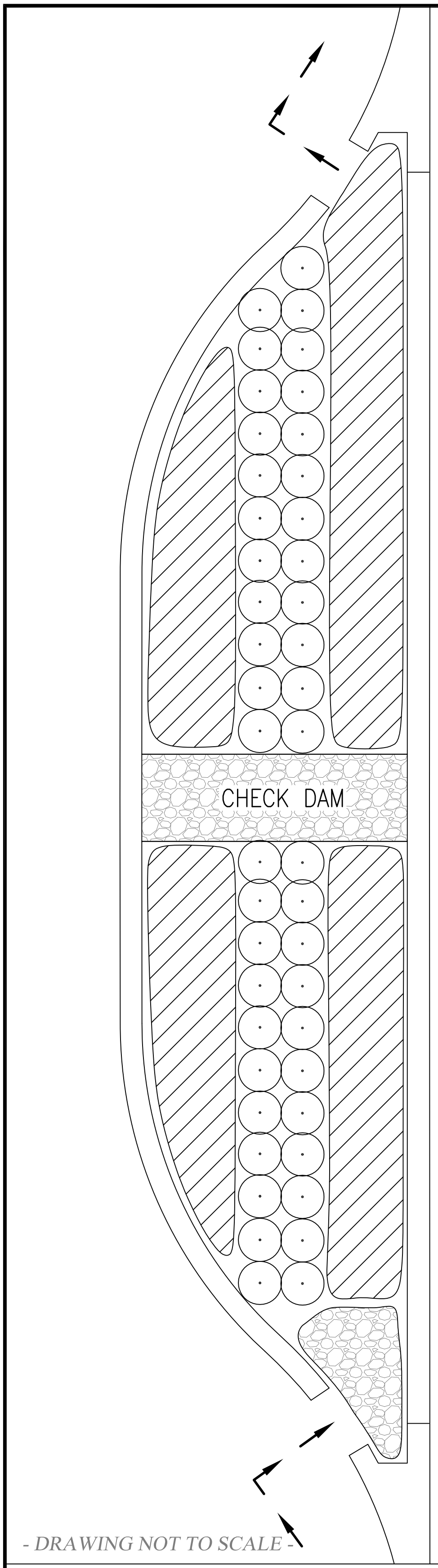
Infiltration Planter

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-422



PLANT LEGEND

SYMBOL	BOTANIC NAME COMMON NAME	
(hatched box)	*CAREX TESTACEA* ORANGE SEDGE	w/ OPTIONAL CAMAS BULBS
(circle)	*DESCHAMPSIA CESPITOSA* TUFTED HAIR GRASS	

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

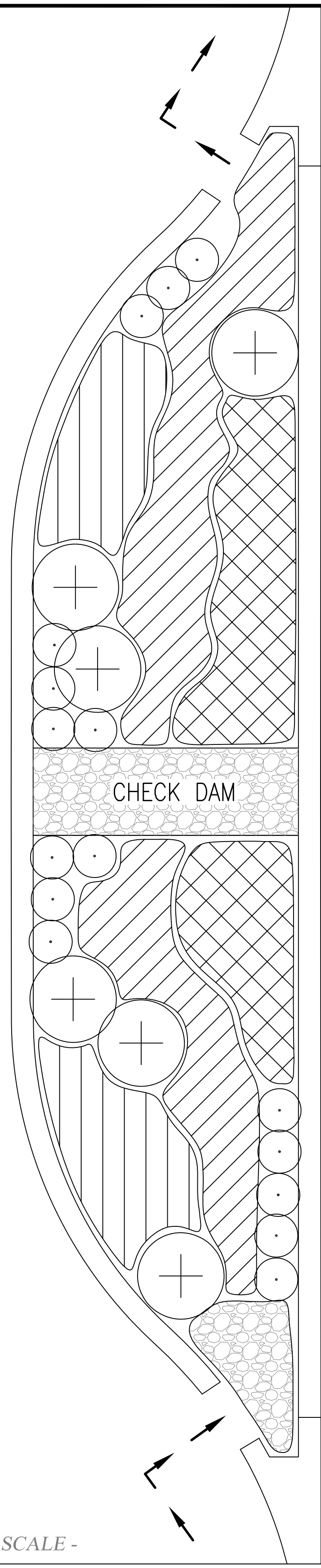
Vegetated Curb Extension

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-430



PLANT LEGEND

SYMBOL	BOTANIC NAME / COMMON NAME
(small circle)	*CAMASSIA QUAMASH* COMMON CAMAS
(diagonal hatch)	*CAREX DENSA* DENSE SEDGE
(large circle with cross)	*CORNUS SERICEA 'KELSEYII'* KELSEY DOGWOOD
(vertical lines)	*DESCHAMPSIA CESPITOSA* TUFTED HAIR GRASS
(cross hatch)	*JUNCUS PATENS* SPREADING RUSH

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

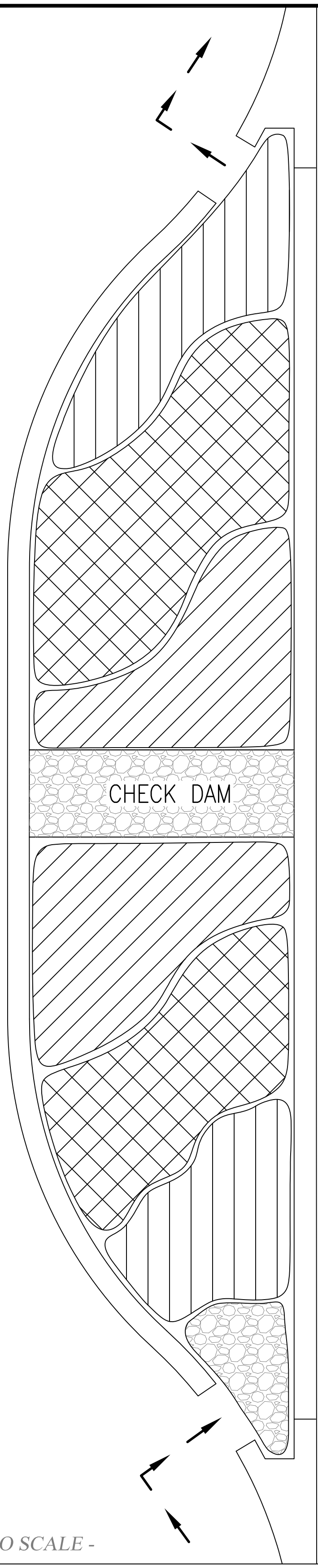
Vegetated Curb Extension

Example Landscape Template

Bureau of Environmental Services

NUMBER

SW-431



PLANT LEGEND

SYMBOL	*BOTANIC NAME* COMMON NAME	
	CAREX OBNUPTA SLOUGH SEDGE	
	CAREX TESTACEA ORANGE SEDGE	
	JUNCUS PATENS SPREADING RUSH	w/ OPTIONAL CAMAS BULBS

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL TYPICAL DETAILS

- Green Street Landscape Information -

Vegetated Curb Extension

Example Landscape Template

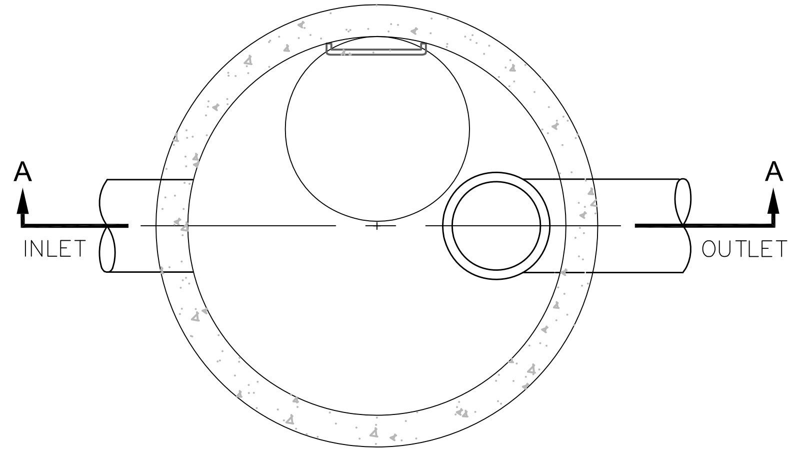
Bureau of Environmental Services

NUMBER

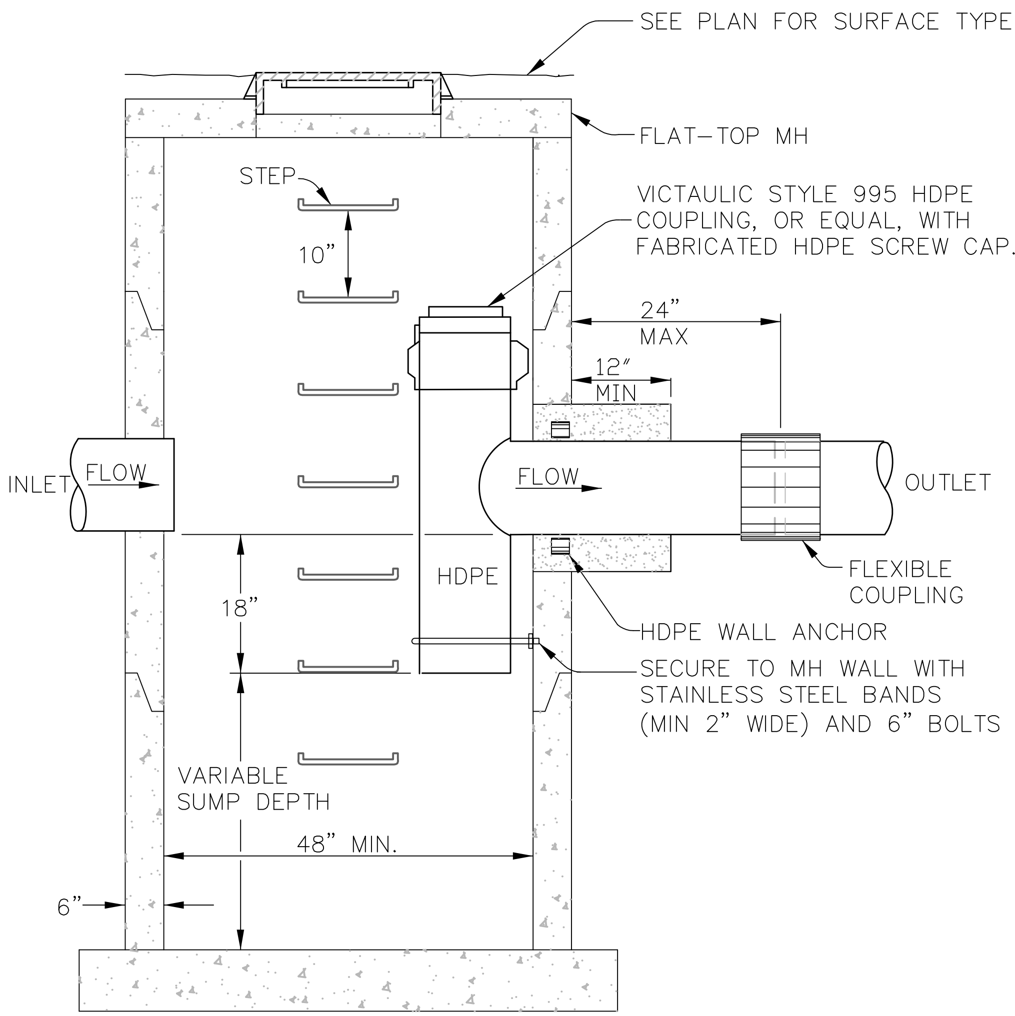
SW-432

Appendix G.5 Table of Contents

- DRAWING NOT TO SCALE -



PLAN



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

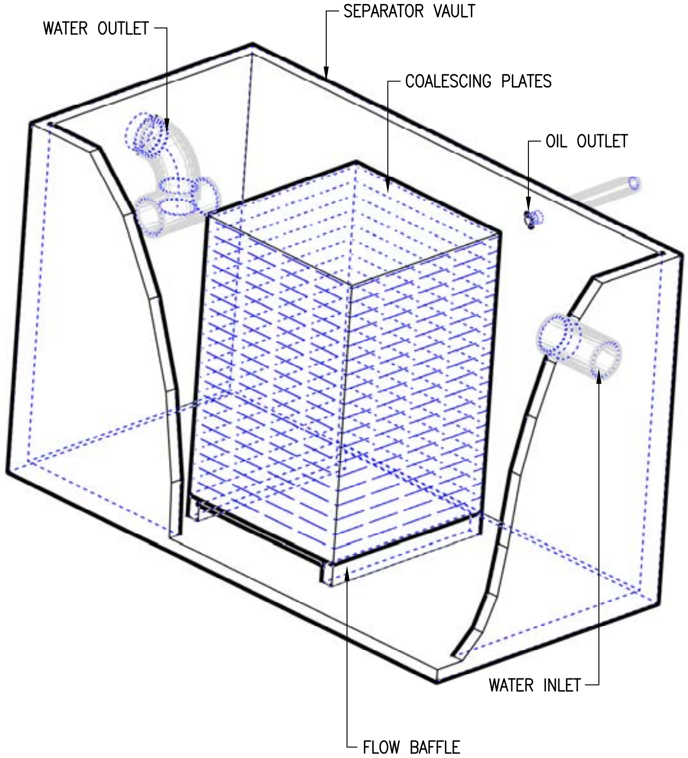
Spill Control Manhole

Source Control

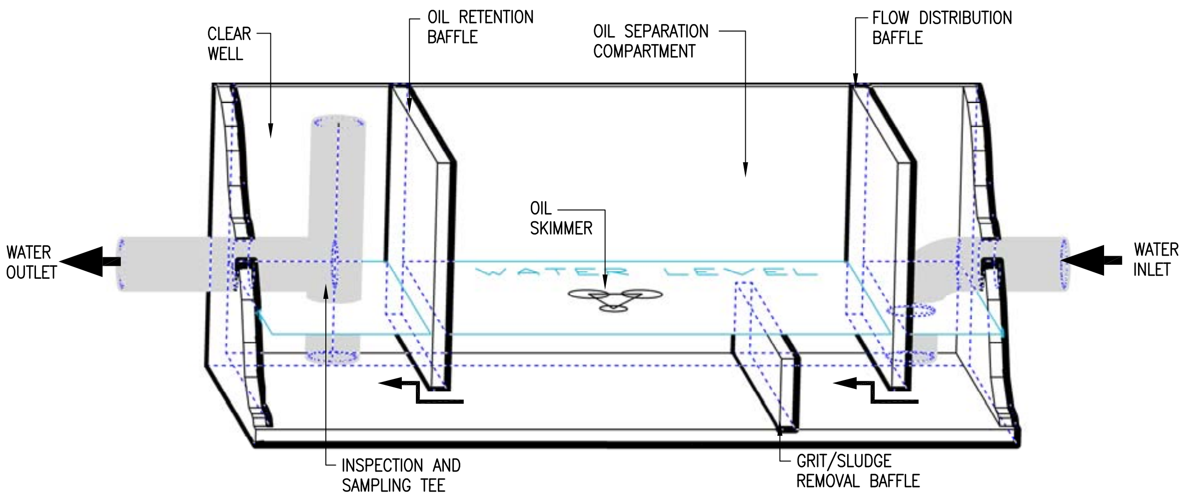
Bureau of Environmental Services

NUMBER

SW-500



COALESCING PLATE (CP) SEPARATOR



AMERICAN PETROLEUM TYPE (API) SEPARATOR

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

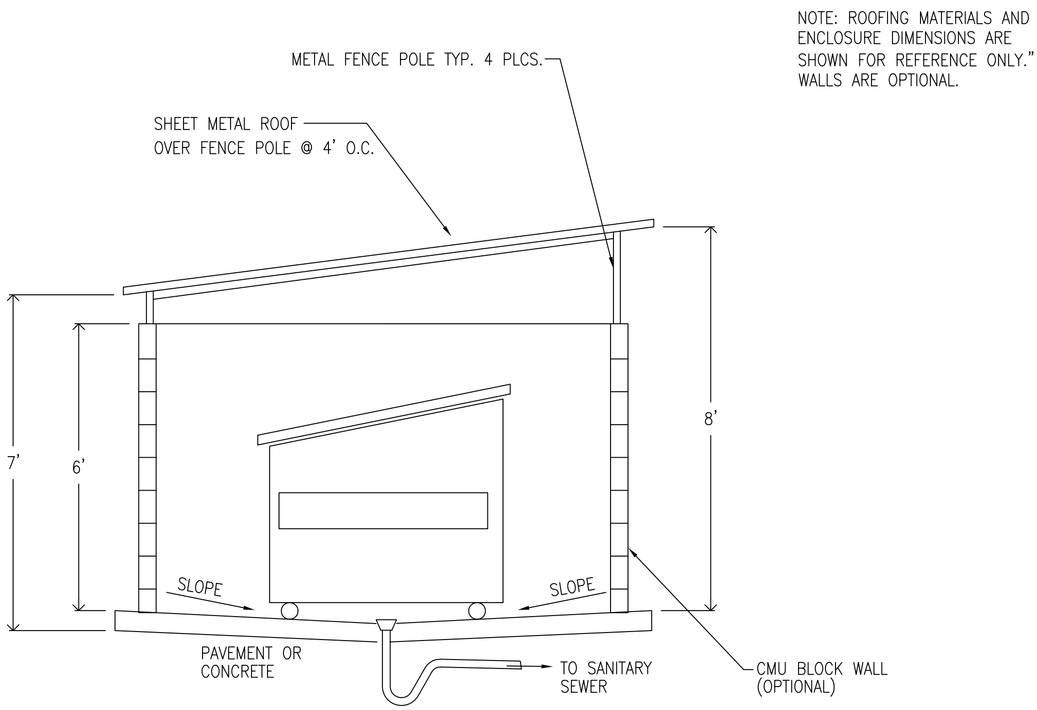
Oil-Water Separators

Source Control

Bureau of Environmental Services

NUMBER

SW-501



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STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

