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 and volume 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 completed to ensure that Bureau of Environmental Services (BES) approval criteria and land use review requirements can be met through the Bureau of Development Services (BDS) processes for land use cases and building permits, including any required inspections. 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 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 manmade 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. Where and when desirable or required by tree preservation and mitigation standards, 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 the 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 BDS 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 of public property or the right-of-way.

- 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., National Pollutant Discharge Elimination System construction site and discharge permits, DEQ 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, seep/spring or other environmental tracts, tree conservation and 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 are complex, contact 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 derived from the State or Oregon plumbing and building code and represent best practices for ensuring safety of nearby structures or features. BES will enforce these setbacks unless an alternative is approved through BDS plumbing code appeal[1]. Setbacks are measured from the center of a drywell or from the outside edge of a surface 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. Under typical conditions, 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, the applicant must provide a signed and stamped geotechnical report that demonstrates that the proposal will meet the intent of the building and/or plumbing code requirements as part of an approved plumbing code appeal. An alternative facility design may be required to meet conditions of appeal approval.

Distance in Feet	Setback from	Stormwater Facility
5	**Property line[2]**	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[3]**	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:

- No setbacks are required for permeable pavers, pervious asphalt, or pervious concrete. A liner may be required where located within 5 feet of infrastructure.
- Stormwater facilities may have typical setbacks. See facility-specific setback information in **Section 2.3.3**.

[1] Information about BDS plumbing code appeals can be found online at www.portlandoregon.gov/bds. To submit a plumbing code appeal, please check the BDS website for instructions (http://www.portlandoregon.gov/bds/34196) or contact the appeals secretary at 503-823-7335.

[2] Waterproof 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.

[3] Where grade is 20 percent or greater and 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 after construction. Determine if drainageway protection is necessary. Refer to Appendix A.3, "Private 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. Source control measures do not meet flow control or pollution reduction requirements.

- 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.

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 slopes 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 and planting plans, **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 operations and maintenance (O&M) submittal guidelines and a sample O&M Plan. Since site plans may change during review, a draft O&M Plan should be submitted with site plans. A final and recorded O&M Plan will be required prior to permit issuance.

- 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 management, structural repairs, and sediment removal are some of the primary maintenance activities 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 that will require registration with DEQ, DEQ also requires an O&M 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.

- BES performs construction inspections on **private property** within the development permitting process**.** The number, type, and sequencing of inspections required for proposed stormwater management systems will vary by a number of factors, including phasing of construction, type of development, and type and number of stormwater facilities. The inspection requirements will be determined during plan review. Vegetated stormwater facilities will usually require multiple inspections throughout the construction phase. Instructions on requesting inspections will be provided during plan review and permit issuance. The applicant is encouraged to contact BES prior to building the facility to schedule preconstruction meetings or to verify inspection requirements. For more information on inspections of onsite stormwater management facilities, contact the BES Development Review Hotline at 503-823-7761.

- BES also inspects private facilities post-construction to ensure long-term compliance with the recorded O&M Plans and provides technical assistance on facility O&M. See **Chapter 3** for O&M requirements. For questions, technical assistance with maintenance, or to revise recorded O&M Plans, contact the Maintenance Inspection Program at 503-823-5320.

2.2 SIZING METHODOLOGIES

This section presents three methodologies for sizing stormwater management facilities: the **Simplified Approach**, **Presumptive Approach,** and **Performance Approach**. Facilities sized with the Simplified and Presumptive approaches comply with the City's infiltration and discharge, flow and volume 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 (0.23 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. BES may require applicants to use a different approach upon review of site conditions and technical constraints.

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 (0.23 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, such as manufactured stormwater treatment technologies not approved for general use in the City of Portland

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**.

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. BES may require applicants to use a different approach upon review of site conditions and technical constraints.

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. Ecoroofs and pervious pavement are also allowed under the Simplified Approach, but those surfaces receive direct rainfall and cannot receive stormwater runoff from adjacent impervious areas. All vegetated surface facilities and ecoroofs 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 not limited to drywells and soakage trenches.