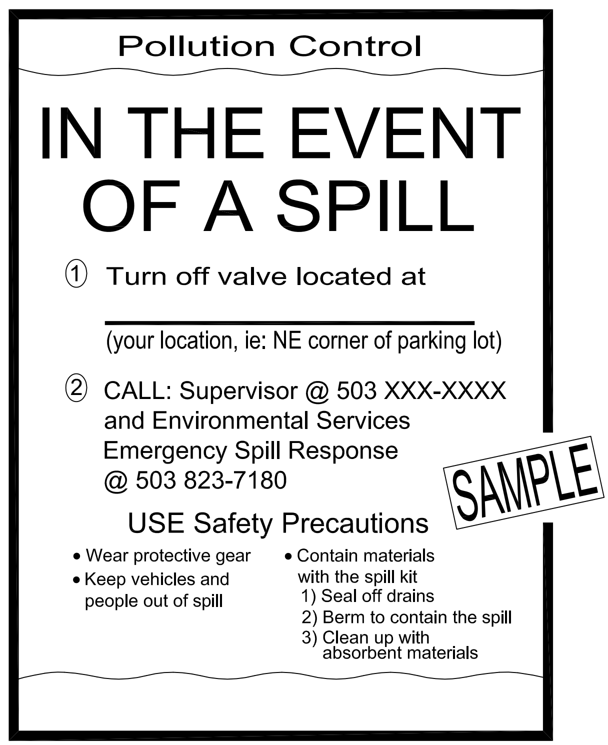
Trash Enclosure

Source Control

Bureau of Environmental Services

NUMBER

SW-510



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

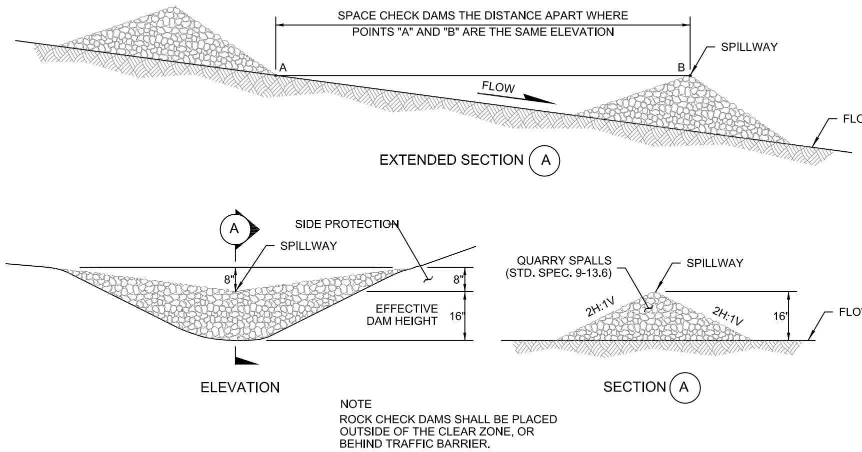
Spill Control Sign Examples

Source Control

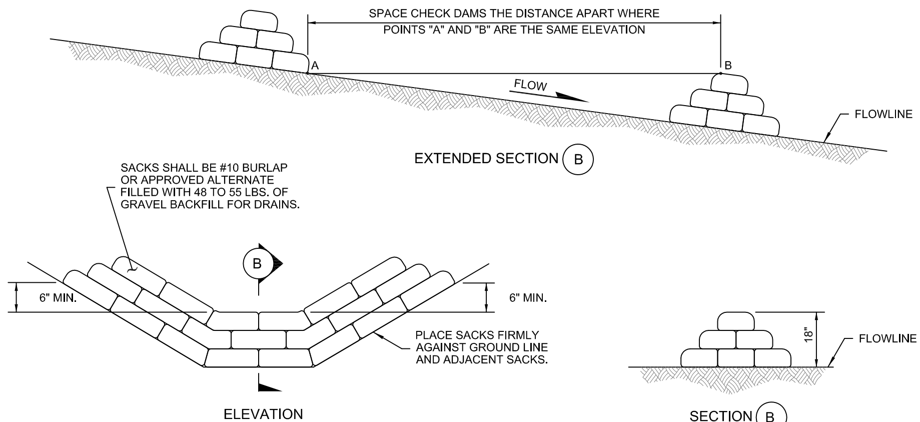
Bureau of Environmental Services

NUMBER

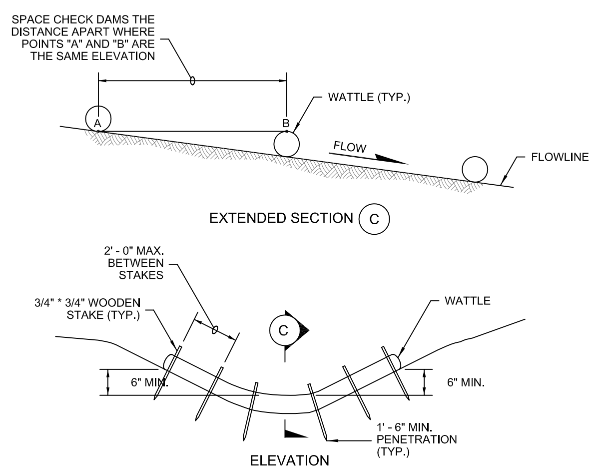
SW-511



ROCK CHECK DAM



SANDBAG CHECK DAM



WATTLE CHECK DAM

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

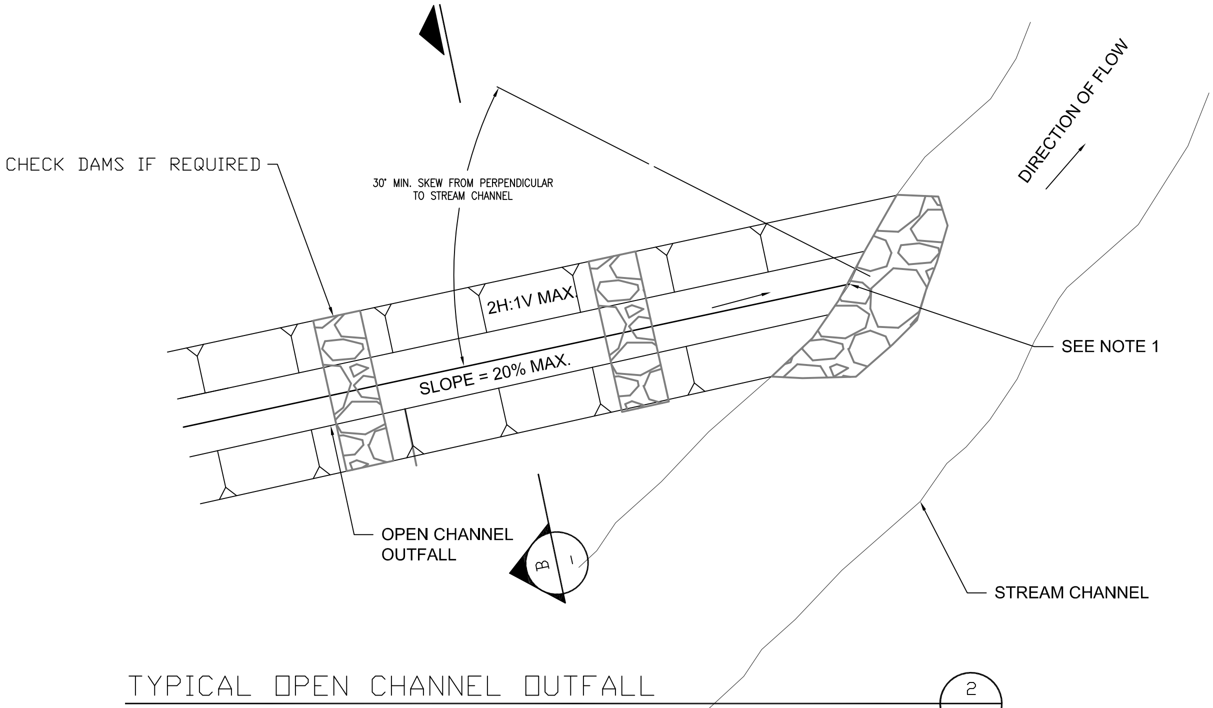
Outfall

Check Dams

NUMBER

SW-520

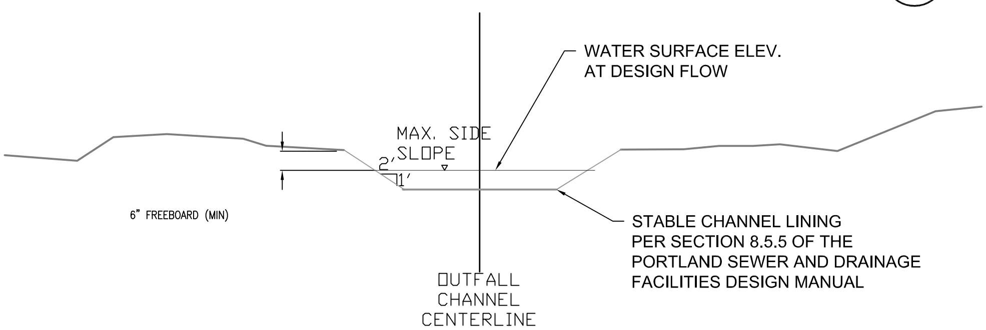
Bureau of Environmental Services



TYPICAL OPEN CHANNEL OUTFALL

NTS

2 / –



SECTION

NTS

B / –

NOTES

1. INVERT ELEVATION OF OPEN CHANNEL OUTFALL AT CONFLUENCE WITH STREAM CHANNEL SHALL BE AT OR NEAR INVERT OF MAIN CHANNEL.

2. OPEN CHANNEL OUTFALLS SHOULD NOT BE CONSTRUCTED IN AREAS WTIH UNSTABLE SOILS.

3. MAXIMUM LONGITUDINAL SLOPE FOR OPEN CHANNEL OUTFALL = 20 PERCENT

4. FOR LINING REQUIREMENTS, SEE SECTION 8.5.1 OF THE PORTLAND SEWER AND DRAINAGE FACILITIES DESIGN MANUAL 2006. FLEXIBLE LININGS RECOMMENDED FOR CHANNEL SLOPES > 2 PERCENT.

5. MAXIMUM SIDE SLOPES 2 H: 1 V. SHALLOWER SIDE SLOPES MAY BE REQUIRED DEPENDING ON THE CHANNEL MATERIAL (SEE SECTION 8.5.1 OF THE DESIGN MANUAL)

6. ALL DISTURBED AREAS TO BE REPLANTED WITH NATIVE VEGETATION. SEE SECTION 8.5.6 OF THE PORTLAND SEWER AND DRAINAGE FACILITIES DESIGN MANUAL 2006 AND SECTION 2.7 OF THE STORMWATER MANAGEMENT MANUAL (BES 2004).

7. CHECK DAMS MAY BE PROVIDED AS AN ALTERNATIVE TO LININGS TO MEET VELOCITY RESTRICTIONS OF SECTION 8.5.3 OF THE DESIGN MANUAL (SEE FIGURE 1)

8. 6 TO 12 INCHES OF FREEBOARD ABOVE THE 25-YEAR DESIGN STORM SURFACE WATER ELEVATION REQUIRED.

9. FOR MORE INFORMATION AND DETAILS SEE *CONCEPT DESIGNS AND TECHNICAL GUIDANCE: STORMWATER OUTFALLS* (HERRERA 2007).

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

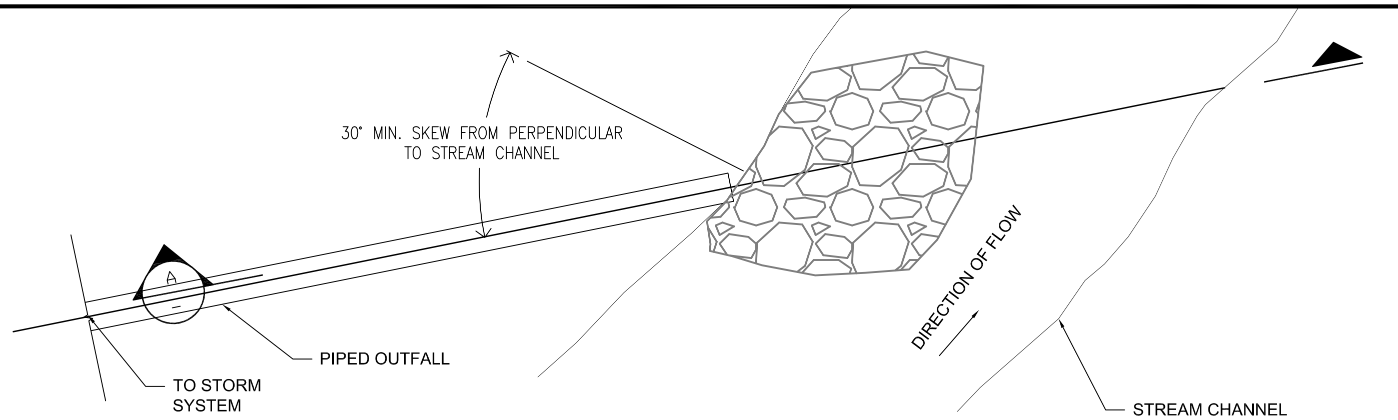
Outfall

Open Channel Outfall

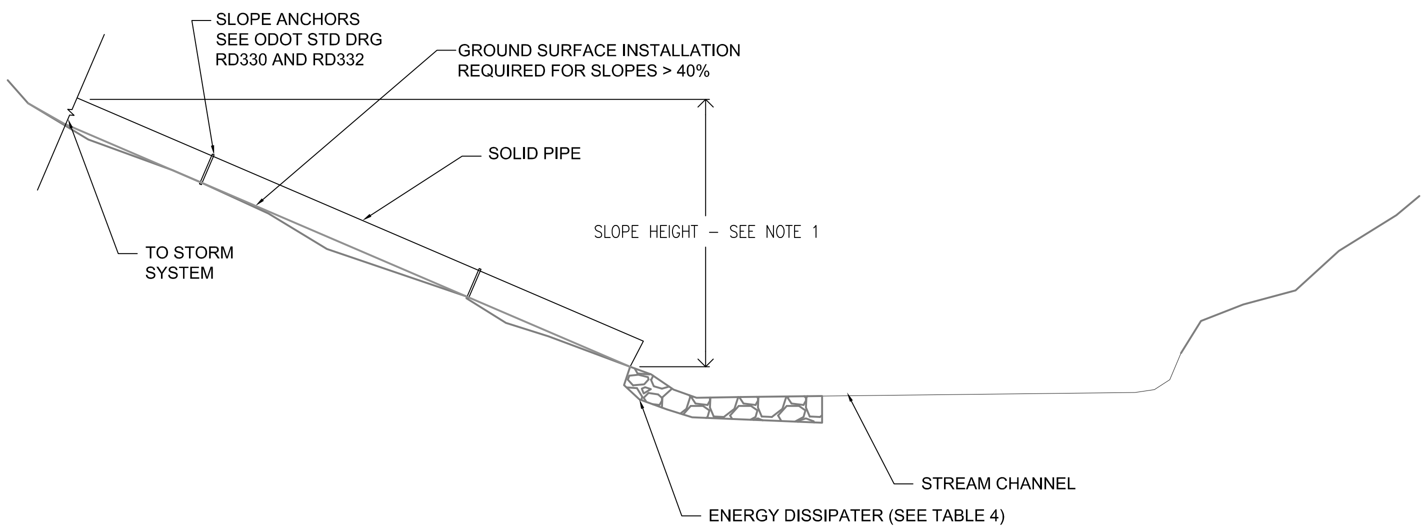
NUMBER

SW-521

Bureau of Environmental Services



TYPICAL PIPED OUTFALL - TIGHTLINE 1 / –



SECTION A / –

Notes:

1. For design guidelines for buried pipe, including materials, minimum cover, and bedding requirements, see Chapter 4 of the Portland Sewer and Drainage Facilities Design Manual 2006.

2. See Part 0400 of the City of Portland Standard Specifications for additional requirements on bedding, backfill and pipe materials.

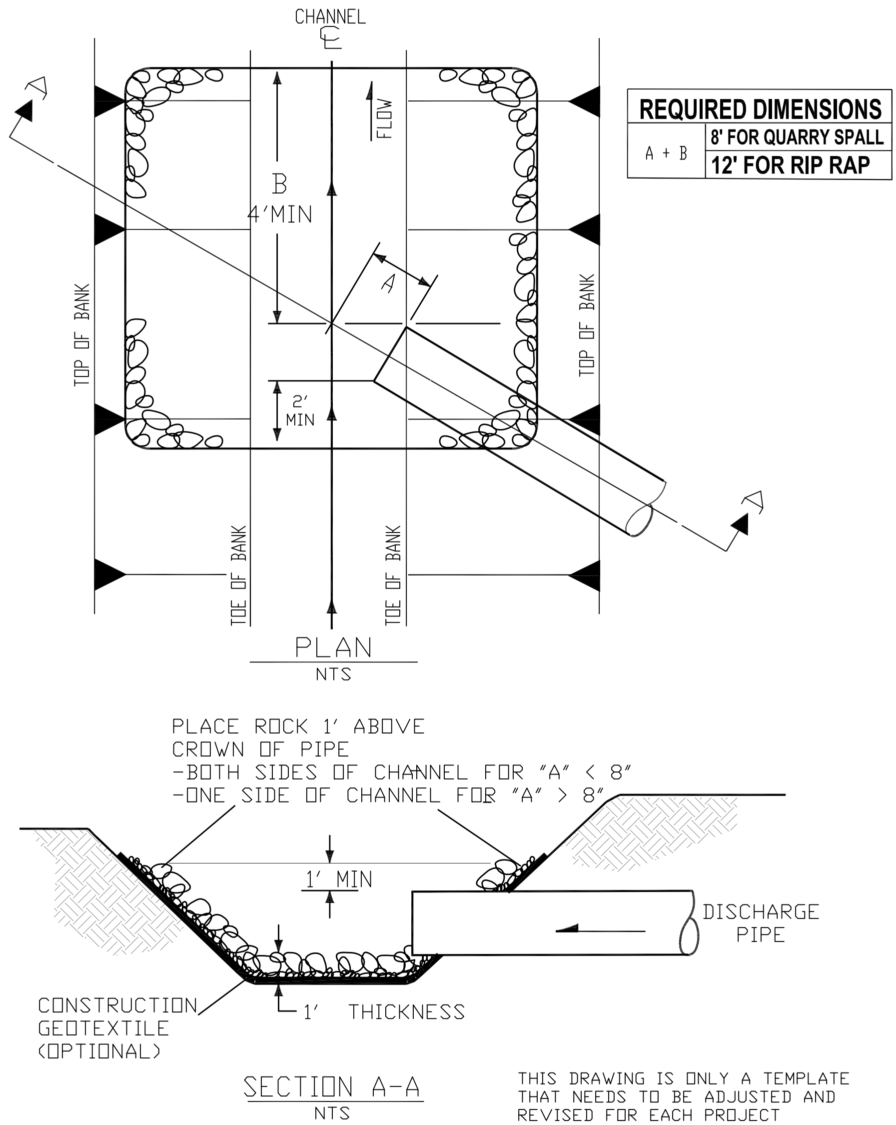
3. Solid pipe required for slopes higher than 20' with gradient of 15% or greater.

4. Solid pipe may be installed in shallow trench if outfall pipe gradient is between 15 and 40%. ground installation (as shown) recommended for slopes greater than 40%.

5. All disturbed areas to be replanted with native vegetation. See section 8.5.6 of the Portland Sewer and Drainage Facilities Design Manual 2006 and Appendix A.5 of the Stormwater Management Manual.

6. For more information and details see Appendix A.5 of the Stormwater Management Manual.

- DRAWING NOT TO SCALE -



REQUIRED DIMENSIONS	
A + B	8' FOR QUARRY SPALL
	12' FOR RIP RAP

PIPE/CULVERT OUTFALL DISCHARGE PROTECTION

NOTES

1. SOURCE: WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) HIGHWAY RUNOFF MANUAL, FIGURE 5.4.3.8.

2. FOR MORE INFORMATION AND DETAILS SEE *CONCEPT DESIGNS AND TECHNICAL GUIDANCE: STORMWATER OUTFALLS* (HERRERA 2007).

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

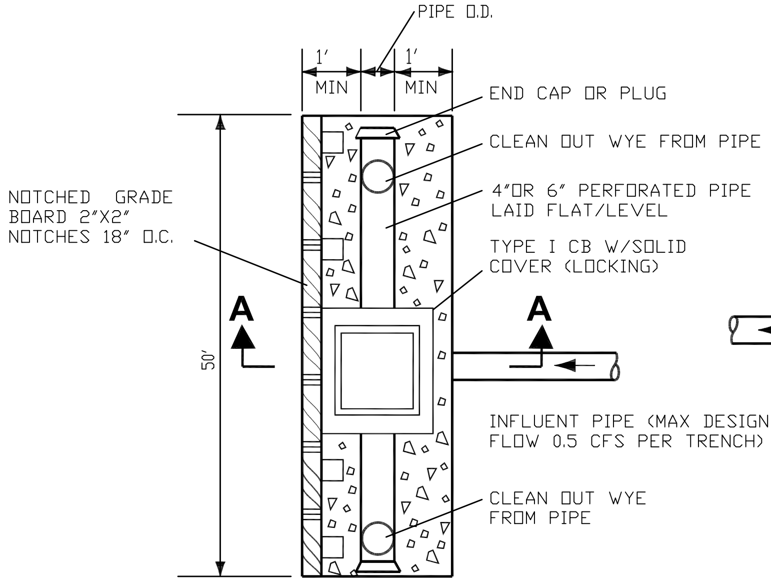
Outfall

Rock Energy Dissipator

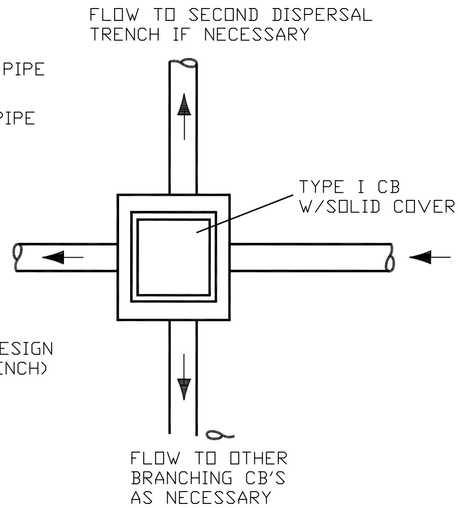
Bureau of Environmental Services

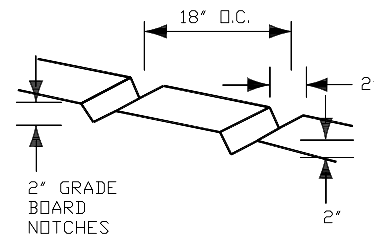
NUMBER

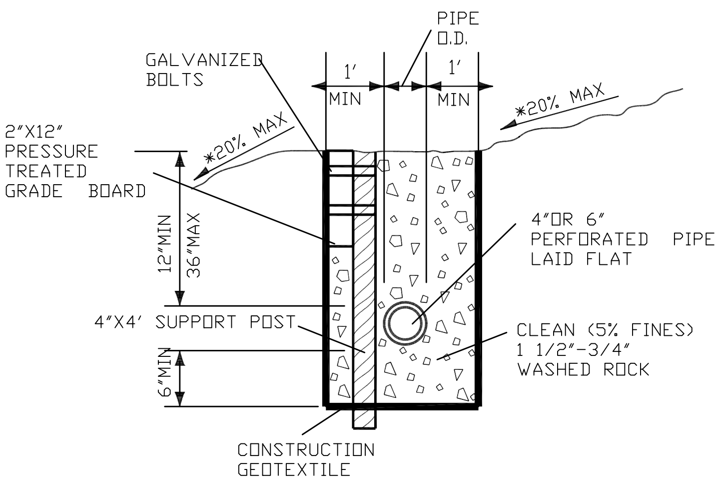
SW-523



PLAN
NTS







SECTION A-A
NTS

*15% MAX FOR FLOW CONTROL/WATER QUALITY TREATMENT IN RURAL AREAS.

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 GRADE BOARD MUST BE LEVEL. ALIGN TO FOLLOW CONTOURS OF SITE.
4. SUPPORT POST SPACING AS REQUIRED BY SOIL CONDITIONS TO ENSURE GRADE BOARD REMAINS LEVEL.

FLOW DISPERSAL TRENCH

THIS DRAWING IS ONLY A TEMPLATE THAT NEEDS TO BE ADJUSTED AND REVISED FOR EACH PROJECT

NOTES

1. SOURCE: WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) HIGHWAY RUNOFF MANUAL, FIGURE 5.4.3.9.
2. FOR MORE INFORMATION AND DETAILS SEE *CONCEPT DESIGNS AND TECHNICAL GUIDANCE: STORMWATER OUTFALLS* (HERRERA 2007).