Simplified Approach Infiltration Testing

The Simplified Approach requires at least one infiltration test to be conducted before selecting and sizing facilities. (See **Appendix F.2** for the **Simplified Approach Infiltration Test** instructions and requirements. The **Simplified Approach Submittal Guide** has instructions on how to submit the infiltration testing information on the **Simplified Approach Form** (both found in **Appendix D**).

The Simplified Approach Infiltration Test 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. 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. On sites with steep slopes or shallow groundwater, BES may require a geotechnical report in order to evaluate the suitability of the proposed facility and its location. BES staff may also require an encased falling head or a double-ring infiltrometer infiltration test under the Presumptive and Performance Infiltration Testing Requirements to verify that the Simplified Approach is appropriate.

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 for swales, basins, and planters. 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.

Standard sizing tools and stormwater calculators allow designers to size basins, swales, and planters with consideration of native infiltration rates and other unique site conditions of the project. See below for a discussion of approved stormwater sizing calculators.

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. Ecoroofs and pervious pavement are also allowed under the Presumptive Approach, but those surfaces receive direct rainfall and do not receive stormwater runoff from adjacent impervious areas. 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 for basins, swales, planters, and UICs. 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.

Approved Stormwater Sizing Calculators

The City maintains a list of approved stormwater sizing calculators allowed under the Presumptive Approach.   BES will post the list of approved stormwater sizing calculators to the BES website at www.portlandoregon.gov/bes/swmm with any required data entry or calculator parameters in order to meet local conditions and the design criteria of the *Stormwater Management Manual*.

If the project designer proposes to deviate from the allowable ranges or maximum catchment sizes specified in an approved stormwater sizing calculator, the proposal must be submitted under the Performance Approach.

Presumptive Approach Calculations

If an approved stormwater sizing calculator 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, use the equations that follow.

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 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 this section, 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.

- **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 public 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 previously 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, such as conveying runoff from impervious area to ecoroofs or pervious pavement
- address unique site conditions
- apply a new or emerging design technology, such as manufactured stormwater treatment technologies not approved for general use in the City of Portland

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.

An approved stormwater sizing calculator 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.

Pollution Reduction

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

- 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). Documented performance is required and must include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.

- For sites regulated under discharge permits, pollution reduction facilities that target a specific pollutant of concern will be considered as long as pollution reduction requirements for the entire site are also being met.

- 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 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 Manual*.)

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 analyses 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 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** for a list of stormwater facilities and their applicable design methodologies.)

2.3.1 Facility Overview

Impervious Area Reduction Techniques

Ecoroofs, pervious pavement, and 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 trees intercept rainfall directly and are not allowed to receive stormwater runoff from other areas. Ecoroofs, pervious pavement, and trees must also be included on an O&M Plan that meets the requirements of Chapter 3.

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.

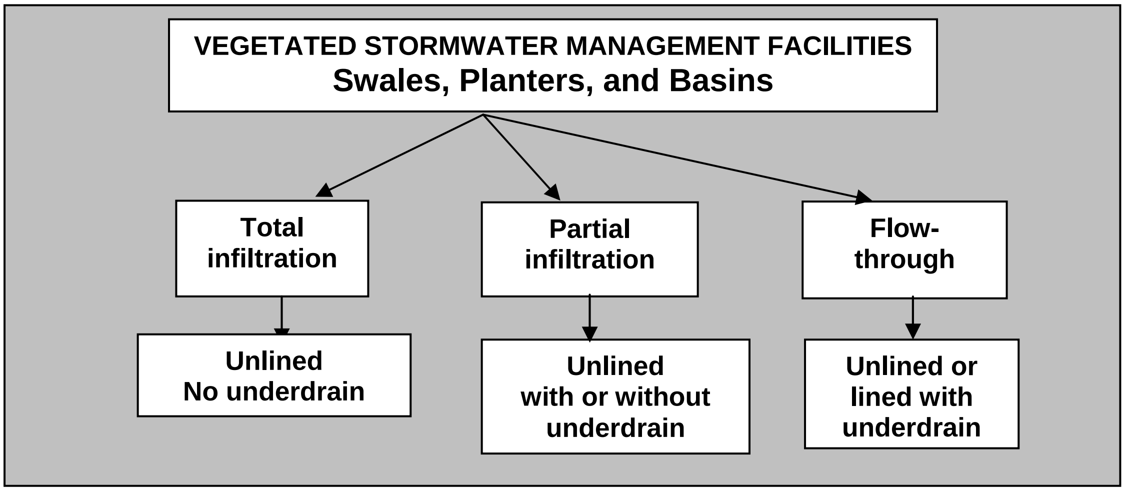
Subsurface infiltration facilities achieve infiltration below the ground surface and include facilities such as sumps, drywells, and soakage trenches. Subsurface infiltration facilities are subject to DEQ's UIC regulations (see **Section 1.4**).

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 belowgrade storage to reduce the size of the facility. Hybrid facilities are also subject to DEQ's UIC regulations.

Vegetated Surface Facilities

Swales, planters and basins can be configured to achieve total infiltration, partial infiltration, or flow-through. See **Appendix G.1**, 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 inches per hour but less than 2 inches 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 the 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 may include an impervious or lined bottom. They 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 the Stormwater Hierarchy (see **Section 1.3.1**). Flow-through facilities with impervious bottoms (poured concrete or lined facilities as appropriate) are required on sites with steep slopes, high groundwater, or contamination. Flow-through facilities with impervious bottoms (poured concrete or lined facilities, as appropriate) are also appropriate next to structures or property lines to protect foundations, basements, and adjacent properties.

Hybrid Facilities

The hybrid facility is a 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 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 Stormwater Treatment Technologies

Manufactured stormwater treatment technologies from the approved list may be used with the Presumptive approaches. Other manufactured stormwater treatment technologies that are not on the list may be used in specific applications but must be submitted to BES as a Performance Approach.

Source Control Devices

Source control devices include, but are not limited to, 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, the 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 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 *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 *Erosion and Sediment Control Manual*, must be used.

2. Piping

- ✓ For private property, piping must be cast iron, ABS SCH40, or PVC SCH40 material. 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 requirements.

- ✓ 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- to 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- to 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- to ¼-inch washed, crushed rock or pea gravel 2 to 3 inches in depth, depending on the facility design. Green streets require ¾ inch No. 4 open graded aggregate 3 inches in depth.

4. Geotextiles (if required or approved)

- ✓ Geotextiles are often used in the design and construction of stormwater facilities. Nonwoven 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 it for that application. Specifications provided in **Exhibit 2-3** are taken directly from the *City of Portland Standard Construction Specifications*, Table 02320-1.

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

Nonwoven 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.

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 for 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. See **Appendix F.3** for recommended blended topsoil specifications.

- ✓ For streets, a blended topsoil is required as specified in **Appendix F.3**.

- ✓ Soil analysis for all growing media 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.

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 plant species on the Nuisance Plants List or Required Eradication List contained in the *Portland Plant List* 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. A planting plan is a required submittal for all vegetated stormwater management facilities. 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.3** 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 90 percent (no replacements) must be achieved. If the survival rate falls below this threshold, additional plants sufficient to meet the 90 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 overapplied.

- ✓ **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.portlandoregon.gov/bds/article/311179 for the landscape requirements for private streets.