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

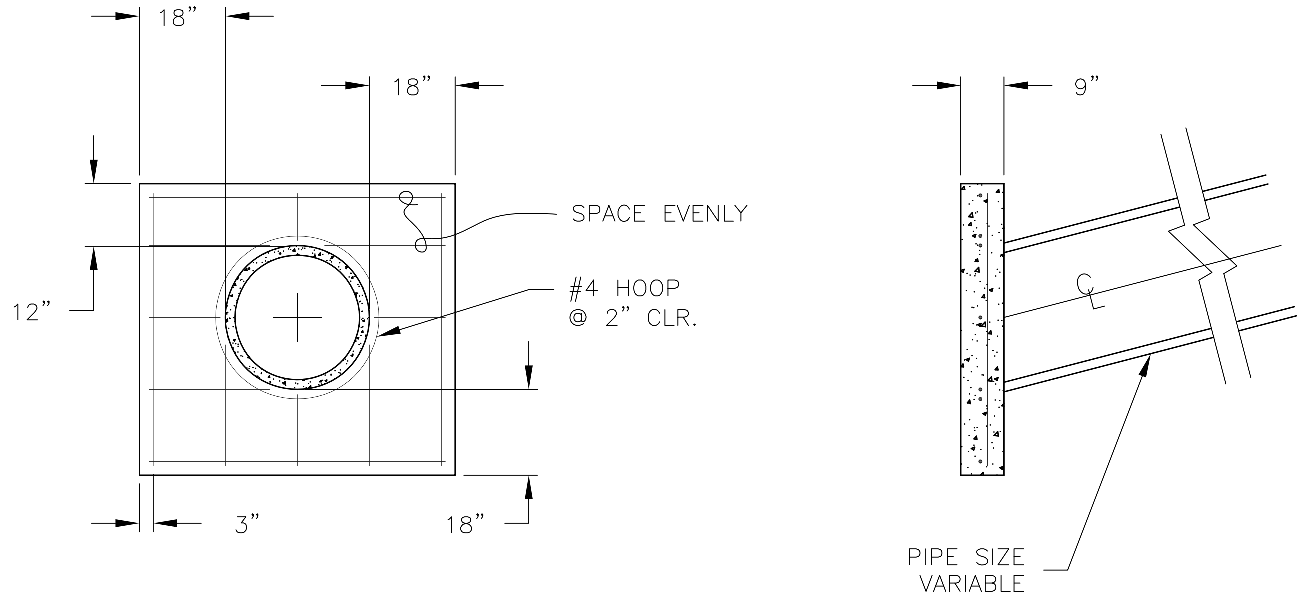
Outfall

Upland Dispersion

NUMBER

SW-524

Bureau of Environmental Services



NOTES:

1. CONCRETE TO BE 3000psi (28 DAYS ULTIMATE STRENGTH, SLUMP OF 2" TO 5" AND 1 1/2" MINUS AGGREGATE).
2. ALL REINFORCING STEEL fy = 60,000psi.
3. FILL AROUND ENDWALLS TO 6" BELOW TOP OF WALL.
4. BASE OF OUTFALL SHALL BE POURED AGAINST UNDISTURBED SOIL.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

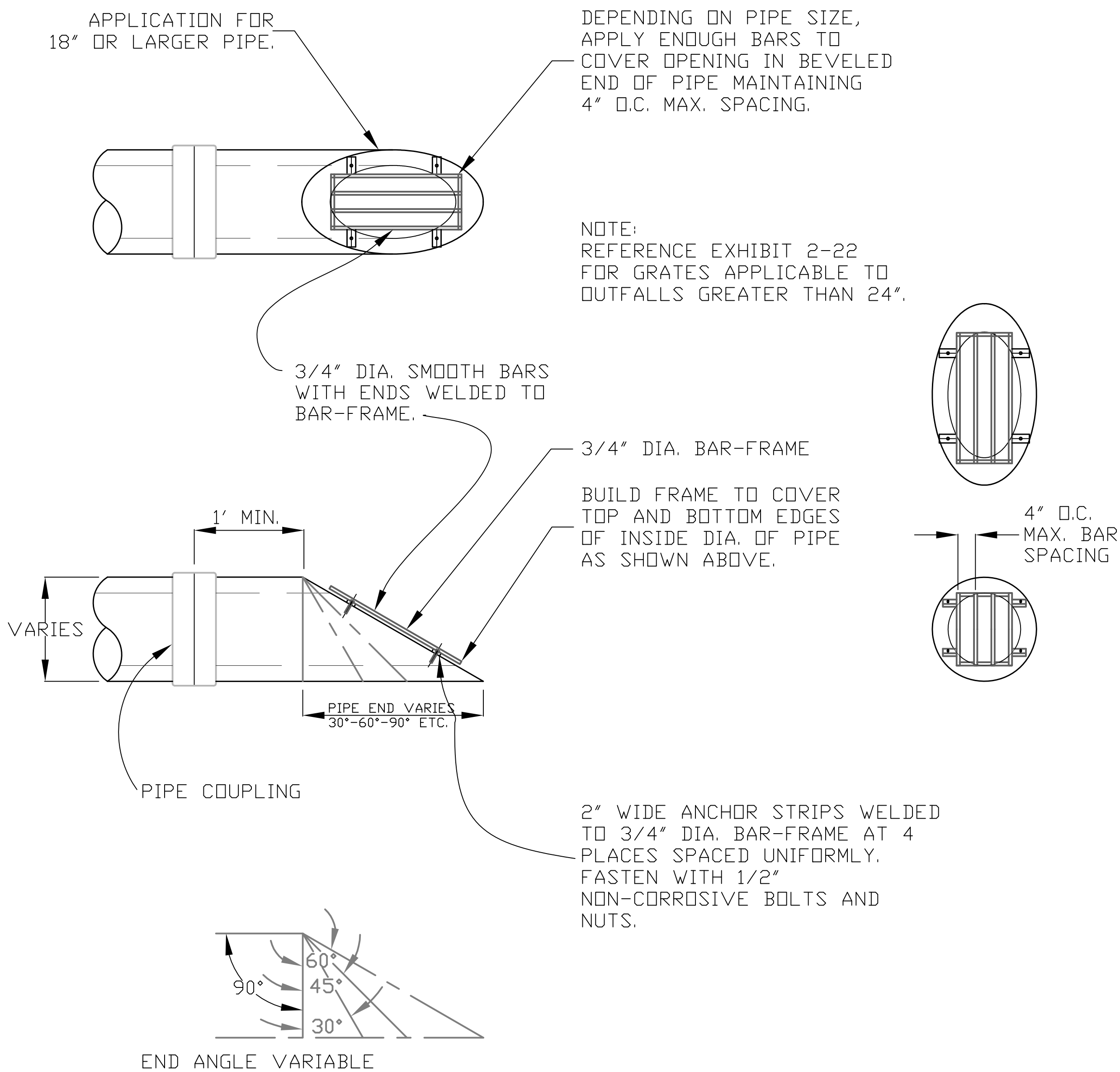
Outfall

End Wall

Bureau of Environmental Services

NUMBER

SW-525



- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

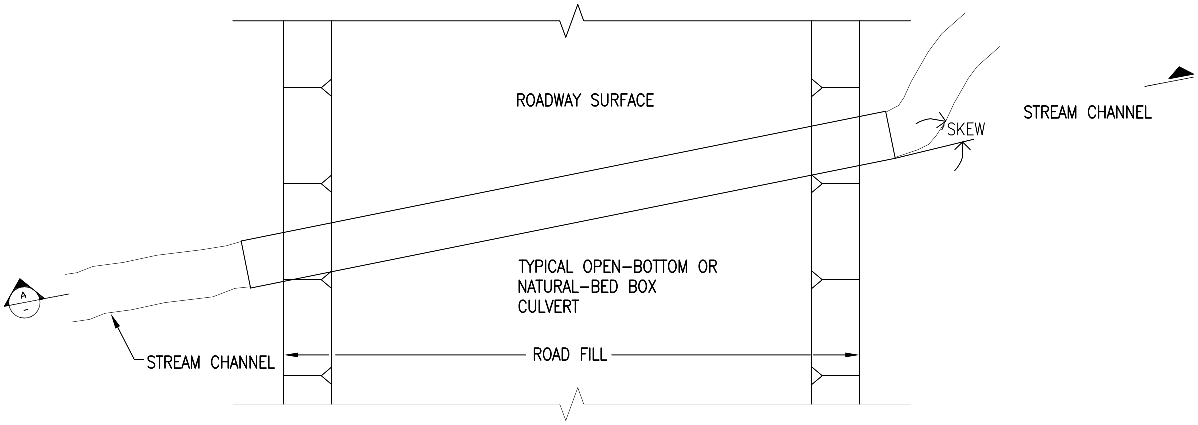
Outfall

Grated Protection

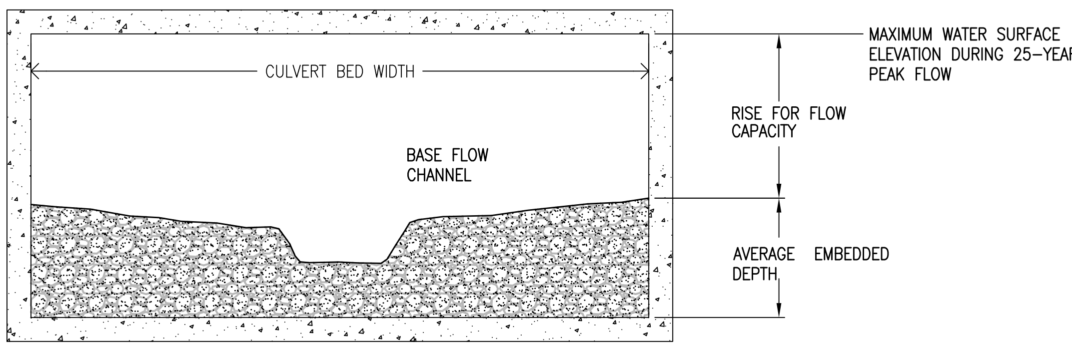
Bureau of Environmental Services

NUMBER

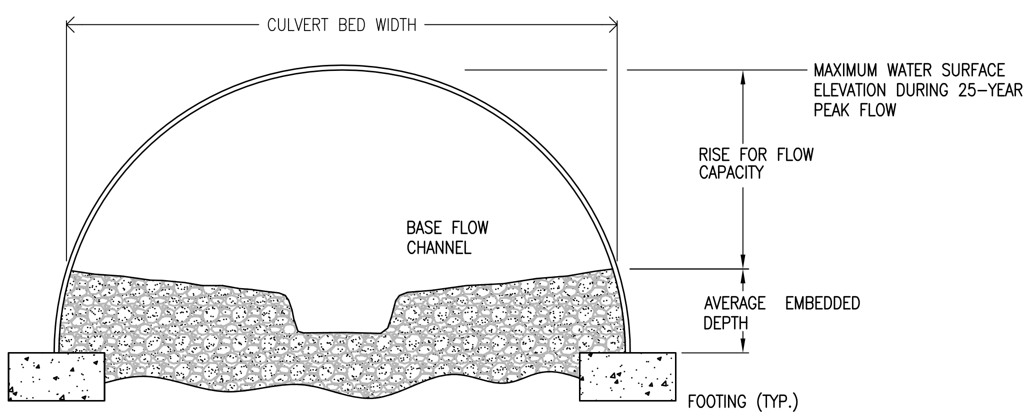
SW-526



TYPICAL OPEN-BOTTOM OR NATURAL-BED BOX CULVERT



TYPICAL NATURAL-BED BOX CULVERT



TYPICAL OPEN-BOTTOM METAL ARCH CULVERT

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT MANUAL SUPPLEMENTAL DETAILS

- Supplemental Details -

Culvert

Alignment & Profile

NUMBER

SW-530

Bureau of Environmental Services

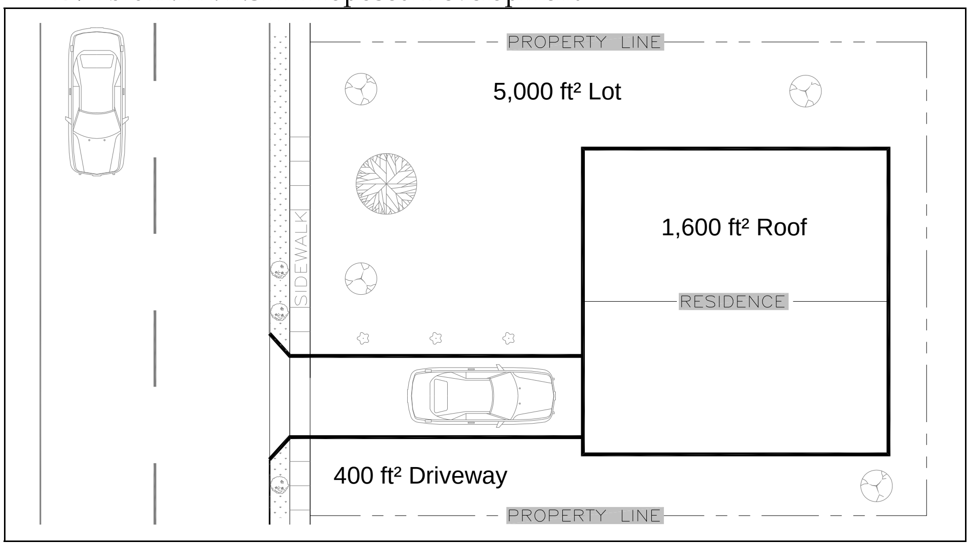
Appendix H Case Studies

This appendix is to help the user navigate the Stormwater Management Manual and apply it to projects of varying size, type, and complexity. The goal is a higher number of successful permit applications, resulting in fewer check-sheet revisions. Case studies 3-6 also focus on how to use the Presumptive Approach Calculator (PAC), including step-by-step iterative solutions.

CASE STUDY 1
New Single-Family Residence (NSFR)
East Side with Well Drained Soils

A single-family house with a footprint of 1,600 square feet and a driveway with a footprint of 400 square feet will be constructed on a 5,000-square-foot lot in southeast Portland (see Exhibit H.1-1).

Exhibit H.1-1: NSFR Proposed Development



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and PortlandMaps.com indicates that the soil in the area is "well drained" (Wetted Drainage Class Map), the hydrologic soil group is B, and depth to groundwater is approximately 100 feet (Depth to Seasonal High Groundwater Map). The lot has slopes less than 5 percent, according to the slope map on Portlandmaps.com.

2. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

Setbacks for stormwater facilities vary, based on the type of facility and the selected piping configuration. Infiltration facilities are required to be 5 feet from property lines and 10 feet from foundations, measured to the center line of the facility. Flow-through facilities can have zero setbacks as long as they are lined and are no taller than 30 inches above adjacent grade. Refer to **Section 2.1.2** for detailed setback requirements.

3. Characterize Site Drainage Area and Runoff

Stormwater from the house and the driveway must be treated. The total impervious area treated will be 2,000 square feet: 1,600 from the house and 400 from the driveway.

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**). For this property, the proposed impervious area is less than 10,000 square feet; therefore, the Simplified Approach may be used. The Presumptive or Performance Approach may also be used to size the stormwater facility if desired.

Infiltration Test

All development projects are required to submit results of infiltration testing. **Appendix F.2** describes four typically accepted testing methods. The simplified open pit test qualifies under the Simplified Approach and is described on the **Simplified Approach Form** (see **Appendix D.3**). Submit open pit infiltration testing results in Section S4 of the Simplified Approach Form.

Following the Simplified open pit test instructions, the tested infiltration rate is 8 inches/hour.

In this case, with well-drained- soils, mild slopes, and > 2 inches/hour tested infiltration rate, total onsite infiltration is required. The Site Development section of the Bureau of Development Services (BDS) approves onsite infiltration facilities on private property.

Hierarchy Category and Discharge Point

Knowing that the native soil infiltration rate tested greater than 2 inches/hour, total onsite infiltration is feasible and required. Referring to **Exhibit 1-2**: Stormwater Hierarchy, we can determine that the site can abide by category 1 requirements, but only has to abide by category 2, since the residential rooftop exemption (**Section 1.3.3**) allows NSFRs to move directly to category 2.

The driveway is not part of the rooftop runoff and therefore requires a separate facility. Since there is adequate infiltration and acceptable slopes, category 1 requirements must be met. The driveway may use pervious pavement or be graded to sheet flow into adjacent lawn areas. The lawn area can be considered a filter strip for the purposes of the manual; a level spreader and vegetation other than lawn may be required, depending on the design.

In certain circumstances, the Bureau of Environmental Services (BES) may approve sheet flow to the public street from runoff generated in a standard-size (500 square feet) residential driveway. This will occur only where there is no practical way to treat the water onsite and must be accompanied by the justification to move down in the hierarchy.

4. Determine Source Control Requirements

There are no required source control requirements for this NSFR.

5. Develop a Preliminary Design

The design of the stormwater facility must meet required setbacks. All setbacks are noted on the facility details and must be shown on the site plan. Pollution reduction and infiltration & discharge facilities should be selected from **Chapter 2.3**, which shows design requirements for all facilities.

Option 1

Drywell: If drywells are used to infiltrate stormwater from the rooftop areas, **Exhibit 2-36:** Drywell Sizing Chart is used. In accordance with this exhibit, a 10-foot-deep, 28-inch-diameter drywell or a 5-foot-deep, 48-inch-diameter drywell is required to infiltrate stormwater from impervious areas between 1,000 and 2,000 square feet in size. The design criteria presented in the private drywell section (see **Appendix G-1, Exhibit SW-170**) must be used to design the drywell and to locate the facility onsite. Location and setbacks must be shown on the permit drawings.

Option 2

Soakage Trench: If soakage trenches are used to infiltrate stormwater from the rooftop areas, **Appendix G-1, Exhibit SW-180**: East Soakage Trench is used. In accordance with this exhibit, 20 feet of soakage trench is required per 1,000 square feet of rooftop area. In this example, the length of soakage trench needed to dispose of stormwater from the roof area will be: 1,600 x (20/1,000) = 32 feet. If used for the roof *and* the driveway, the soakage trench will need to be: 2,000 x (20/1,000) = 40 feet. The design criteria presented in the trench section must be used for design and to locate the facility onsite. Location and setbacks must be shown on the permit drawings.

Option 3

Surface Infiltration Facilities: If surface infiltration facilities are used to infiltrate stormwater from the rooftop areas, the **Simplified Approach Form** (in **Appendix D.3**) can be used to size the facility. The Simplified Approach Form shows the sizing factor for an infiltration basin as 9percent of the impervious area treated. A basin 190 square feet would be required to treat the 2,000 square feet of roof and driveway. An overflow is required from the facility. An infiltration swale or infiltration planter could also be used. See **Section 2.3** for design requirements for all facilities. Setbacks from the building structure must be considered. The detailed design and location must be shown on the permit drawings.

6. Develop a Landscape Plan

Subsurface facilities, such as drywells and soakage trenches, do not require landscaping plans. If a surface infiltration facility is used, the minimum submittal requirement (since Simplified Approach sizing is used) is the number and type of plants that will be installed (see **Appendix D.1**).

7. Complete a Stormwater Management Report

This application follows the Simplified Approach and therefore is not required to submit a Stormwater Management Report.

8. Prepare an Operation and Maintenance Plan

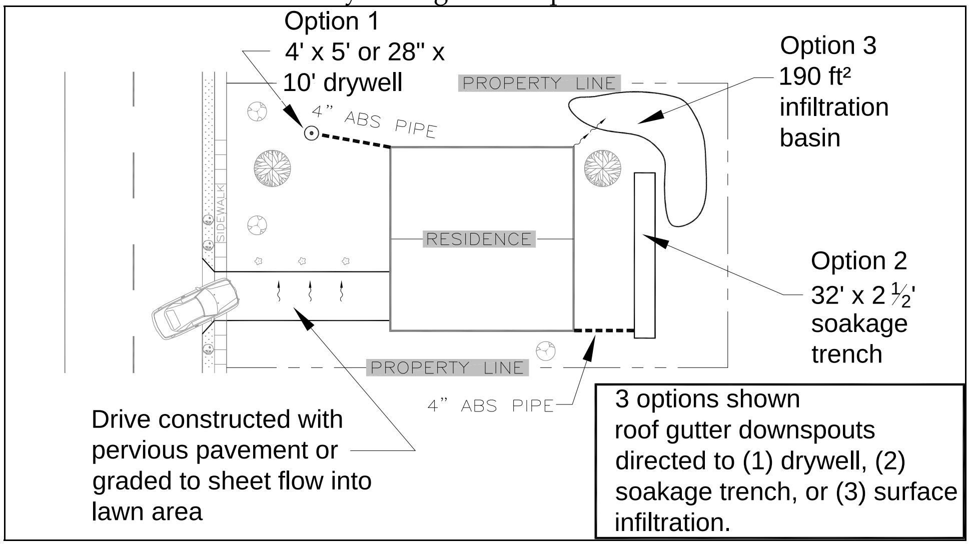
An **O&M Form** (see **Appendix D.5**) will be required if the vegetated surface facility is chosen. The form must be filled out and recorded with the applicable county and submitted to BES prior to permit approval. Provide the completed O&M Form and attach the applicable O&M specification found in **Section 3.3.1**.

At least a draft of the O&M Form must be submitted with the building plans. The final O&M Form may be submitted after partial City review (check sheet notice from the BES reviewer). Because the recorded O&M Form must reflect the approved plan set rather than the proposed plan set, however, it may be advantageous to delay the final submission until the plan set has been approved.

9. Submit Final Plans and Obtain Permits

Submit a plan set (including site plan and cross section) and the completed Simplified Approach Form. The drywell, soakage trench, or other stormwater management facilities must be shown on the site plan, with adequate setbacks provided, as shown on **Exhibit H.1-2**.

Exhibit H.1-2: Case Study Management Options for Well-Drained Soils



10. Construct and Inspect

BDS will perform inspections on private property. Use the BDS interactive voice response (IVR) Line (see **Exhibit 2.2**) to schedule residential (RS) permit inspections.

END

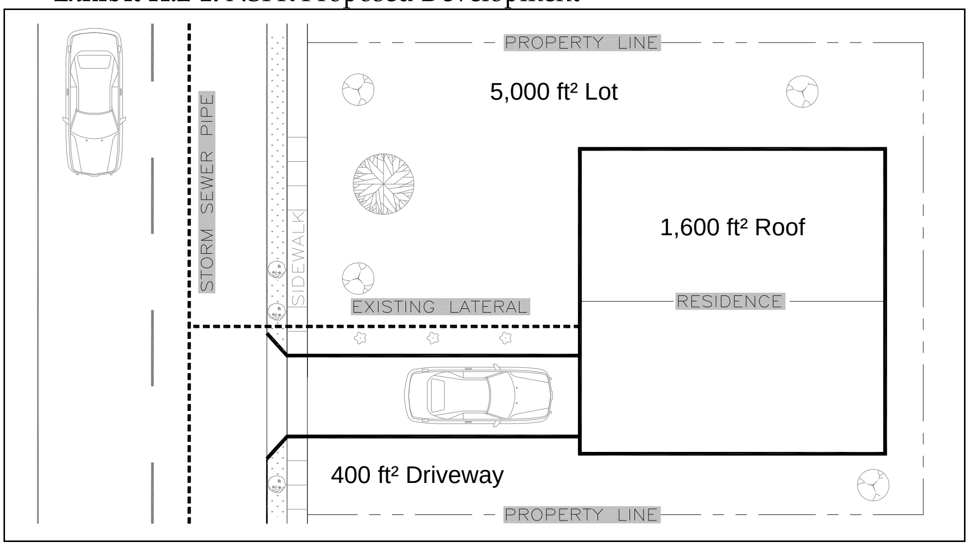
CASE STUDY 2

New Single-Family Residence (NSFR)

West Side with Poorly Drained Soils

A single-family house with a footprint of 1,600 square feet and a driveway with a footprint of 400 square feet will be constructed on a 5,000-square-foot lot in southwest Portland (see Exhibit H.2-1).

Exhibit H.2-1: NSFR Proposed Development



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and PortlandMaps.com indicates that the soil in the area is "poorly drained" (Wetted Drainage Class Map), the hydrologic soil group is C, and depth to groundwater is approximately 40-60 feet (Depth to Seasonal High Groundwater Map), but the depth to the relatively impervious fragipan layer is only 2-3 feet (Depth to Fragipan Layer). The lot has slopes less than 10-20 percent, according to the slope map on Portlandmaps.com. There is an existing public storm sewer pipe in the frontage street, with a lateral to the lot.

2. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

Setbacks for stormwater facilities vary, based on the type of facility and the selected piping configuration. Infiltration facilities are required to be 5 feet from property lines and 10 feet from foundations, measured to the center line of the facility. Flow-through facilities can have zero setbacks as long as they are lined and are no taller than 30 inches above adjacent grade. Refer to **Section 2.1.2** for detailed setback requirements.

3. Characterize Site Drainage Area and Runoff

Stormwater from the house and the driveway must be treated. The total impervious area treated will be 2,000 square feet: 1,600 from the house and 400 from the driveway.

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**). For this property, the proposed impervious area is less than 10,000 square feet; therefore, the Simplified Approach may be used. The Presumptive or Performance Approach may also be used to size the stormwater facility if desired.

Infiltration Test

All development projects are required to submit results of infiltration testing. **Appendix F.2** describes four typically accepted testing methods. The simplified open pit test qualifies under the Simplified Approach and is described on the **Simplified Approach Form** (see **Appendix D.3**). Submit open pit infiltration testing results in Section S4 of the Simplified Approach Form.

Following the simplified open pit test instructions, the tested infiltration rate is 0.3 inch/hour.

In this case, with poorly drained soils and relatively steep slopes, onsite infiltration is most likely not feasible. The Site Development section of the Bureau of Development Services (BDS) should be consulted for proposal of onsite infiltration facilities in these conditions.

Hierarchy Category and Discharge Point

Category 1 (surface infiltration facilities) and category 2 (onsite infiltration with drywell or soakage trench) of the stormwater hierarchy (see **Exhibit 1-2**) depend on project site soils that infiltrate relatively well (2 inches per hour minimum). The reason these categories cannot be met must be provided—for example:

> Categories 1 and 2 cannot be met because of a low infiltration rate, a wetted drainage class of "poorly drained," and moderate slopes.

Category 3 (offsite flow to drainageway, river, or storm-only pipe system) depends on the availability of such resources. Portlandmaps.com (Natural Resource and Sewer maps) or other City maps available from BES staff at the Development Services Center (1900 SW 4th Avenue) can be used to identify offsite stormwater conveyance systems. In this case, there is an existing storm sewer service lateral that the property will use, so the stormwater hierarchy will be category 3. Pollution reduction and flow control are required prior to discharge into the storm sewer.

In certain circumstances, the Bureau of Environmental Services (BES) may approve sheet flow to the public street from runoff generated in a standard-size (500 square feet) residential driveway. This will occur only where there is no practical way to treat the water onsite and must be accompanied by the justification to move down in the hierarchy.

4. Determine Source Control Requirements

There are no required source control requirements for this NSFR.

5. Develop a Preliminary Design

The design of the stormwater facility must meet required setbacks. All setbacks are noted on the facility details and must be shown on the site plan.

Pollution reduction and flow control facilities should be selected from **Chapter 2.3**, which shows design requirements for all facilities. Many facility types achieve both pollution reduction and flow control.

Option 1

Infiltration Planter: An infiltration planter will be used to manage stormwater from the rooftop and driveway, and the overflow will be connected to the storm sewer service lateral. This option provides partial infiltration. The Simplified Approach Form can be used to size the facility and shows the sizing factor for an infiltration planter to be 6 percent of the impervious area treated. A 120-square-foot planter would therefore be required to treat the 2,000 square feet of roof and driveway.

Option 2

Flow-through Planter: A flow-through planter will be used to manage stormwater from the rooftop, and the overflow will be connected to the storm sewer service lateral. The Simplified Approach Form can be used to size the facility and shows the sizing factor for an infiltration planter to be 6 percent of the impervious area treated. A 96-square-foot basin would be required to treat the 1,600 square feet of roof.

The driveway may be paved with pervious pavement, and the grade will allow sheet flow into adjacent lawn area. Since infiltration is limited, the lawn must meet the filter strip design criteria (at least 1 square foot of lawn area per 5 square feet of driveway area), so the lawn area must be at least 8 x 10 feet.

The downspouts can be plumbed to one large planter, or the planters can be split up and located at each roof downspout (assuming proportionate impervious area to facility area).See **Section 2.3** for design requirements for all facilities   Setbacks from the building structure must be considered. The detailed design and location must be shown on the permit drawings.

6. Develop a Landscape Plan

The minimum landscaping submittal requirement for these surface infiltration facilities (since Simplified Approach sizing is used) is the number and type of plants that will be installed (see **Appendix D.1**). Subsurface facilities such as drywells and soakage trenches do not require landscaping plans.

7. Complete a Stormwater Management Report

This application follows the Simplified Approach and therefore is not required to submit a Stormwater Management Report.

8. Prepare an Operation and Maintenance Plan

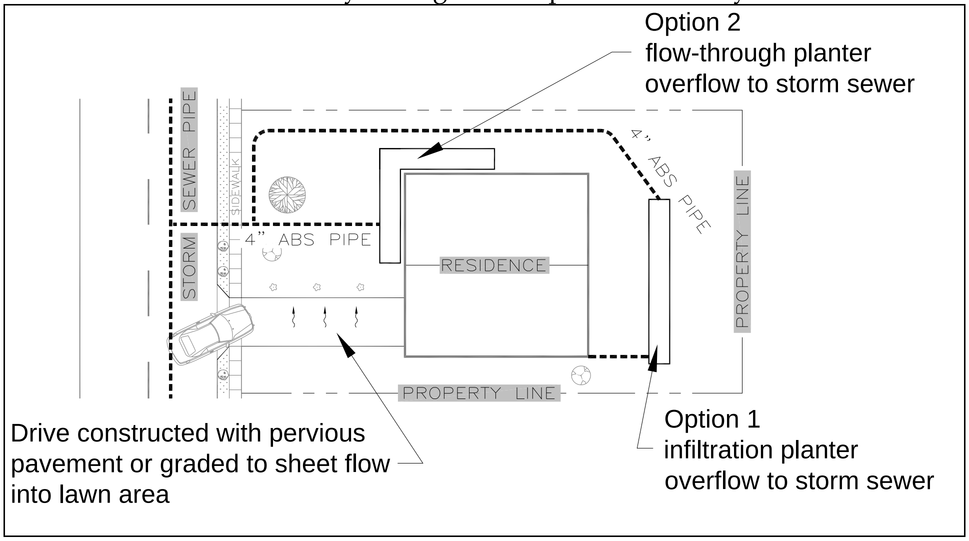
An **O&M Form** (see **Appendix D.5**) will be required if the vegetated surface facility is chosen. The form must be filled out and recorded with the applicable county and submitted to BES prior to permit approval. Provide the completed O&M Form and attach the applicable O&M specification found in **Section 3.3.1**.

At least a draft of the O&M Form must be submitted with the building plans. The final O&M Form may be submitted after partial City review (check sheet notice from the BES reviewer). Because the recorded O&M Form must reflect the approved plan set rather than the proposed plan set, however, it may be advantageous to delay the final submission until the plan set has been approved.

9. Submit Final Plans and Obtain Permits

Submit a plan set (including site plan and cross section) and the completed Simplified Approach Form. The stormwater management facilities must be shown on the site plan, with adequate setbacks provided, as shown on Exhibit H.2-2.

Exhibit H.2-2: Case Study Management Options for Poorly Drained Soils



10. Construct and Inspect

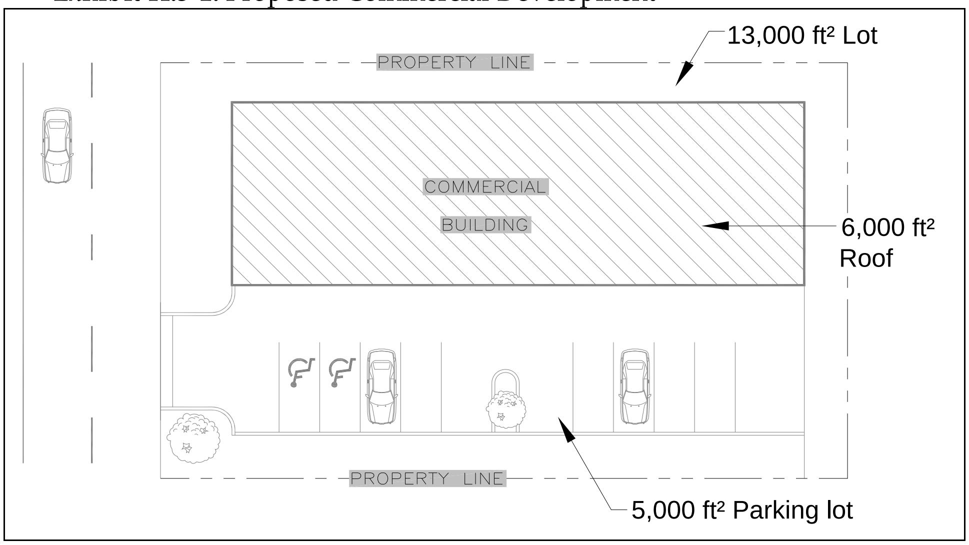
BDS will perform inspections on private property. Use the BDS interactive voice response (IVR) line (see **Exhibit 2.2**) to schedule residential (RS) permit inspections.

END

CASE STUDY 3
Commercial Development with Parking Lot
(North Portland with Well-Drained Soils)

A commercial building development with a 6,000-square-foot building footprint and a 5,000-square-foot parking lot will be constructed on a 13,000-square-foot lot in north Portland (see Exhibit H.3-1).

Exhibit H.3-1: Proposed Commercial Development



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and Portlandmaps.com indicates that the soil in the area is well drained (Wetted Drainage Class Map), the soil is within hydrologic group B, and the depth to groundwater is approximately 100 feet to seasonal high water table (Depth to Seasonal High Groundwater Map). Research of nearby well logs found on www.oregon.gov/owrd indicates the static ground water level to be 90 feet deep, approximately confirming the results of the water table map. The lot is sloped <5 percent, according to the slope map on Portlandmaps.com.

2. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

Setbacks for stormwater facilities vary, based on the type of facility and the selected piping configuration. Infiltration facilities are required to be 5 feet from property lines and 10 feet from foundations, measured to the center line of the facility. Flow-through facilities can have zero setbacks as long as they are lined and are no taller than 30 inches above adjacent grade. Refer to **Section 2.1.2** for detailed setback requirements.

3. Characterize Site Drainage Area and Runoff

Stormwater from the roof and the parking lot must be treated. The total impervious area treated will be 11,000 square feet: 6,000 square feet from the building and 5,000 square feet from the parking lot.

Based on this preliminary analysis and the fact that sumps exist in the street in front of the lot, the applicant should create a conceptual site plan that assumes total infiltration onsite.

Design Approach

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**).

Because the proposed impervious area is greater than 10,000 square feet, either the Presumptive or Performance Approach must be used. The applicant does not intend to use Performance Approach types of facilities (ponds, grassy swales, sand filters, rainwater harvesting, or detention facilities, as specified in **Exhibit 2-5**), so the Presumptive Approach will be used.

The applicant does have the option to provide enough impervious area reduction to qualify for the Simplified Approach. In that case, the applicant would need to provide 1,000 square feet or more of pervious pavement to be under the 10,000 square feet for total proposed impervious area.

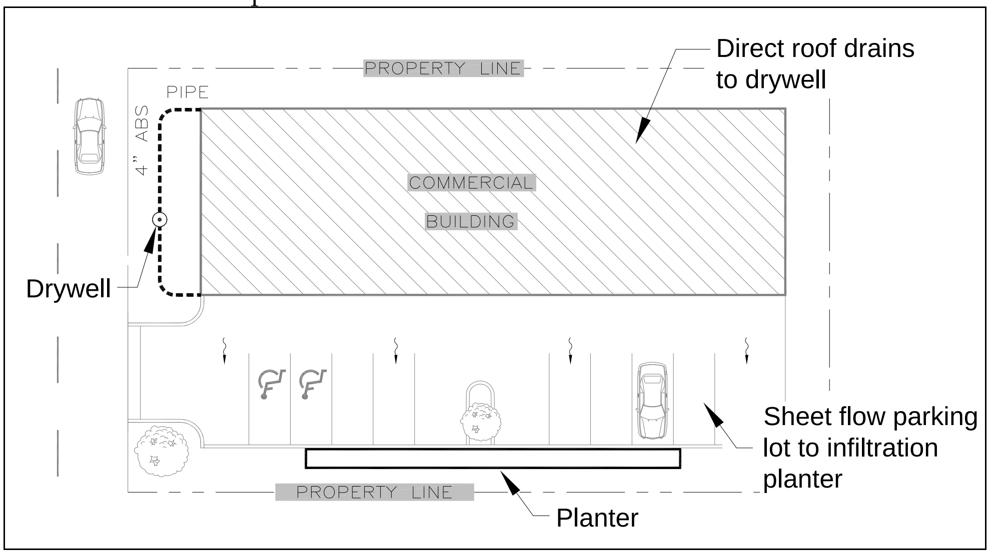
Conceptual Stormwater Plan

To test the soil infiltration rate in the appropriate locations and depths, a conceptual storm drainage plan must be created at this time (see Exhibit H.3-2). The conceptual stormwater strategies are identified below.

Roof Runoff: Because of the space constraints on the site and the earlier infiltration feasibility research, the concept for roof runoff will be to ultimately drain it to a drywell located in the landscape area.

Parking Lot Runoff: This example will examine two basic stormwater strategies for the parking lot area. The first is to use pervious pavement instead of impervious pavement, which would simply infiltrate any stormwater that fails on it. The second strategy is to grade the parking lot to drain to the southern edge of the parking lot, where there is just room enough for a 100-foot-long by 3-foot-wide infiltration planter with a 5-foot setback from the property line. Either of these strategies would satisfy the pollution reduction, flow control, and discharge requirements for the new developed area as long as the infiltration rates are adequate for infiltration.

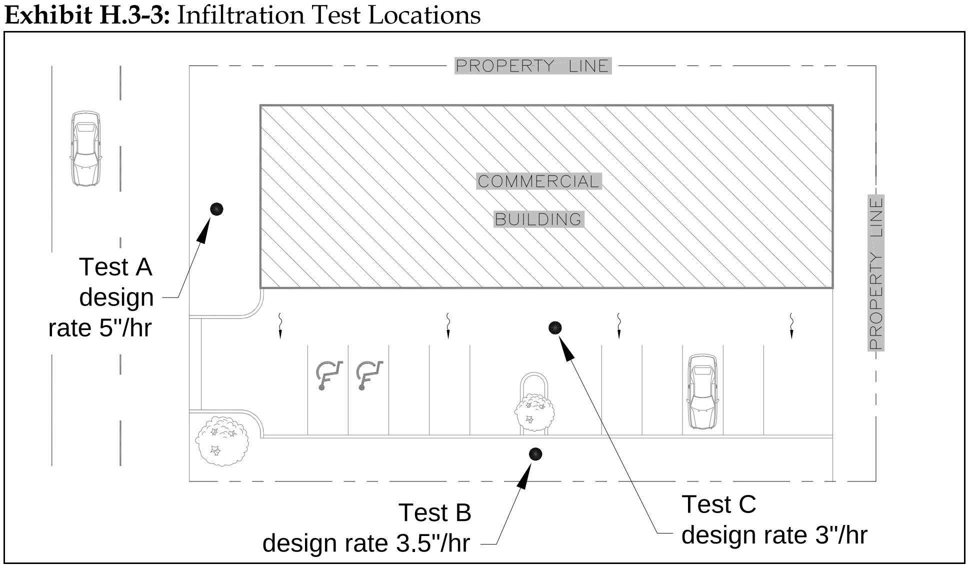
Exhibit H.3-2: Conceptual Site Plan



<u>Infiltration Tests</u>

Based on the conceptual site plan, the applicant must perform infiltration tests at three places: the proposed locations of the drywell, the infiltration planter, and the pervious pavement (see Exhibit H.3-3). Where infiltration rates are 2 inches per hour or greater (for the Simplified Approach refer to the tested infiltration rate; for the Presumptive Approach refer to the design infiltration rate) onsite infiltration is feasible and required.

Exhibit H.3-3: Infiltration Test Locations



Results of the infiltration tests are as follows:

Test A: Drywell location—hollow stem auger falling head test:
Tested rate of **15 inches/hour** at 12 feet in depth.

Test B: Infiltration planter location—open pit falling head test:
Tested rate of **7 inches/hour** at 3 feet in depth.

Test C: Pervious pavement location–open pit falling head test:
Tested rate of **6 inches/hour** at 1 foot in depth.

Correction or safety factors must be applied (see **Exhibit F.2-1** in **Appendix F.2**). The resulting **design** infiltration rates are as follows:

Test A: Hollow stem auger test, encased falling head; safety factor of 3:
Design infiltration rate = 15/3 = **5.0 inches/hour**.

Test B: Open pit falling head; safety factor of 2:
Design infiltration rate = 7/2 = **3.5 inches/hour**.

Test C: Open pit falling head; safety factor of 2:
Design infiltration rate = 6/2 = **3 inches/hour**.

Onsite infiltration is feasible and required because the soils are classified as well drained, slopes are minimal, and all design infiltration rates are greater than 2.0 inches per hour.

<u>Stormwater Management Requirements</u>

Every stormwater facility must meet the stormwater management requirements listed in **Section 1.3,** including infiltration and discharge, flow control, and pollution reduction.

Infiltration and Discharge
Based on the stormwater hierarchy (**Section 1.3, Exhibit 1-2**), it appears possible to follow the category 1 requirements, with category 2 as a reasonable backup. The research above indicates that this project will be able to provide onsite infiltration for all of the stormwater runoff. The project will meet category 1 or, if site restraints exist, will at least meet category 2.

Pollution Reduction
Parking lot runoff must meet pollution reduction requirements prior to infiltration or conveyance offsite. A "pass" result of the water quality storm within the Presumptive

Approach Calculator (PAC) (see #5, below) satisfies the pollution reduction requirement for this example.

Flow Control
Based on the stormwater hierarchy, discharge will be onsite. Onsite discharge satisfies the flow control requirement.

4. Determine Source Control Requirements

Source Control requirements must be met, see **Chapter 4**. For all new development, trash and recycling areas must meet **Section 4.4** source control requirements. For tenant improvements, trash and recycling areas must be categorized as high or low risk and follow the applicable requirements per **Section 4.4**. The trash enclosure must provide cover, pavement, and isolated drainage to the sanitary sewer.

5. Develop a Preliminary Design

The design of the stormwater facility must meet required setbacks. All setbacks are noted on the facility details and must be shown on the site plan.

Roof Runoff: The infiltration testing results indicate that there are good infiltration rates that would support discharge through a drywell. In accordance with **Exhibit 2-36**, a 10-foot-deep, 48-inch-diameter drywell should be sufficient to infiltrate stormwater from the 6,000-square-foot impervious rooftop area. However, if post-installation testing shows that it is not able to handle the 10-year event, a second drywell may be required. To avoid this, the drywell will be sized 15 feet deep. The roof water must first be treated for pollution reduction; a planter (planter #1) at the building foundation may be the easiest solution.

Parking Lot Runoff: The infiltration testing results indicate that there are fairly good infiltration rates at only a few feet below the proposed finished ground. Test C shows a design infiltration rate of 3 inches per hour, which is much higher than needed to use pervious pavement. However, because of the cost and anticipated maintenance of pervious pavement, the owner would rather have a vegetated infiltration facility to manage the parking lot runoff. Along the southern edge of the parking lot there is just room enough for a 100- by 3-foot-wide infiltration planter (planter 2), and the parking lot can be graded to drain there.

Presumptive Approach Calculator

The PAC is used to perform sizing calculations for the vegetated facility treating parking lot runoff. This case study is intended to be used as an exercise within the PAC.

Catchment Data Tab

Multiple values need to be entered into the catchment data tab (see **Exhibit H.3-4**).

Site-specific details are entered into the PAC summary page for the planter:

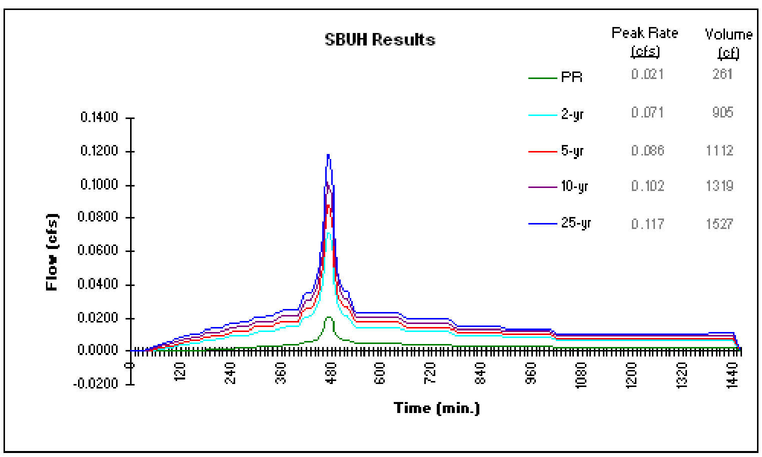
> *Project Name, Designer, Company*
> *Impervious Area:* 5,000 square feet
> *Curve Number:* 98 is default; otherwise, provide reasoning
> *Time of Concentration:* 5 minutes is default; otherwise, provide reasoning
> *Infiltration Test:* Open pit falling head
> *Tested Infiltration Rate:* 7.0inches/hour (no correction factor applied)

Execute SBUH Calculation, and print this page to include with stormwater submittals. The impervious area curve number and time of concentration can also be modified as long as adequate reasoning is provided.

Exhibit H.3-4: Catchment Data

Drainage Catchment Information		
Catchment ID	A	
	Catchment Area	
Impervious Area	5,000	SF
Impervious Area	0.11	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.
Site Soils & Infiltration Testing Data		
Infiltration Testing Procedure:	Open Pit Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	7	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section	Yes	
Correction Factor Component		
CF_{test} (ranges from 1 to 3)	2	
Design Infiltration Rates		
I_{dsgn} for Native (I_{test} / CF_{test}):	3.50	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH Calculations



Facility Design Tab

Four qualitative selections within the facility design tab set the underlying facility design (see Exhibits H.3-5 and H.3-6):

> *Hierarchy Category*

Facility Type
Facility Shape
Facility Configuration

Six to 10 quantitative selections within the facility design tab set the exact dimensions for the facility. The field names and the option to modify them depend directly on the qualitative selections from above.

As previously stated in this case example, the goal is to meet stormwater hierarchy category 1, but the roof area space restraints bump it to Category 2. The rectangle/square is chosen because it is the easiest shape to adjust when only rough dimensions of a facility are known. The selected facility configuration is A. This facility configuration contains no subsurface rock storage layer, which makes it generally simpler and less expensive to construct.

Hierarchy Category: 2
Facility Type: Planter
Facility Shape: Rectangle/square
Facility Configuration: A

Data For Above-Ground Storage Component
In the next several data entry cells, the facility bottom area, bottom width, side slope, and storage depth can be entered, based on the concept stormwater plan. There are different and potentially additional fields to populate for different qualitative selections. The *Run PAC* button must be checked every time any information is modified.

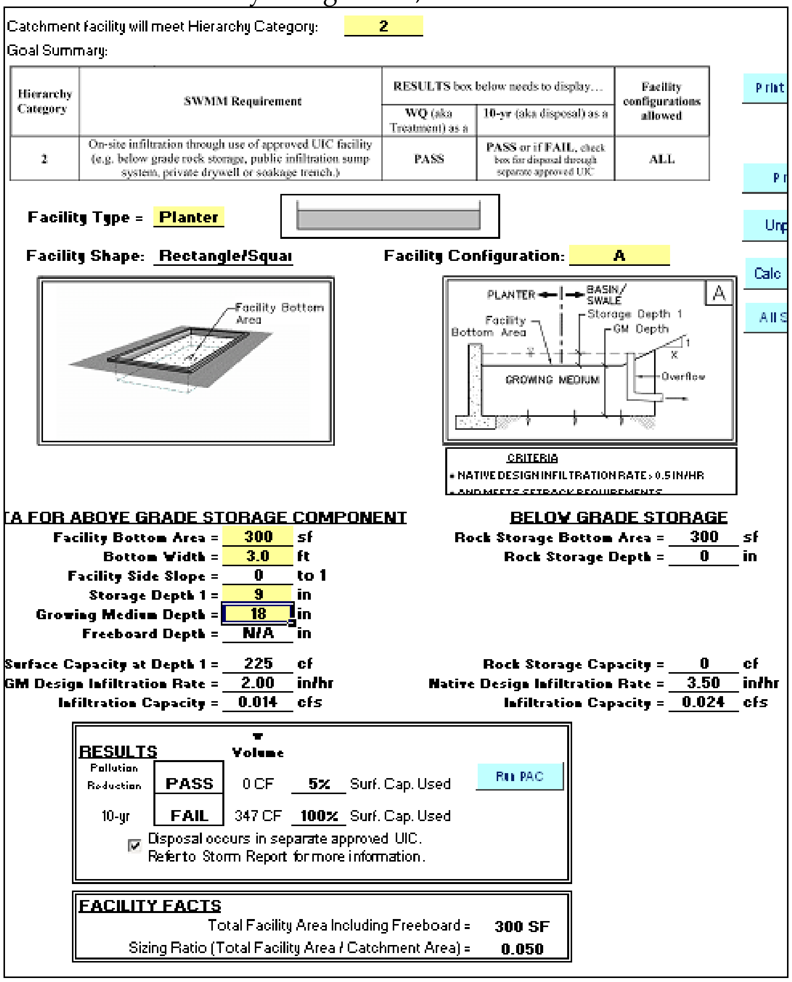
Planter Design (**Exhibits H.3-5** and **H.3-6 pages H-19 and H-21**)
The parking lot planter will serve as the discharge point as well as the pollution reduction (the 10-year event must be met). Simplified sizing is a good place to start [5000 x 0.06 = 300sf]. Each time a value is changed, the PAC must be recalculated: *Run PAC.*

- ***Trial A: Surface Infiltration Only:***
  The analysis is run based on a planter with 5,000 square feet of impervious area and no overflow outlet, relying on total infiltration (see Exhibit H.3-5). For this example, the pollution reduction and 10-year event both must have a pass. With a 300-square-foot planter at 9 inches maximum depth, this scenario fails. Increasing the depth of the planter to 15 inches will change it to a pass. However, the client would like to minimize the storage depth of water. Increasing the bottom area to 375 square feet would also give a pass, but would take up more room than is available.

  Trial A Input:
  Category: 1 (total onsite infiltration through surface facility)

Facility: Planter
Configuration: A (planter with no rock gallery and just growing medium)
Size: 300sf & 9” deep → 300sf & 15” deep → Pass → However, prefer less deep.
Bottom width: 3′

Exhibit H.3-5: Facility Design Data, Planter Trial A



- ***Trial B: Surface Infiltration with Overflow:***
  Since surface infiltration could not be achieved with these site and owner constraints, the analysis will be re-run for a planter with an overflow pipe to a drain rock storage layer directly beneath the planter. Entering the same parameters for the planter (300-square-foot bottom, 9 deep), but adding 300 square feet of 12-inch-deep drain rock beneath it gets a pass.
  *Note***:** This approach is considered Category 2 and will need to be registered with DEQ as an underground injection control (UIC) facility.

  Trial B Input:
  Category: 2 (total onsite infiltration through subsurface facility)
  Facility: Planter

Configuration: F (planter with overflow to rock gallery)
Size: 300sf & 9" deep & 12" rock → Pass → May be able to downsize it.
Storage Depth 3: 12'
Bottom width: 3'

- ***Trial C: Downsizing Trial B:***
  To see if the planter's overall size can be reduced, the analysis is run again with 260 square feet of planter with a 9-inch surface depth and drain rock at 12 inches deep; however, this results in a fail. If the rock is increased to 24 inches, the facility design will pass. With this input, the amount of surface capacity used for the water quality storm is 5 percent, the amount of surface capacity used for the 10-year storm is 100 percent, and 87 percent of the rock capacity is used. The surface has filled and overflowed to the rock gallery, filling up the drain rock to 87 percent of capacity (see Exhibit H.3-6).

  Trial C Input:
  Category: 2 (total onsite infiltration through surface facility)
  Facility: Planter
  Configuration: F (planter with overflow to rock gallery)
  Size: 260sf & 9" deep & 12" rock → 260sf & 9" deep & 24" rock → Pass
  Storage Depth 3: 24"
  Bottom width: 3

The facility therefore will be 100 feet long and 2.6 feet wide (260 square feet) with 2 feet of drain rock below the growing medium. The plumbing configuration will show an overflow to the rock trench, with no offsite discharge. (See **SW-150** in **Appendix G.1** for plumbing configuration and **SW-130** for planter typical detail).

Exhibit H.3-6: Facility Design Data, Planter Trial C

Catchment facility will meet Hierarchy Category: 2

Goal Summary:

Hierarchy Category	SWMM Requirement	RESULTS box below needs to display... WQ (aka Treatment) as a	10-yr (aka disposal) as a	Facility configurations allowed
2	On-site infiltration through use of approved UIC facility (e.g. below grade rock storage, public infiltration sump system, private drywell or soakage trench.)	PASS	PASS or if FAIL, check box for disposal through separate approved UIC	ALL

Print F

Pro

Unpr

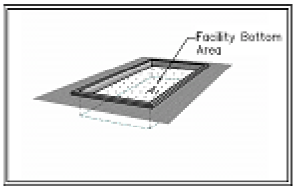
Calc S

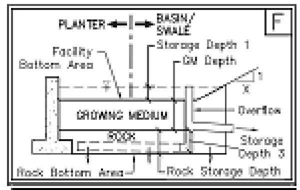
All S

Facility Type - Planter

Facility Shape: Rectangle/Squ

Facility Configuration: F





CRITERIA
* NATIVE DESIGN INFILTRATION RATE > 0.5 IN/HR
* AND MEETS SETBACK REQUIREMENTS

ATA FOR ABOVE GRADE STORAGE COMPONENT

Facility Bottom Area -	260	sf
Bottom Width -	3.0	ft
Facility Side Slope -	0	to 1
Storage Depth 1 -	9	in
Growing Medium Depth -	18	in
Freeboard Depth -	N/A	in
ace Capacity at Depth 1 -	195	cf
Design Infiltration Rate -	2.00	in/hr
Infiltration Capacity -	0.012	cfs

BELOW GRADE STORAGE

Rock Storage Bottom Area -	260	sf
Rock Storage Depth -	24	in
Rock Void Ratio -	0.3	
Storage Depth 3 -	24	in
Rock Storage Capacity -	156	cf
Native Design Infiltration Rate -	3.50	in/hr
Infiltration Capacity -	0.021	cfs

RESULTS

		Overflow		
Pollution Reduction	PASS	0 CF	5%	Surf. Cap. Used
			0%	Rock Cap. Used
10-yr	PASS	0 CF	100%	Surf. Cap. Used
			87%	Rock Cap. Used

Run PAC

☑ Disposal occurs in separate approved UIC. Refer to Storm Report for more information.

FACILITY FACTS

Total Facility Area Including Freeboard - 260 SF

Sizing Ratio (Total Facility Area / Catchment Area) - 0.052

6. Develop a Landscape Plan

Subsurface facilities such as drywells and soakage trenches do not require landscaping plans. A landscaping plan is required for the infiltration planter (see **Appendix D.1**).

7. Complete a Stormwater Management Report

The required contents of a Stormwater Management Report are shown below.

Stormwater Management Report

- **Cover Sheet**
- **Design Professional's Stamp**
- **Project Overview**
  The overview should provide perspective on what the project will encompass. The applicant must provide a brief overview of the location, size, and type of development. The description should continue with the potential effects on the existing watershed and drainage patterns. Please provide details about which permit authorities are being or have been contacted as well as the recent history of the site. Include recent case history or permit numbers with the City of Portland or other permit authorities.
- **Methodology**
  This section of the Stormwater Management Report shall first cover the local drainage within the project and surrounding areas. It is imperative to identify the drainage interaction between the project and the proposed development site.
  This section should also describe the infiltration results and their implications on discharge points including Hierarchy justifications; see **Section 1.3**.
- **Analysis**
  The analysis must cover the design assumptions and software used including design coefficients and safety factors. Tables are essential to clearly describe the facilities, their catchments, sizes, types, impervious areas treated, and peak flow rates showing compliance.
- **Engineering Conclusions**
  Conclusions must show how compliance is met with statements of the imposed requirements. Pollution reduction, flow control, and discharge requirements must be met.

See **Appendix D.4** for complete information about the submittal requirements for the Presumptive Approach.

8. Prepare an O&M Plan

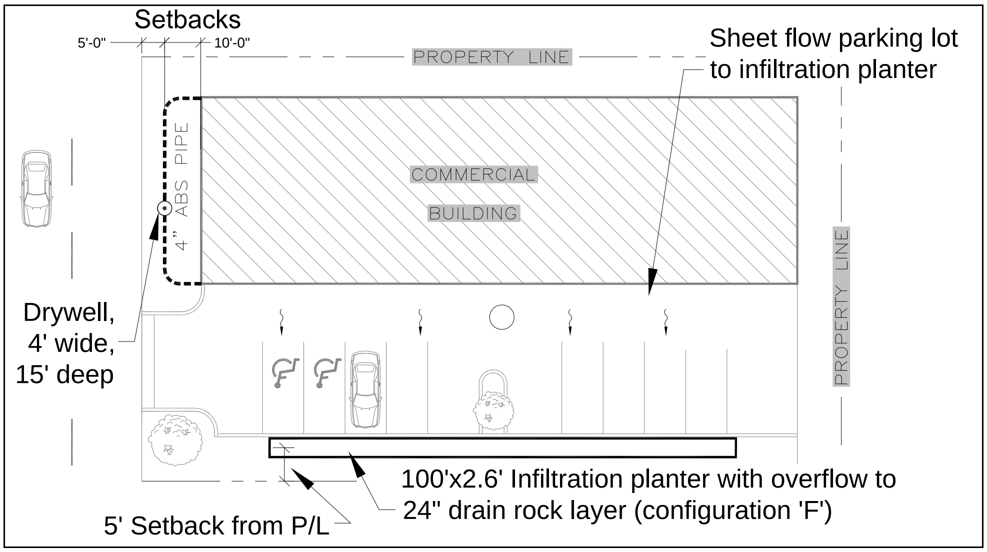
The **Operations and Maintenance Form** found in **Appendix D.6** must be recorded with the applicable county and submitted with the plan set at time of permit application.

Presumptive Approach permit applications are required to submit site-specific operations and maintenance plans. See **Sections 3.2** and **3.3** for further guidance.

9. Submit Final Plans and Obtain Permits

Exhibit H.3-7 shows the final site plan. Depending on whether the development is public or private, the applicant will follow the Public Works or the Bureau of Development Services (BDS) permit application process, respectively. Follow the links below for further submittal requirements.

Exhibit H.3-7: Final Site Plan



Public Works:
http://www.portlandonline.com/index.cfm?c=43826

Private Development:
http://www.portlandonline.com/bds/index.cfm?c=35883

10. Construct and Inspect

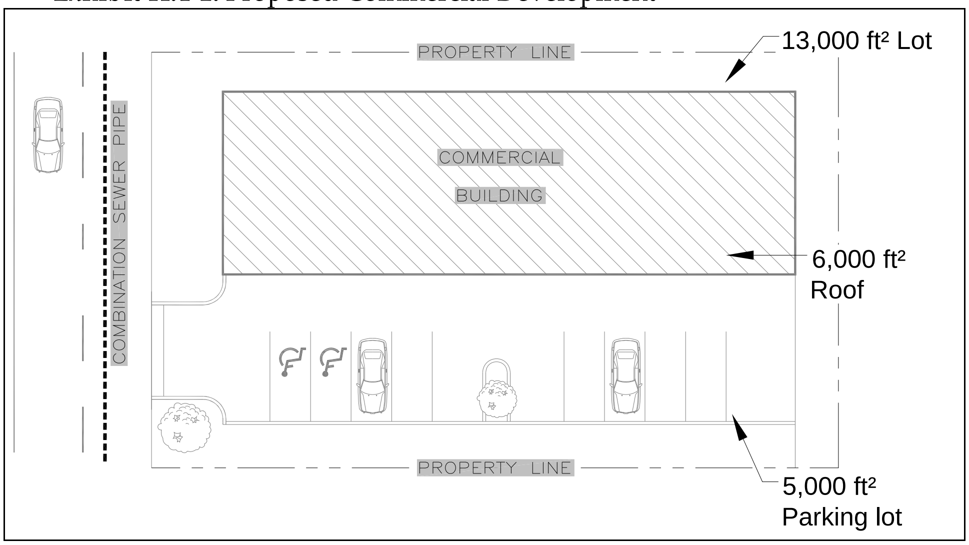
BDS will perform inspections on private property. Use the BDS interactive voice response (IVR) line (see **Exhibit 2.2**) to schedule residential (RS) permit inspections.

END

CASE STUDY 4
Commercial Development with Parking Lot
(Southeast Portland with Somewhat Poorly Drained Soils)

A commercial building development with a 6,000-square-foot building footprint and a 5,000-square-foot parking lot will be constructed on a 13,000-square-foot lot in southeast Portland (see Exhibit H.4-1).

Exhibit H.4-1: Proposed Commercial Development



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and Portlandmaps.com indicates that the soil in the area is poorly drained (Wetted Drainage Class Map), the soil is within hydrologic group is C, and the depth to groundwater is approximately 20 feet to seasonal high water table (Depth to Seasonal High Groundwater Map). Research of two nearby well logs found on www.oregon.gov/owrd indicates the static ground water level to be 23 feet and 9 feet deep, approximately confirming the results of the water table map. The lot is sloped 5-10 percent, according to the slope map on Portlandmaps.com.

1. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

Setbacks for stormwater facilities vary, based on the type of facility and the selected piping configuration. Flow-through facilities can have zero setbacks as long as they are lined and are no taller than 30 inches above adjacent grade. Infiltration facilities must be 5 feet from property lines and 10 feet from foundations, measured to the center line of the facility. Refer to **Section 2.1.2** for detailed setback requirements.

2. Characterize Site Drainage Area and Runoff

Stormwater from the roof and the parking lot must be treated. The total impervious area treated will be 11,000 square feet: 6,000 square feet from the building and 5,000 square feet from the parking lot.

Based on this preliminary analysis and the fact that no sumps exist in the nearby streets, the applicant should create a conceptual site plan that assumes either partial infiltration or flow-through to offsite discharge.

Design Approach

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**).

Because the proposed impervious area is greater than 10,000 square feet, the Presumptive or Performance Approach must be used.

The applicant wants to provide the smallest stormwater facility and spend the least amount of money. To avoid the requirement of hiring a profession engineer, the applicant decides to avoid the Presumptive Approach by using impervious area reduction techniques. The applicant proposes 1,001 square feet of permeable pavers to decrease the total impervious area to less than 10,000 square feet, which qualifies the site for the Simplified Approach.

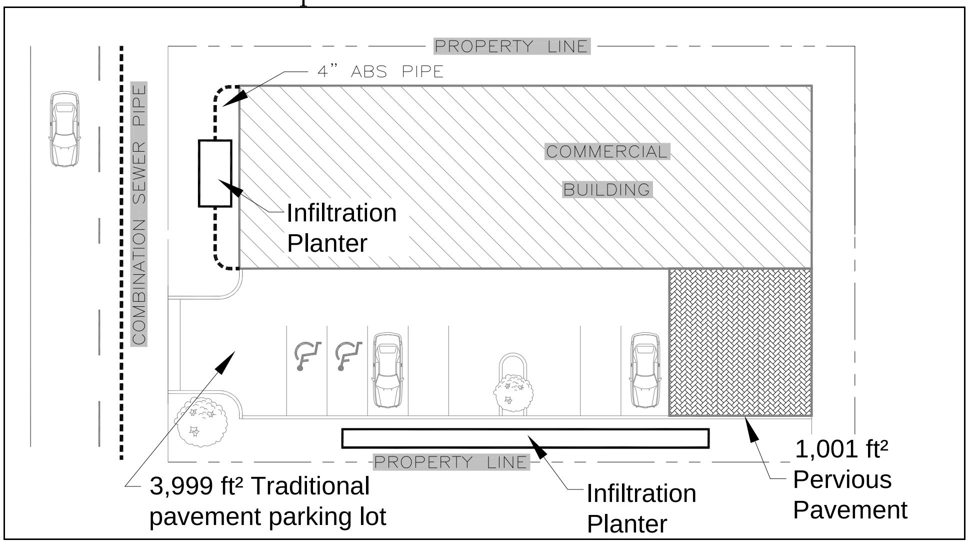
Conceptual Stormwater Plan

To test the soil infiltration rate in the appropriate locations and depths, a conceptual storm drainage plan must be created at this time (see **Exhibit H.4-2**). The f conceptual stormwater strategies are shown below.

Roof Runoff: Based on the earlier infiltration feasibility research, the concept for roof runoff will be to direct it to an infiltration planter, with discharge to the combination sewer.

Parking Lot Runoff: The applicant would like to pave a small portion of the parking lot with pervious pavement to take advantage of the impervious area reduction techniques and qualify the design for the Simplified Approach. It is proposed to have the rest of the parking lot sheet flow to the southern edge of the parking lot, where there is just room enough for a 100-foot-long by 3-foot-wide infiltration or flow-through planter with a 5-foot setback from the property line. Either of these facilities would satisfy the water quality, flow control, and discharge requirements for the new developed area, as long as the infiltration rate testing results are adequate for infiltration.

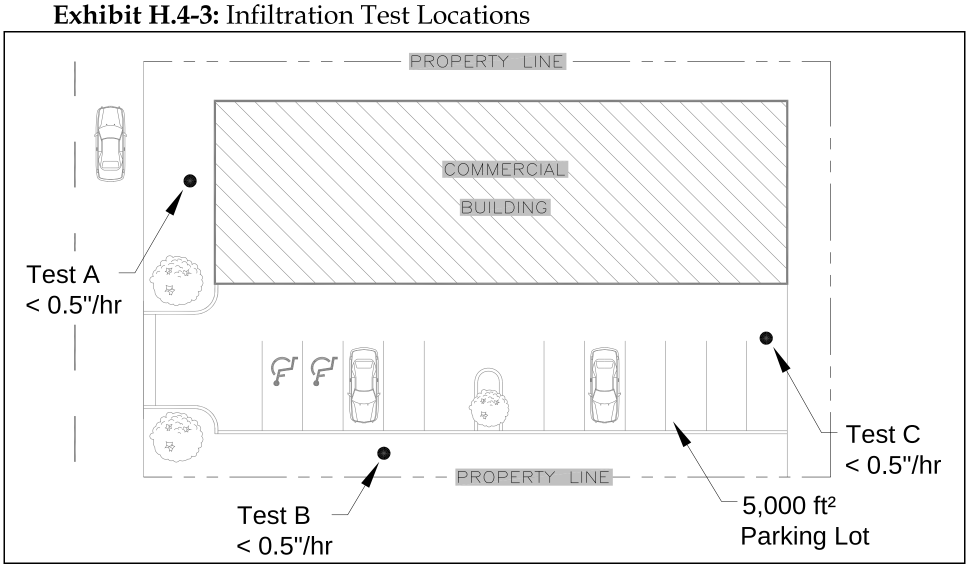
Exhibit H.4-2: Conceptual Site Plan



Infiltration Rates

Based on the conceptual site plan, the applicant must perform infiltration tests at three places: beneath the proposed parking lot, at the west planter location, and at the south planter location (see Exhibit H.4-3). Where infiltration rates are 2 inches per hour or greater (for the Simplified Approach refer to the tested infiltration rate; for the Presumptive Approach refer to the design infiltration rate) onsite infiltration is feasible and required.

Exhibit H.4-3: Infiltration Test Locations



Results of the infiltration tests are as follows:

Test A: Infiltration planter west location—Simplified Approach open pit test: **Tested** rate of **0.3inch/hour** at 2.5 feet in depth.

Test B: Infiltration planter south location—Simplified Approach open pit test: **Tested** rate of **0.2 inch/hour** at 2.5 feet in depth.

Test C: Pervious pavement location—Simplified Approach open pit test: **Tested** rate of **0.4inch/hour** at 1 foot in depth.

Unfortunately for the applicant, the Simplified Approach infiltration tests result in tested infiltration rates of less than 0.5 inches per hour. Since the tested rate is too low for infiltration, pervious pavement is not an appropriate management technique.

Revision of Conceptual Stormwater Plan

Based on the results of the infiltration tests, the applicant cannot use the Simplified Approach, so the Presumptive Approach will be used. The very low infiltration rates require the applicant to find an alternative discharge point. The design must be performed by an engineer, and Presumptive Approach submittal requirements are required.

Stormwater Management Requirements

Every stormwater facility must meet the requirements listing in **Section 1.3**, including: infiltration and discharge, flow control, and pollution reduction.

Infiltration and Discharge

Infiltration and discharge requirements are met by abiding by the stormwater hierarchy.

- Category 1 of the hierarchy cannot be met because surface infiltration rates are not adequate for total infiltration.
- Category 2 cannot be met because subsurface infiltration rates are not adequate for total infiltration.
- Category 3 cannot be met because the only offsite discharge point is to the combination sewer.
- Category 4 requirements will be met.

Pollution Reduction

Parking lot and roof runoff must meet pollution reduction requirements prior to infiltration or conveyance offsite. A "pass" result of the pollution reduction storm within the Presumptive Approach Calculator (PAC) (see #5, below) satisfies the pollution reduction requirement for this example.

Flow Control

Based on the stormwater hierarchy, discharge will be to the combination sewer. The flow control requirements prior to discharge to the combination sewer (**Exhibit 1-4**) are to limit the 25-year post development peak runoff rate to the 10-year pre-development peak rate. The PAC will be used to perform this evaluation.

4. Determine Source Control Requirements

Source Control requirements must be met, see **Chapter 4**. For all new development, trash and recycling areas must meet **Section 4.4** source control requirements. For tenant improvements, trash and recycling areas must be categorized as high or low risk and follow the applicable requirements per **Section 4.4**. The trash enclosure must provide cover, pavement, and isolated drainage to the sanitary sewer.

5. Develop a Preliminary Design

Stormwater from the roof and parking lot will be treated by using one or more planters, with an offsite discharge to the combination sewer. For evaluation purposes, calculations are based on one large facility; this may or may not be appropriate, depending on site conditions and available space. It is imperative to delineate that the right catchment area is directed to an adequately sized facility. In most circumstances, the individual facilities should be calculated individually within the PAC. The shortcut of one large facility is for demonstration purposes.

Presumptive Approach Calculator

The PAC is used to perform sizing calculations for the vegetated facilities. This case study is intended to be used as an exercise within the PAC.

Catchment Data Tab

Multiple values need to be entered into the catchment data tab (see **Exhibit H.4-4**).

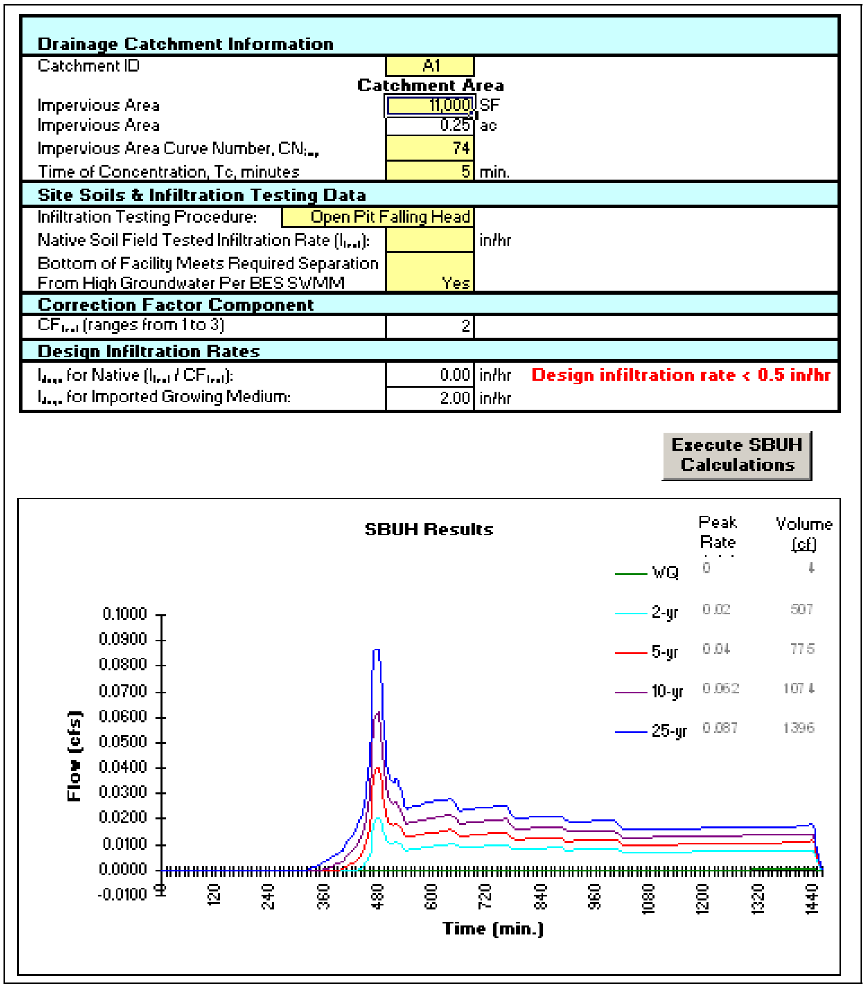
Site-specific details are entered into the PAC summary page:

Project Name, Designer, Company
Impervious Area: 11,000 square feet
Curve Number: 98 is default; otherwise, provide reasoning
Time of Concentration: 5 minutes is default; otherwise, provide reasoning

Infiltration Test: Open pit falling head
Tested Infiltration rate: N/A (Simplified Approach testing result not applicable)

Execute SBUH Calculation, and print this page to include with stormwater submittals. The impervious area curve number and time of concentration can also be modified as long as adequate reasoning is provided.

Exhibit H.4-4: Catchment Data



To establish that the flow control standards are being met, the runoff from the pre-developed lot is first evaluated. Assuming the same proposed impervious area, a curve number is used that more accurately reflects the pre-developed site conditions. A curve number of 74 is used for this example to represent *Open Space in Good Condition (grass cover > 75%)*. Curve numbers are found in **Appendix C.1, Table C.1-2** of the *Stormwater Management Manual* or Table 6-6 of the *Sewer Design Manual*. *Execute SBUH Calculation* and print this page for reference and submittal.

The SBUH results graphic within the catchment data tab presents the peak rate and volume for each of the water quality 2-, 5-, 10-, and 25-year storms. The point of interest is the 10-year pre-development storm, where the peak flow is **0.062 cfs**. The post-development 25-year storm must be less than this value, since the facility overflow will be to the combination sewer. The catchment information stays the same, except the curve number, which is set back to 98 for the post-development analysis. *Execute SBUH Calculation* again.

Facility Design Tab

Once the post-development SBUH is executed, the facility needs to be designed (see **Exhibits H.4-5** and **H.4-6**). The specific dimensions and design goals are populated within the facility design data tab. Four qualitative selections within the facility design tab set the underlying facility design: *Hierarchy Category, Facility Type, Facility Shape,* and *Facility Configuration:*

Hierarchy Category: 4 (offsite flow to combined sewer)
Facility Type: Planter
Facility Shape: Rectangle is default for planter
Facility Configuration: D (Flow-through)

Six to 10 quantitative selections within the facility design tab set the exact dimensions for the facility. The field names and the option to modify them depend directly on the qualitative selections from above.

Data for Above-Ground Storage Component

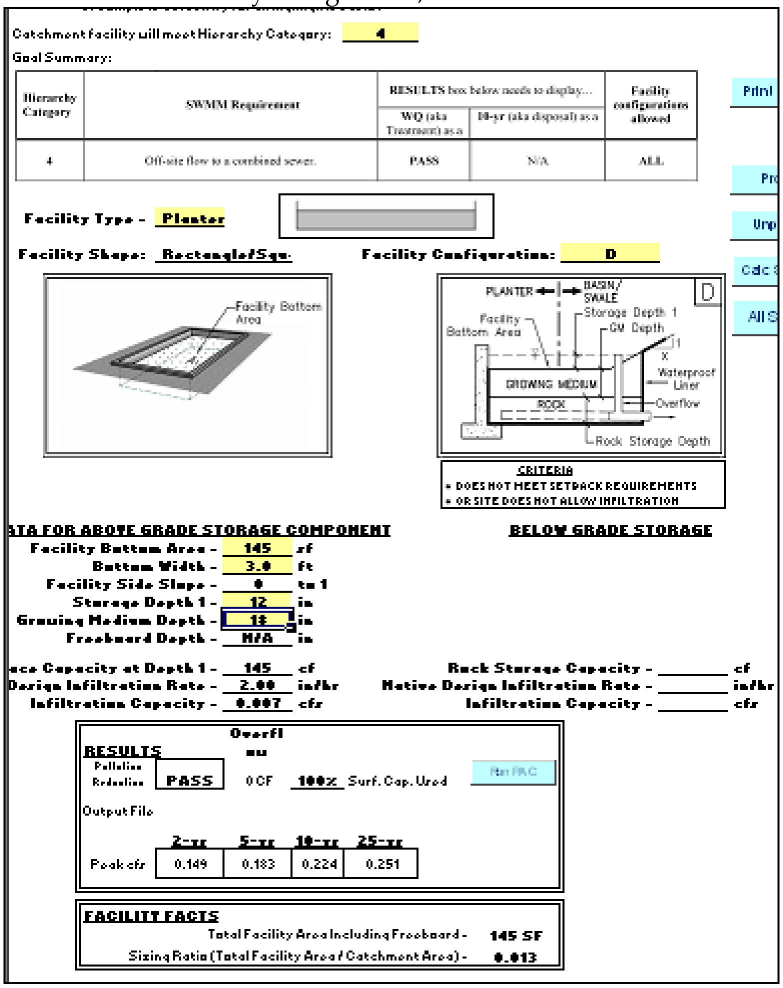
Simplified sizing is a good place to start for the planter [11,000 x 0.06 = 660sf]. Each time a value is changed, the PAC must be recalculated: *Run PAC.*

- ***Trial A***

  Size: 660sf & 12" deep → 145sf & 12" deep → Pass for water quality→Discharge to combination sewer.
  Bottom Width: 3'

  The water quality storm is relatively small (0.83 inch/24 hours); 100 percent of the surface capacity will be utilized for a 145-square-foot planter that is 12 inches deep. The flow control requirement is the more restricting constraint. To meet flow control, the resulting peak discharge from the 25-year storm must be must be less than **0.062 cfs**, found above.

Exhibit H.4-5: Facility Design Data, Trial A

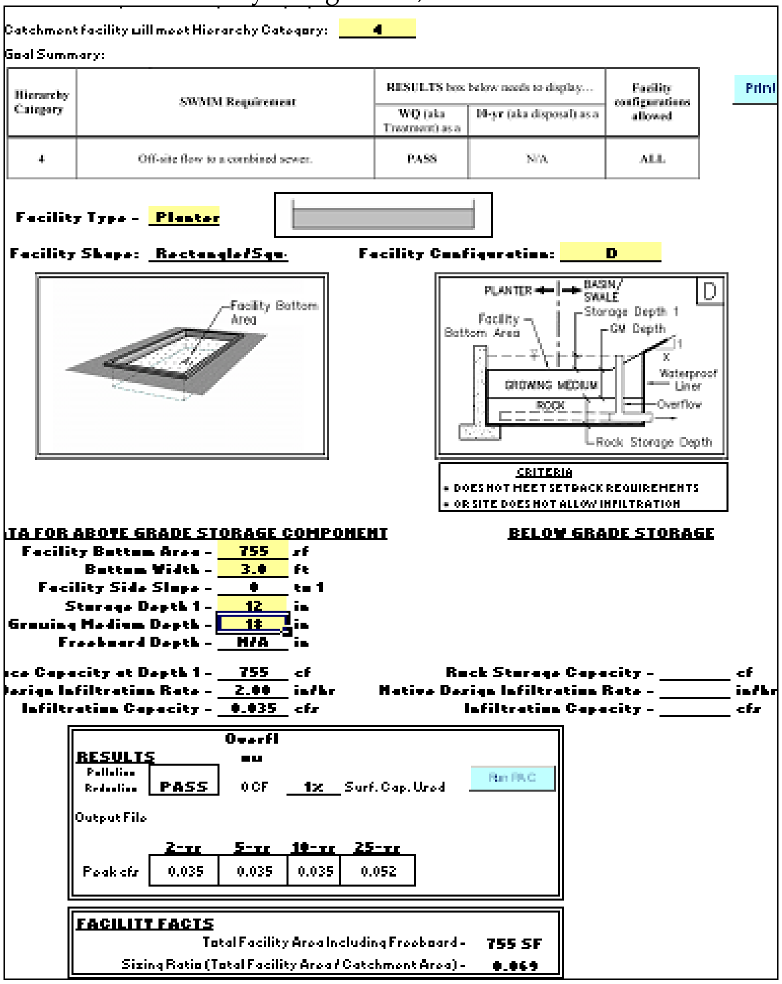


- *Trial B*

The planter is upsized through trial and error until flow control is met. A planter 755 square feet in area results in a 25-year post-development peak discharge of 0.05 cfs.

Size: 145sf & 12" deep → 660sf & 12" deep → 755sf & 12" deep → 25 post< 10yr pre → Pass → Discharge to combination.

Exhibit H.4-6: Facility Design Data, Trial B



The 755-square-foot planter can be broken into multiple planters, assuming the sum of the facilities adds up to all relevant design dimensions and the individual facilities are sized appropriately for their catchment sizes.

This method of using the PAC to determine pre-development runoff may be a simplification of the site. This is not a technique that can be used on all scales and without justification. This technique is limited to 15,000 square feet of proposed impervious area; justifications and assumptions must be stated with the analysis.

6. Develop a Landscape Plan

A landscaping plan is required for the infiltration planter (see **Appendix D.1**).

7. Complete a Stormwater Management Report

The required contents of a Stormwater Management Report are shown below.

Stormwater Management Report

- **Cover Sheet**
- **Design Professional's Stamp**
- **Project Overview**
  The overview should provide perspective on what the project will encompass. The applicant must provide a brief overview of the location, size, and type of development. The description should continue with the potential effects on the existing watershed and drainage patterns. Please provide details about which permit authorities are being or have been contacted as well as the recent history of the site. Include recent case history or permit numbers with the City of Portland or other permit authorities.
- **Methodology**
  This section of the Stormwater Management Report shall first cover the local drainage within the project and surrounding areas. It is imperative to identify the drainage interaction between the project and the proposed development site.
  This section should also describe the infiltration results and their implications on discharge points including Hierarchy justifications; see **Section 1.3**.
- **Analysis**
  The analysis must cover the design assumptions and software used including design coefficients and safety factors. Tables are essential to clearly describe the facilities, their catchments, sizes, types, impervious areas treated, and peak flow rates showing compliance.
- **Engineering Conclusions**
  Conclusions must show how compliance is met with statements of the imposed requirements. Pollution reduction, flow control, and discharge requirements must be met.

See **Appendix D.4** for complete information about the submittal requirements for the Presumptive Approach.

8. Prepare an O&M Plan

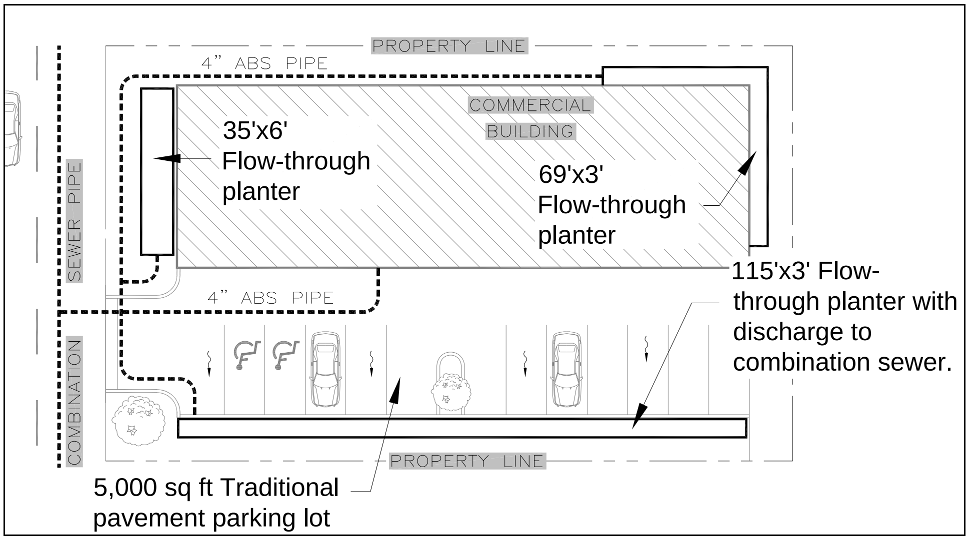
The **Operations and Maintenance Form** found in **Appendix D.6** must be recorded with the applicable county and submitted with the plan set at time of permit application.

Presumptive Approach permit applications are also required to submit a site-specific operations and maintenance plan. See **Sections 3.2** and **3.3** for further guidance.

9. Submit Final Plans and Obtain Permits

Exhibit H.4-7 shows the final site plan. Depending on whether the development is public or private, the applicant will follow the Public Works or the Bureau of Development Services (BDS) permit application process, respectively. Follow the links below for further submittal requirements.

Exhibit H.4-7: Final Site Plan



Public Works:
http://www.portlandonline.com/index.cfm?c=43826

Private Development:
http://www.portlandonline.com/bds/index.cfm?c=35883

10. Construct and Inspect

BDS will perform inspections on private property. Use the BDS interactive voice response (IVR) line (see **Exhibit 2.2**) to schedule residential (RS) permit inspections.

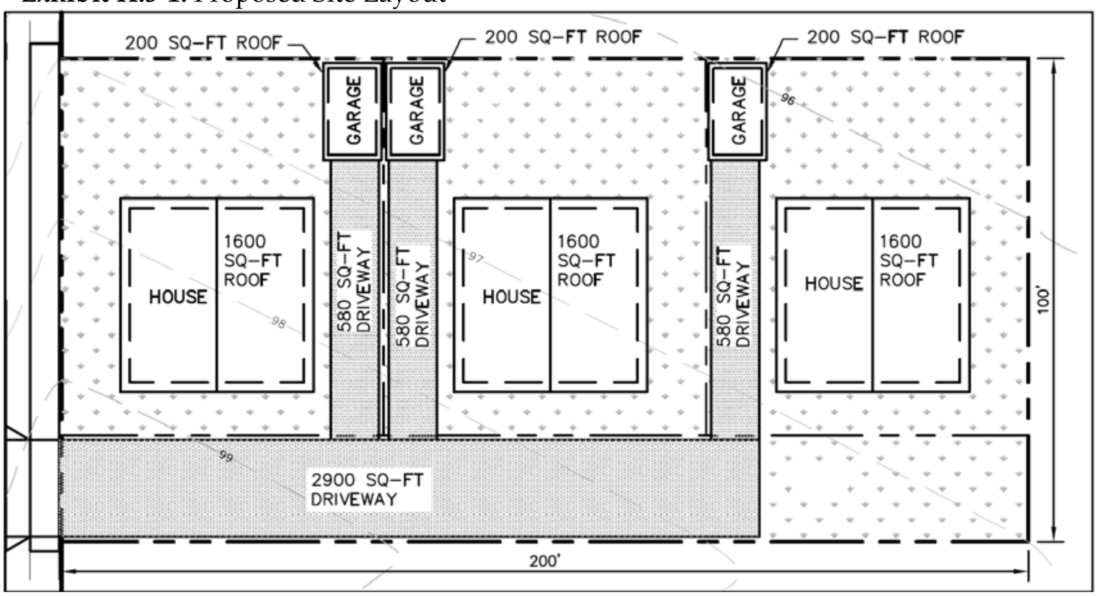
END

CASE EXAMPLE 5
Three-Lot Residential Land Division
East Side with Moderately Well Drained Soils

A 100-foot x 200-foot lot in northeast Portland is being divided into three separate residential lots (see Exhibit H.5-1). The lots are served by a private street along one edge of the properties. (See Case Example 6 for the stormwater design for the public frontage improvements associated with this project example.)

The total project area is 100 feet x 200 feet, or 20,000 square-feet. Each lot will contain a single-family house with a 1,600-square-foot roof, a garage with a 200-square-foot roof, and a 580-square-foot driveway. All three lots are served by a common 2,900-square-foot private driveway.

Exhibit H.5-1: Proposed Site Layout



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and PortlandMaps.com indicates that the soil in the area is moderately well drained (Wetted Drainage Class Map), the soil is within hydrologic group B, and the depth to groundwater is approximately 40 feet (Depth to Seasonal High Groundwater Map). The lot is sloped <5 percent, according to the slope map on Portlandmaps.com.

2. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

Setbacks for stormwater facilities vary, based on the type of facility and the selected piping configuration. Infiltration facilities must be 5 feet from property lines and 10 feet from foundations, measured to the center line of the facility. Flow-through facilities can have zero setbacks as long as they are lined and are no taller than 30 inches above adjacent grade. Refer to **Section 2.1.2** for detailed setback requirements.

3. Characterize Site Drainage Area and Runoff

This project example has both roof and surface areas that require stormwater management. The roof areas (all residential) are not required to provide pollution reduction prior to onsite discharge; the paved areas are required to provide pollution reduction prior to any discharge point.

Based on the preliminary analysis, the applicant should create a conceptual site plan that assumes total infiltration of all roof and paved areas.

Design Approach

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**).

For this catchment, the proposed impervious area is greater than 10,000 square feet:
(1,600 + 200 + 580) x 3 + 2,900 = 10,040 square feet.

The Simplified Approach cannot be used for this permit for two reasons: the impervious area for the development is over 10,000 square feet and a private street facility is being permitted.

Note: the single-family residential permit applications (submitted as separate permits) can use the Simplified Approach unless the PAC was used for facility design on each separate lot. The residential impervious areas are included as part of the 10,000 square feet, so that appropriate stormwater management is developed for the entire site. This site development or land use review application needs to address how the individual residences will provide stormwater management whether it is onsite subsurface infiltration, is only pretreated onsite, or is entirely treated on a separate tract.

Conceptual Stormwater Plan

This case study divides the site into four catchments: one for the private street and one for each residential lot. Each separate lot provides stormwater management for the total impervious area within that lot.

Another option would be to provide one facility to treat the impervious areas for all four catchments. Easement and maintenance agreements between all the property owners would be required for the shared facility.

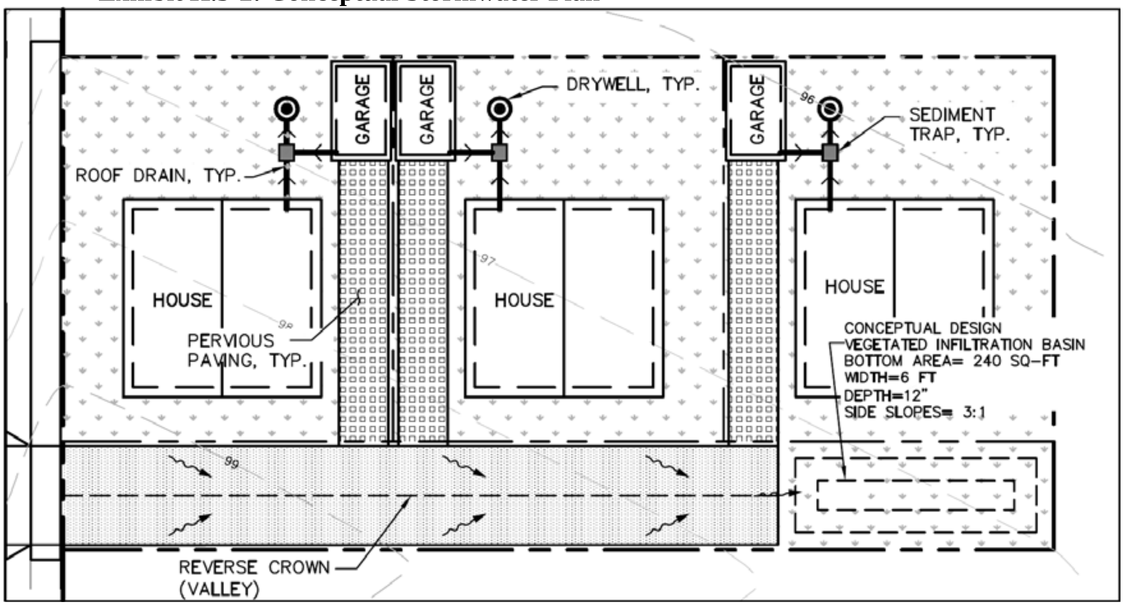
> Residential Lots: Since each lot is essentially identical, the same conceptual design will be used for each.
>
> Roof Areas: Based on the space constraints on the site and the earlier infiltration feasibility research, the concept for roof runoff will be to drain to a drywell located in the backyard area.
>
> Driveway Areas: Based on the space constraints and existing grades, the simplest way to reduce the stormwater impact from the driveway is to use an impervious area reduction technique, such as constructing the driveway out of pervious pavement or draining it to the lawn areas.
>
> Private Street: Stormwater from the private street must be treated and discharged onsite if infiltration results permit. By reverse crowning the cross-section of the driveway, all impervious runoff can be drained overland to a vegetated infiltration basin at the low end of the site.

A conceptual stormwater plan that estimates the size and the location of the stormwater facilities is created to determine where to perform the infiltration tests (**Exhibit H.5-2**).

Infiltration Tests

Based on the conceptual site plan and the infiltration testing requirements (see **Appendix F.2**), the applicant will need to perform a minimum of two infiltration tests for every 10,000 square feet of lot area. Since three separate types of facilities are proposed at three different depths, the applicant performs a test at each depth. Each test is performed as close as possible to the proposed facilities.

Exhibit H.5-2: Conceptual Stormwater Plan



Results of the infiltration tests are as follows:

Test A: Drywell location—hollow stem auger falling head test:
Tested rate of **10 inches per hour** at 8 feet in depth.

Test B: Pervious pavement location—open pit falling head:
Tested rate of **2.5 inches per hour** at 1 foot in depth.

Test C: Infiltration basin location—open pit falling head:
Tested rate of **2 inches per hour** at 1.5 feet in depth.

Correction or safety factors must be applied (see **Exhibit F.2-1** in **Appendix F.2**). The resulting **design** infiltration rates are:

Test A: Hollow stem auger, encased falling head; safety factor of 3:
Design infiltration rate = 10/3 = **3.33 inches per hour**.

Test B: Open pit falling head; safety factor of 2:
Design infiltration rate = 2.5/2 = **1.25 inch per hour**.

Test C: Open pit falling head; safety factor of 2:
Design infiltration rate = 2/2 = **1 inch per hour**.

Onsite infiltration is feasible and required because the soils are classified as moderately well drained, slopes are minimal, and there are design infiltration rates 2.0 inches per hour or greater.

Stormwater Management Requirements

Every stormwater facility must meet the requirements list in **Section 1.3,** including infiltration and discharge, flow control, and pollution reduction.

Infiltration and Discharge
Based on the stormwater hierarchy (**Section 1.3, Exhibit 1-2**), it appears possible to follow the category 1 requirements, with category 2 as a reasonable backup. The research above indicates that this project will be able to provide onsite infiltration for all of the stormwater runoff. The project will meet category 1 or, if site restraints exist, will at least meet category 2.

Pollution Reduction
Parking lot and roof runoff must meet pollution reduction requirements prior to infiltration or conveyance offsite. A "pass" result of the pollution reduction storm within the Presumptive Approach Calculator (PAC) (see #5, below) satisfies the pollution reduction requirement for this example.

Flow Control
Based on the stormwater hierarchy, discharge will be onsite. Onsite discharge satisfies the flow control requirement.

4. Determine Source Control Requirements

Source control requirements will need to comply with **Chapter 4** of the manual.

5. Develop a Preliminary Design

The design of the stormwater facility must meet required setbacks. All setbacks are noted on the facility details and must be shown on the site plan.

Roof Area**:** Infiltration Test A yielded a design infiltration rate of 3.33 inches per hour, which is greater than the recommended minimum of 2 inches per hour for using drywells. In accordance with **Exhibit 2-36**, a 5-foot-deep, 48-inch-diameter drywell should be sufficient to infiltrate stormwater from the combined (house and garage) 1,800-square-foot impervious rooftop area.

Pervious Pavement Area**:** Infiltration Test B yielded a design infiltration rate of 1.25 inches per hour, which is not great but is above the recommended minimum of 0.5 inch per hour for pervious pavement use.

Private Street Area: Infiltration Test C yielded a design infiltration rate of 1 inch per hour, which is also not very good. However, using the space area available and the PAC calculator, a working facility should be achievable.

Presumptive Approach Calculator

The PAC is used to perform sizing calculations for the vegetated facility treating parking lot runoff. This case study is intended to be used as an exercise within the PAC.

Catchment Data Tab
Multiple values need to be entered into the catchment data tab (see Exhibit H.5-3):

Project Name, Designer, Company
Impervious Area: 2,900 square feet
Curve Number: 98 is default; otherwise, provide reasoning
Time of Concentration: 5 minutes is default; otherwise, provide reasoning
Infiltration Test: Open pit falling head
Tested Infiltration Rate: 2.0 inches/hour (no correction factor applied)

Execute SBUH Calculation, and print this page to include with stormwater submittals. The impervious area curve number and time of concentration can also be modified as long as adequate reasoning is provided.

Exhibit H.5-3: Catchment Data

Drainage Catchment Information		
Catchment ID	B	
	Catchment Area	
Impervious Area	2,900	SF
Impervious Area	0.07	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.
Site Soils & Infiltration Testing Data		
Infiltration Testing Procedure:	Open Pit Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	2	in/hr
Groundwater >5' Below Bottom of Facility:	Yes	
Correction Factor Component		
CF_{test} (ranges from 1 to 3)	2	
Design Infiltration Rates		
I_{dsgn} for Native (I_{test} / CF_{test}):	1.00	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Facility Design Tab

Four qualitative selections within the facility design tab set the underlying facility design (see Exhibit H.5-4):

Hierarchy Category
Facility Type
Facility Shape
Facility Configuration

Six to 10 quantitative selections within the facility design tab set the exact dimensions for the facility. The field names and the option to modify them depend directly on the qualitative selections from above.

As previously stated in this case example, the goal is to meet stormwater hierarchy Category 1. Note that the goal summary in Exhibit H.5-4 states that only configurations A or B will meet this category. The rectangle/square is chosen because it is the easiest shape to adjust when only rough dimensions of a facility are known. The selected facility configuration is A. This facility configuration contains no subsurface rock storage layer, which makes it generally simpler and less expensive to construct.

Hierarchy Category: 1
Facility Type: Basin
Facility Shape: Rectangle/Square
Facility Configuration: A

Data For Above-Ground Storage Component

In the next several data entry cells, the facility bottom area, bottom width, side slope, and storage depth can be entered, based on the concept stormwater plan. There are different and potentially additional fields to populate for different qualitative selections (*Hierarchy Category*, *Facility Type*, *Facility Shape*, and *Facility Configuration*). The *Run PAC* button must be checked every time any information is modified.

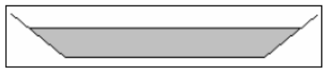
Exhibit H.5-4: Four Qualitative Selections within the Facility Design Tab

Catchment facility will meet Hierarchy Category: 1

Goal Summary:

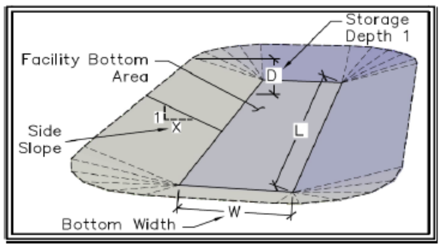
Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…		Facility configurations allowed
		WQ (aka Treatment) as a	10-yr (aka disposal) as a	
1	On-site infiltration with a surface infiltration facility.	PASS	PASS	A or B

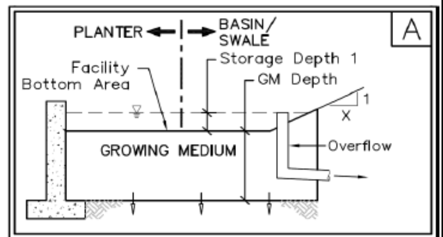
Facility Type = Basin



Facility Shape: Rectangle/Square

Facility Configuration: A





CRITERIA
- NATIVE DESIGN INFILTRATION RATE > 0.5 IN/HR
- AND MEETS SETBACK REQUIREMENTS

- ***Trial A***

Exhibit H.5-5 shows the entries for the first try at the facility dimensions. The initial value used for the facility bottom area was based on the Simplified Approach, as a starting point (2900sf x 0.09 = 261sf).

After *Run PAC*, both the pollution reduction and the 10-year result are "pass." With only 29 percent of the surface capacity used for the entire 10-year event, the facility is currently oversized.

Note that there is a message that says *Native Infiltration Rate Used in PAC*, as opposed to *Growing Medium Rate Used in PAC*. This means that the native infiltration rate is less than the growing medium and therefore the limiting factor, or bottleneck, prior to infiltration. To design a more efficient facility, the configuration could be changed to B, which allows a greater rock storage layer footprint than the surface infiltration area. This can increase the infiltration capacity of the rock layer so it could equal or exceed the surface infiltration capacity, eliminating the native soil as the bottleneck. However, as the PAC results show, this project example has more space available than needed for a facility to work, without needing the rock layer.

Exhibit H.5-5: Quantitative Fields for Trial A

DATA FOR ABOVE GRADE STORAGE COMPONENT			BELOW GRADE STORAGE		
Facility Bottom Area =	261	sf	Rock Storage Bottom Area =	501	sf
Bottom Width =	6.0	ft	Rock Storage Depth =	0	in
Facility Side Slope =	3	to 1			
Storage Depth 1 =	12	in			
Growing Medium Depth =	18	in			
Freeboard Depth =	3	in			
Surface Capacity at Depth 1 =	422	cf	Rock Storage Capacity =	0	cf
Infiltration Area at 75% Depth1 =	501	SF			
GM Design Infiltration Rate =	2.00	in/hr	Native Design Infiltration Rate =	1.00	in/hr
Infiltration Capacity =	0.023	cfs	Infiltration Capacity =	0.012	cfs

RESULTS		Overflow Volume		
Pollution Reduction	PASS	0 CF	0%	Surf. Cap. Used
10-yr	PASS	0 CF	29%	Surf. Cap. Used

Run PAC

FACILITY FACTS

Total Facility Area Including Freeboard = **689 SF**

Sizing Ratio (Total Facility Area / Catchment Area) = **0.237**

- ***Trial B***

Many variables within the PAC can be adjusted to find the most efficient design. For this example, the adjustments are limited to *Facility Bottom Area*, *Bottom Width*, *Side Slope*, and *Storage Depth*. After a few iterations, a more efficient facility is designed (see Exhibit H.5-6).

After *Run PAC*, both the pollution reduction and the 10-year result are "pass." With only 90 percent of the surface capacity used for the entire 10-year event, further adjustments and iterations could bring the facility closer to 100 percent, but the overall facility size would not be noticeably reduced. It is good engineering practice to factor some additional safety into the design. In addition, freeboard was set at 3 inches to account for additional storage above the 10-year event.

Now that there is a successfully sized design, it can be documented in the construction plans and the Stormwater Management Report. The emergency escape route must be identified on the plans.

Exhibit H.5-6: Quantitative Fields for Trial B

DATA FOR ABOVE GRADE STORAGE COMPONENT			BELOW GRADE STORAGE		
Facility Bottom Area =	168	sf	Rock Storage Bottom Area =	359	sf
Bottom Width =	5	ft	Rock Storage Depth =	0	in
Facility Side Slope =	4	to 1			
Storage Depth 1 =	9	in			
Growing Medium Depth =	18	in			
Freeboard Depth =	3	in			
Surface Capacity at Depth 1 =	222	cf	Rock Storage Capacity =	0	cf
Infiltration Area at 75% Depth1 =	359	SF			
GM Design Infiltration Rate =	2.00	in/hr	Native Design Infiltration Rate =	1.00	in/hr
Infiltration Capacity =	0.017	cfs	Infiltration Capacity =	0.008	cfs

RESULTS		Overflow Volume		
Pollution Reduction	PASS	0 CF	2%	Surf. Cap. Used
10-yr	PASS	0 CF	90%	Surf. Cap. Used

Run PAC

FACILITY FACTS	
Total Facility Area Including Freeboard =	541 SF
Sizing Ratio (Total Facility Area / Catchment Area) =	0.186

6. Develop a Landscape Plan

Subsurface facilities such as drywells do not require a landscaping plan.

A surface infiltration facility does require a landscape plan. It should show the location, number, and types of plants that will be installed (see **Appendix D.1**).

7. Complete a Stormwater Management Report

The Stormwater Management Report must include the stormwater calculations and catchment area map, PAC narrative, and all PAC printout sheets. The required contents of a Stormwater Management Report are shown below. Refer to **Appendix D.4** for more information.

Stormwater Management Report

- **Cover Sheet**
- **Design Professional's Stamp**
- **Project Overview**
  The overview should provide perspective on what the project will encompass. The applicant must provide a brief overview of the location, size, and type of development. The description should continue with the potential effects on the existing watershed and drainage patterns. Please provide details about which permit authorities are being or have been contacted as well as the recent history of the site. Include recent case history or permit numbers with the City of Portland or other permit authorities.
- **Methodology**
  This section of the Stormwater Management Report shall first cover the local drainage within the project and surrounding areas. It is imperative to identify the drainage interaction between the project and the proposed development site.
  This section should also describe the infiltration results and their implications on discharge points including Hierarchy justifications; see **Section 1.3**.
- **Analysis**
  The analysis must cover the design assumptions and software used including design coefficients and safety factors. Tables are essential to clearly describe the facilities, their catchments, sizes, types, impervious areas treated, and peak flow rates showing compliance.
- **Engineering Conclusions**
  Conclusions must show how compliance is met with statements of the imposed requirements. Pollution reduction, flow control, and discharge requirements must be met.

8. Prepare an O&M Plan

The **Operations and Maintenance Form** found in **Appendix D.6** is required for the vegetated surface facility. The form must be filled out and recorded with the applicable county and submitted to BES prior to permit approval.

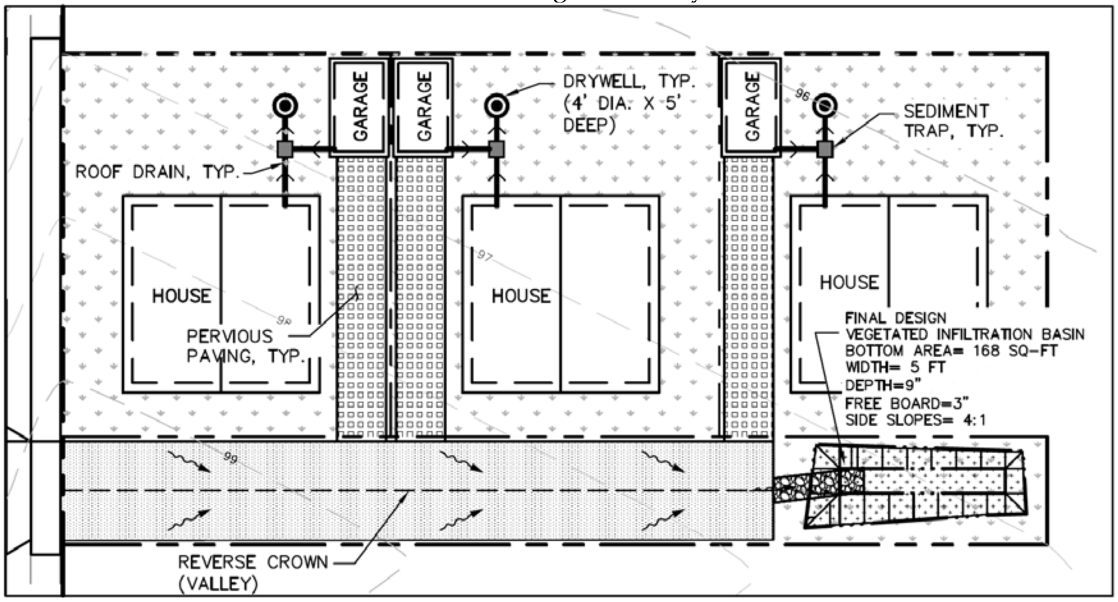
Presumptive Approach permit applications are also required to submit a site-specific O&M plan. See **Sections 3.2** and **3.3** for further guidance. An imperative part of this requirement is to determine the long-term maintenance process and responsibilities.

At least a draft of the O&M Form must be submitted with the building plans. The final O&M Form may be submitted after partial City review (check sheet notice from the BES reviewer). Because the recorded O&M Form must reflect the approved plan set rather than the proposed plan set, however, it may be advantageous to delay the final submission until the plan set has been approved.

9. Submit Final Plans and Obtain Permits

Exhibit H.5-7 shows the final site plan. Submit a plan set (including the site plan and details) and the completed PAC documentation. Follow the links below for further submittal requirements.

Exhibit H.5-7: Final Site Plan with PAC-designed Facility



Public Works:
http://www.portlandonline.com/index.cfm?c=43826

Private Development:
http://www.portlandonline.com/bds/index.cfm?c=35883

10. Construct and Inspect

The Bureau of Development Services (BDS) will perform inspections on private property. Use the BDS interactive voice response (IVR) line (see **Exhibit 2.2**) to schedule residential (RS) permit inspections.

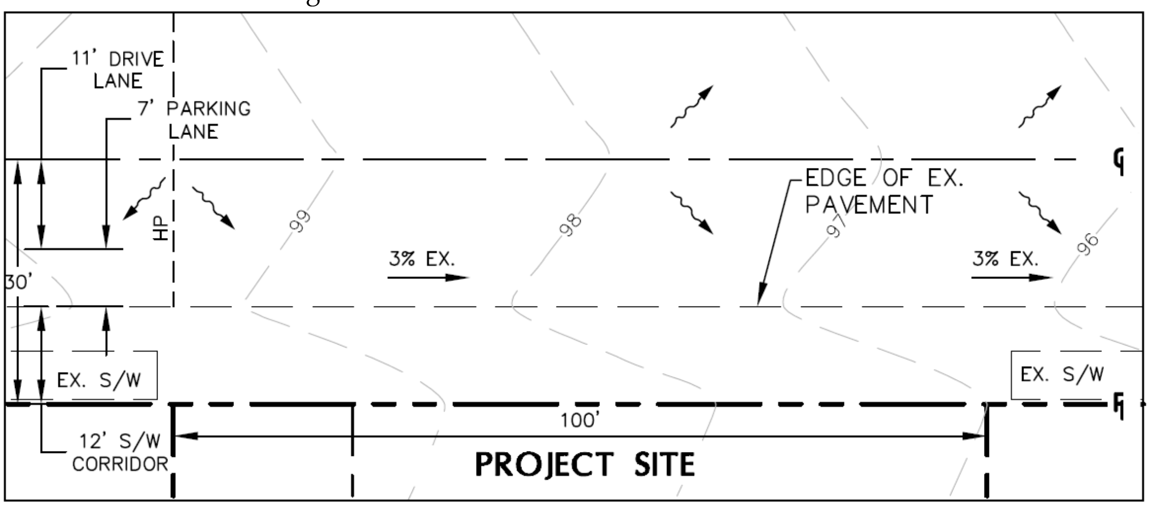
END

CASE EXAMPLE 6
Half Public Street Improvement Using Swales, without Parking East Side with Moderately Well-Drained Soils

A 100-foot x 200-foot lot in northeast Portland is being divided into three separate residential lots (see **Exhibit H.6-1**). The lot frontage is 100 feet of unimproved street; improvement of half the street is required and must include stormwater management. The total catchment area within the public improvement is 3,000 square feet (30 feet x 100 feet). (See Case Example 5 for the private street stormwater design associated with this project.)

The Portland Office of Transportation (PDOT) has designated that the half-street cross-section will be an 11-foot travel lane, 7-foot on-street parking, and 12-foot sidewalk corridor (face of curb to property line).

Exhibit H.6- 1: Existing Conditions



1. Evaluate the Site

Preliminary research using the Soil Survey of Multnomah County (Soil Conservation Service, 1982) and PortlandMaps.com indicates that the soil in the area is moderately well drained (Wetted Drainage Class Map), the soil is within hydrologic group B, and the depth to groundwater is approximately 15 feet (Depth to Seasonal High Groundwater Map). The street grade has a running slope of approximately 3 percent (based on field observation).

2. Confirm Current Requirements

Confirm that all zoning requirements are being met, which includes all land use development standards that were listed in the land use decision.

As stated above, PDOT has designated that the half-street cross-section will be an 11-foot travel lane, 7-foot on-street parking, and 12-foot sidewalk corridor (face of curb to property line).

3. Characterize Site Drainage Area and Runoff

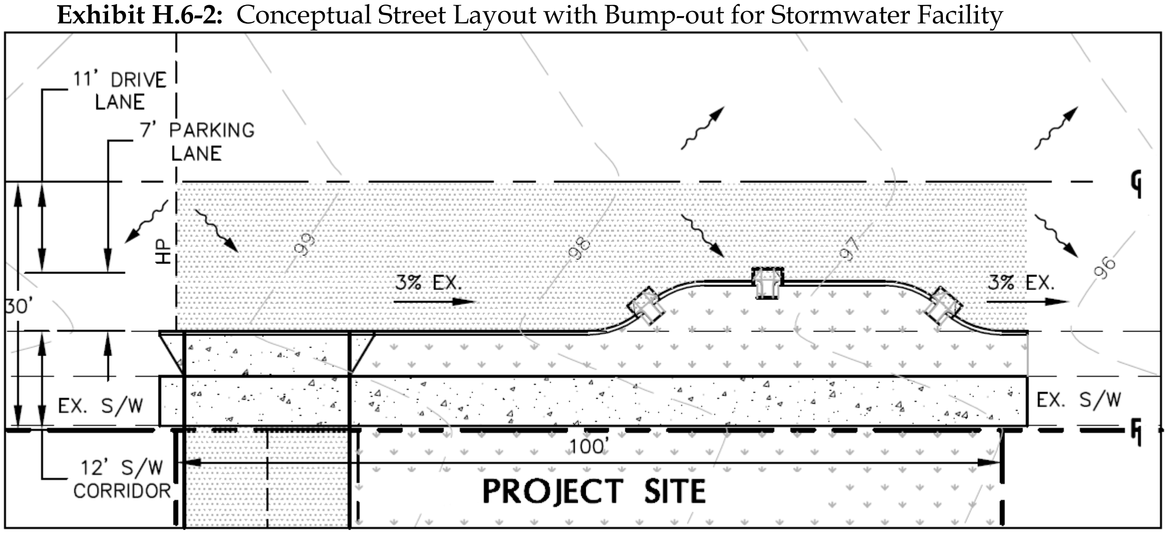
Design Approach

Facility design, infiltration testing, and submittal requirements vary, based on whether the application is using the **Simplified**, **Presumptive**, or **Performance Approach** (see **Section 2.2**). Although this project is under the 10,000 square foot threshold for the Simplified Approach, the Presumptive Approach must be used because a street is being developed. The Simplified Approach cannot be used for street development.

Conceptual Stormwater Plan

Stormwater from the improved street must be treated and, when possible, infiltrated within the project limits. The total impervious area treated will be approximately 2,600 square feet, which includes 1,900 square feet from the road and 700 square feet from the sidewalk and driveway. The only way to manage runoff within the improvement area in this example is to sacrifice some on-street parking area to fit a stormwater facility at the low end of the site. Therefore, the final impervious area to be created is not yet known. A conceptual site plan that estimates the size and the location of the stormwater facility can be created to determine where to perform the infiltration tests (see **Exhibit H.6-2**).

Exhibit H.6-2: Conceptual Street Layout with Bump-out for Stormwater Facility



Infiltration Test

All development projects are required to submit results of infiltration testing. **Appendix F.2** describes three accepted testing methods. .

Following the open pit test instructions, the tested infiltration rate is 2 inches/hour.

The open pit test requires a correction factor of 2 (as specified in **Exhibit F.2-1**):

Design infiltration rate = 2.0"/hr /2 = 1 inch/hour.

In this case, with moderately well drained soils, mild slopes, and 1 inch/hour design infiltration rate, total onsite infiltration is not required, but can be achieved.

Stormwater Management Requirements

Every stormwater facility must meet the requirements listed in **Section 1.3,** including infiltration and discharge, flow control, and pollution reduction.

Infiltration and Discharge

Based on the stormwater hierarchy (**Section 1.3, Exhibit 1-2**), it appears possible to follow the category 1 requirements. The research above indicates that this project will be able to provide onsite infiltration for all of the stormwater runoff. Should hierarchy category 1 prove impractical, given the limited flexibility of the right-of-way, infiltration and discharge via drywell or other type of UIC could be analyzed, thus moving to hierarchy category 2. However, justification must accompany the design in order to move down in the hierarchy. The project will meet category 1 or, if site restraints exist, will at least meet Category 2.

Pollution Reduction

Street runoff must meet pollution reduction requirements prior to infiltration or conveyance offsite. A "pass" result of the water quality storm within the Presumptive Approach Calculator (PAC) (see #5, below) satisfies the pollution reduction requirement for this example.

Flow Control

Based on the stormwater hierarchy, discharge will be onsite. Onsite discharge satisfies the flow control requirement.

4. Determine Source Control Requirements

Source control requirements will need to comply with **Chapter 4** of the manual.

5. Develop a Preliminary Design

The design and location of a stormwater facility within the right-of-way, and especially within a typical right-of-way, must be acceptable to the Portland Office of Transportation (PDOT), Bureau of Environmental Services (BES), and potentially other City bureaus and parties.

In this project example, with an existing sidewalk corridor of only 12 feet, there is not enough room for a facility without creating a curb extension and removing some of the on-street parking. This could be done at the low end of the project to capture as much of the new impervious area as possible.

Presumptive Approach Calculator

The PAC is used to perform sizing calculations for the vegetated facilities. This case study is intended to be used as an exercise within the PAC.

Catchment Data Tab
Multiple values need to be entered into the catchment data tab (see Exhibit H.6-3):

Project Name, Designer, Company
Impervious Area: 2,300 square feet (2,500 sf – 200 sf of estimated pervious area from the proposed facility).
Curve Number: 98 is default; otherwise, provide reasoning
Time of Concentration: 5 minutes is default; otherwise, provide reasoning
Infiltration Test: Open pit falling head
Tested Infiltration Rate: 2.0 inches/hour (no correction factor applied)

Exhibit H.6-3: Catchment Data

Drainage Catchment Information		
Catchment ID	A	
	Catchment Area	
Impervious Area	2,300	SF
Impervious Area	0.05	ac
Impervious Area Curve Number, CN_{imp}	98	
Time of Concentration, Tc, minutes	5	min.
Site Soils & Infiltration Testing Data		
Infiltration Testing Procedure:	Open Pit Falling Head	
Native Soil Field Tested Infiltration Rate (I_{test}):	2	in/hr
Bottom of Facility Meets Required Separation From High Groundwater Per BES SWMM Section 1.4:	Yes	
Correction Factor Component		
CF_{test} (ranges from 1 to 3)	2	
Design Infiltration Rates		
I_{dsgn} for Native (I_{test} / CF_{test}):	1.00	in/hr
I_{dsgn} for Imported Growing Medium:	2.00	in/hr

Execute SBUH Calculation, and print this page to include with stormwater submittals. The impervious area curve number and time of concentration can also be modified as long as adequate reasoning is provided.

Facility Design Tab

Four qualitative selections within the facility design tab set the underlying facility design (see Exhibit H.6-4):

Hierarchy Category
Facility Type
Facility Shape
Facility Configuration

Six to 10 quantitative selections within the facility design tab set the exact dimensions for the facility. The field names and the option to modify them depend directly on the qualitative selections from above.

As previously stated in this case example, the facility goal is to meet stormwater hierarchy category 1. Note that the goal summary on Exhibit H.6-4 states that only configurations A or B will meet this category. The rectangle/square is chosen because it is the easiest shape to adjust when only rough dimensions of a facility are known. The selected facility configuration is A. This facility configuration contains no subsurface rock storage layer, which makes it generally simpler and less expensive to construct.

Hierarchy Category: 1
Facility Type: Swale, because of the 3 percent running slope of the street and the narrowness of the potential facility area.
Facility Shape: Rectangle/square
Facility Configuration: A

Exhibit H.6-4: Four Qualitative Selections within the Facility Design Tab

Catchment facility will meet Hierarchy Category: 1

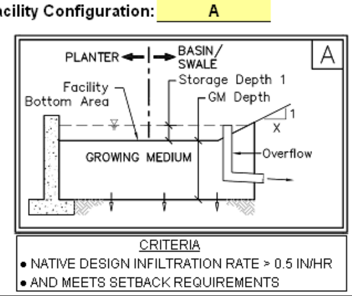
Goal Summary:

Hierarchy Category	SWMM Requirement	RESULTS box below needs to display…		Facility configurations allowed
		WQ (aka Treatment) as a	10-yr (aka disposal) as a	
1	On-site infiltration with a surface infiltration facility.	PASS	PASS	A or B

Facility Type = Swale

Facility Configuration: A

Refer to Swale Worksheet and enter Swale Parameters



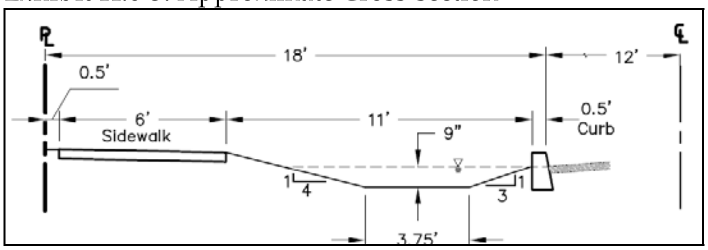
Swale Worksheet Tab

This is where the most of data entry iterations will be done to find swale parameters that are most efficiently sized for this catchment.

Step 1: Determine typical cross-section (see Exhibit H.6-5).

A swale cross-section with a larger bottom width and depth will yield more storage and therefore more overall capacity. Using the Greenstreet typical details for a swale (see **SW-300** in **Appendix G.2**) and the given the space available, a typical cross-section can be determined.

Exhibit H.6-5: Approximate Cross-section



Step 2: Fill in the *Swale Worksheet.*

Fill in what is known from the cross-section and guess at the rest for the first attempt.

Step 3: (Re-)*Run Pac* from within the *Facility Design Data Tab*.

This case study will only show variation in the number of check dams to convey the idea of how to use the tool to optimize the design.

Note: There are many *Swale Parameters* within the PAC that can be adjusted to find the most efficient design, including number of segments, *Length of Segment, Check Dam Length, Swale Slope, Bottom Width, Side Slopes, Downstream Depth, Landscape Width, Rock Storage Width and Depth, and Rock Void Ratio*. All of these variables are defined through the graphics within the *Swale Worksheet Tab*.

- ***Trial 1: One Swale Segment***

  Create one swale segment, 36 feet long, with 3–foot-wide check dams (see Exhibit H.6-6).

Exhibit H.6-6: Input for One Segment

Data Entry								
Swale Parameters								
Swale Segment	Length of swale segment (ft)	Downstream Check Dam Length (ft)	Longitudinal Swale Slope (ft/ft)	Bottom Width (ft)	Side Slope Right	Side Slope Left	Downstream Depth (inches)	Landscape Width (ft)
	$L_{segment}$	L_{dam}	S	W_{bottom}	X_{right}:1	X_{left}:1	D_{ds}	$W_{landscape}$
1	36	3	0.0300	3.75	3	4	9	11
2								
3								
4								

Error Messages

Swale segment with warning message not fully utilized. Create shorter swale segments to increase surface storage capacity and infiltration area.

Warning

Notice the error message that appears on the right side. This means that the swale segment is too long, given the 3 percent running slope. Basically, the upstream portion never stores any water. That part of the swale could be considered as being left "high and dry" and therefore makes for an inefficient design.

- ***Trial 2: Two Swale Segments***

Using the same total length, create two swale segments, each 18 feet long (see Exhibit H.6-7).

Exhibit H.6-7: Two-Segment Input

Data Entry								
Swale Parameters								
Swale Segment	Length of swale segment (ft)	Downstream Check Dam Length (ft)	Longitudinal Swale Slope (ft/ft)	Bottom Width (ft)	Side Slope Right	Side Slope Left	Downstream Depth (inches)	Landscape Width (ft)
	$L_{segment}$	L_{dam}	S	W_{bottom}	X_{right}:1	X_{left}:1	D_{ds}	$W_{landscape}$
1	18	3	0.0300	3.75	3	4	9	11
2	18	3	0.0300	3.75	3	4	9	11
3								

Then go back to the *Facility Design Tab* and hit the *Run PAC* button. Notice that the 10-year produces a "fail" message, with 166 cubic feet as overflow volume.

With the *Facility Configuration* set as A (see Exhibit H.6-8), a message appears that says *Native Infiltration Rate Used in PAC.* This means that the limiting factor, or "bottleneck," in the design is the poorer-draining native soil.

Exhibit H.6-8: Two-Segment Output with Configuration A

RESULTS		Overflow Volume			
Pollution Reduction	PASS	0 CF	7%	Surf. Cap. Used	Run PAC
10-yr	FAIL	166 CF	100%	Surf. Cap. Used	

FACILITY FACTS	
Total Facility Area Including Freeboard =	396 SF
Sizing Ratio (Total Facility Area / Catchment Area) =	0.172

To design a more efficient facility, change the *Facility Configuration* to B, which allows a greater rock storage layer footprint than the surface infiltration area (see Exhibits H.6-9 and H.6-10). This should increase the infiltration capacity of the rock layer so it is now greater than the surface infiltration capacity.

Again, hit the *Run PAC* button. Notice that the 10-year still produces a "fail" message, but with only 11 cubic feet as overflow volume.

Note: This will only work if the rock storage number had been filled in on the swale worksheet.

Now go back to the *Swale Worksheet Tab.*

Exhibit H.6-9: Two-Segment Output with Configuration B

RESULTS		Overflow Volume			
Pollution Reduction	PASS	0 CF	1%	Surf. Cap. Used	Run PAC
			6%	Rock Cap. Used	
10-yr	FAIL	11 CF	100%	Surf. Cap. Used	
			100%	Rock Cap. Used	

FACILITY FACTS	
Total Facility Area Including Freeboard =	396 SF
Sizing Ratio (Total Facility Area / Catchment Area) =	0.172

Exhibit H.6-10: Configuration B Input

Rock Storage Parameters		
Rock Storage Width (ft)	Rock Storage Depth (inches)	Rock Void Ratio
W_{rock}	D_{rock}	v
11	6	0.3
11		

- **Trial 3: Three Swale Segments**

  Using the same total length, create three swale segments, each 12 feet long (see Exhibit H.6-11). Also fill the rock storage section, since configuration B is being used.

Exhibit H.6-11: Trial 3 Input

Swale Parameters									Rock Storage Parameters		
Swale Segment	Length of swale segment (ft)	Downstream Check Dam Length (ft)	Longitudinal Swale Slope (ft/ft)	Bottom Width (ft)	Side Slope Right	Side Slope Left	Downstream Depth (inches)	Landscape Width (ft)	Rock Storage Width (ft)	Rock Storage Depth (inches)	Rock Void Ratio
	$L_{segment}$	L_{dam}	S	W_{bottom}	X_{right}:1	X_{left}:1	D_{ds}	$W_{landscape}$	W_{rock}	D_{rock}	v
1	12	3	0.0300	3.75	3	4	9	11	11	6	0.3
2	12	3	0.0300	3.75	3	4	9	11	11		
3	12	3	0.0300	3.75	3	4	9	11	11		

Back within the *Facility Design tab*, hit the *Run PAC* button. Notice that the 10-year produces a "pass" message, with 0 cubic feet as overflow volume (see Exhibit H.6-12).

Exhibit H.6-12: Trial 3 Output

RESULTS		Overflow Volume			
Pollution Reduction	**PASS**	0 CF	**0%**	Surf. Cap. Used	Run PAC
			16%	Rock Cap. Used	
10-yr	**PASS**	0 CF	**94%**	Surf. Cap. Used	
			100%	Rock Cap. Used	

FACILITY FACTS	
Total Facility Area Including Freeboard =	**396 SF**
Sizing Ratio (Total Facility Area / Catchment Area) =	**0.172**

Now that there is a successfully sized design that must be documented in the construction plans and the Stormwater Management Report. *Print* page.

The final facility will be 396 square feet. According to the swale worksheet, the swale will have three 12-foot segments, each with a landscape width of 11 feet.

6. Develop a Landscape Plan

A surface infiltration facility requires a landscape plan. It should show the location, number, and types of plants that will be installed. **SW-410**, **SW-411**, and **SW-412** in **Appendix G.4**) can be used as an excellent starting point for the swale.

7. Complete a Stormwater Management Report

The Stormwater Management Report must include the stormwater calculations, catchment area map, PAC narrative, and all PAC printout sheets. The required contents of a Stormwater Management Report are shown below. Refer to **Appendix D.4** for more information.

Stormwater Management Report

- **Cover Sheet**
- **Design Professional's Stamp**
- **Project Overview**
  The overview should provide perspective on what the project will encompass. The applicant must provide a brief overview of the location, size, and type of development. The description should continue with the potential effects on the existing watershed and drainage patterns. Please provide details about which permit authorities are being or have been contacted as well as the recent history of the site. Include recent case history or permit numbers with the City of Portland or other permit authorities.
- **Methodology**
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- **Engineering Conclusions**
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8. Prepare an O&M Plan

The **Operations and Maintenance Form** found in **Appendix D.6** is required for the vegetated surface facility. The form must be filled out and recorded with the applicable county and submitted to BES prior to permit approval.
Presumptive Approach permit applications are also required to submit a site-specific O&M plan. See **Sections 3.2** and **3.3** for further guidance.

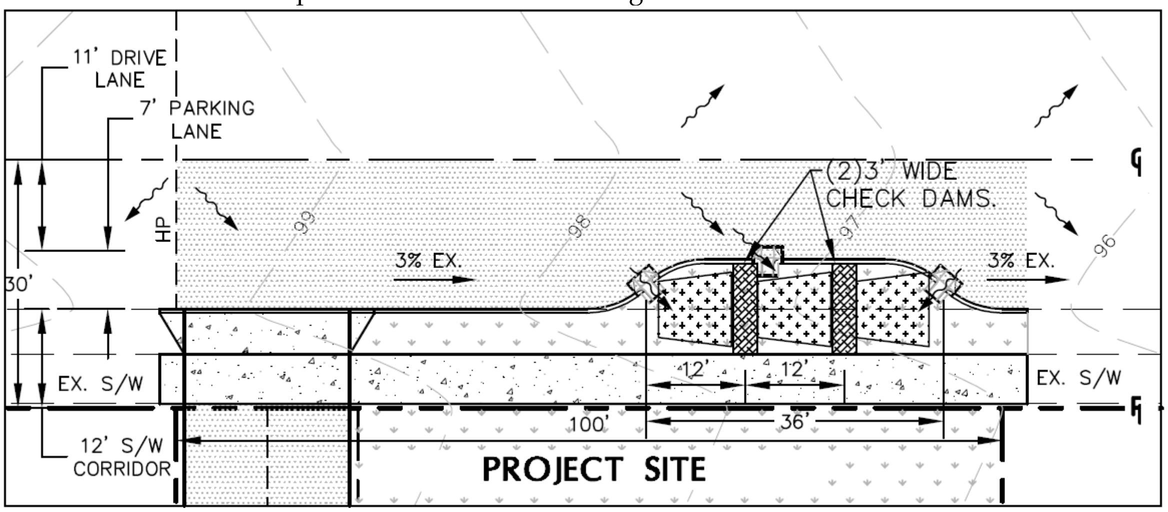
At least a draft of the O&M Form must be submitted with the building plans. The final O&M Form may be submitted after partial City review (check sheet notice from the BES reviewer). Because the recorded O&M Form must reflect the approved plan set rather than the proposed plan set, however, it may be advantageous to delay the final submission until the plan set has been approved.

A contract with the Watershed Revegetation Program (WRP) does NOT exempt facilities from O&M requirements. The WRP can accept maintenance of only the vegetation.

9. Submit Final Plans and Obtain Permits

Exhibit H.6-13 shows the final site plan. Submit a plan set (including the site plan and cross-section) and the completed PAC documentation. Follow the links below for further submittal requirements.

Exhibit H.6-13: Final Proposed Street and Swale Design



Public Works:
http://www.portlandonline.com/index.cfm?c=43826

Private Development:
http://www.portlandonline.com/bds/index.cfm?c=35883

10. Construct and Inspect

BES will perform inspections on public property.

END

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