See **Appendix G.3** 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 a 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 Approach for Private	Presumptive Approach for Private	Presumptive Approach for Streets	Performance Approach for Streets
2-26	Ecoroof	•	•		
2-40	Pervious Pavement	•	•		•
2-45	Tree Credit	•		•	

Page	Vegetated Facility	Simplified Approach for Private	Presumptive Approach for Private	Presumptive Approach for Streets	Performance Approach
2-49	Downspout Extension	•			
2-52	Swale	•	•	•	
2-57	Curb Extension			•	
2-64	Planter	•	•	•	
2-68	Basin	•	•	•	
2-72	Filter Strip	•			•
2-74	Grassy Swale				•
2-79	Pond				•

Page	Facility	Simplified Approach for Private	Presumptive Approach for Private	Presumptive Approach for Streets	Performance Approach
2-89	Sand Filter				•
2-93	Soakage Trench	•	•		
2-98	Drywell	•	•		
2-102	Sump		•	•	
2-107	Manufactured Stormwater Treatment Technology		•	•	•
2-109	Rainwater Harvesting				•
2-112	Structural Detention				•

Page	Facility	As Required	Source Control
2-117	Oil/Water Separator	•	•
2-120	Spill Control Manhole	•	•

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

Facility Description

An ecoroof, also called a green roof, is a lightweight vegetated roof system consisting of waterproofing material, a 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 50 percent. 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.
- **Overflow:** Ecoroofs are not a full stormwater disposal system and need to have a conventional drainage system to manage excess runoff during periods of sustained or heavy rainfall. An approved discharge location must be identified for every ecoroof and a drain(s) provided. Downspouts or rain drains must be connected to an approved disposal location.
- **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 these plants 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.

- **Access:** The design must consider safe access for maintenance of the ecoroof and other maintenance needs that require roof access.

- **Permits:** Residential (RS) or commercial (CO) building permits are required. Ecoroofs proposed to meet stormwater mitigation or stormwater management requirements must be included in an O&M Plan that meets the standards of Chapter 3.

<u>**Maintenance Requirements**</u>

- **Fertilizers:** Only nonchemical 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 bonus for ecoroofs in the Central City, refer to City Code Chapter 33.510.210, Option #10.

City of Portland ecoroof website: http://www.portlandoregon.gov/bes/ecoroof

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, which are poured in place, and permeable pavers, which are discrete units set in place. These methods of infiltrating stormwater provide a stable load-bearing surface without increasing the project impervius 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 to 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 precast 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), or the pervious pavement subsurface rock may be sized for necessary detention. 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. A liner may be required for areas located within 5 feet of structures or infrastructure. See **Exhibit 2-1** for more information on setbacks.
- **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 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. The subgrade should not be constructed or compacted during wet conditions.
- 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 may be 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- to 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 2-7** 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 to 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 BDS's 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.
- Pervious pavement proposed to meet stormwater mitigation or stormwater management requirements must be included in an O&M Plan that meets the standards of Chapter 3.

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 subgrade should not be constructed or compacted during wet conditions. 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 Specifications
AASHTO Guide for Design of Pavement Structures

BDS's administrative rules on private streets:
http://www.portlandoregon.gov/bds/article/311179.

Exhibit 2-8: Portland street trees. See **Appendix G.3,** SW-300, for typical street tree details.

Facility Description

Trees intercept precipitation and provide several stormwater management benefits: they hold water on their 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.

Existing trees can have significant benefits in addition to stormwater management. Trees provide habitat for urban wildlife, energy conservation, aesthetics, visual screens, heritage value, windbreaks and recreation.

Trees are allowed as an impervious area reduction technique on both private property and in the public right-of-way under specific criteria and with provisions. The specifications that follow were developed to maximize the use of trees to mitigate stormwater impacts. The City Forester maintains authority over trees in the public right-of-way. BES will inspect trees on private property during installation and post-construction, and the property owner is responsible for maintenance.

Design Requirements

- **Site applicability**: For residential development on private property, new tree credit can only be used at sites larger than 5,000 square feet. For all sites including right-of-way with over 1,000 square feet of impervious surface to manage, no more than 10 percent of the impervious area can be mitigated through the use of trees. Exceeding this allowance in the right-of-way will be considered on a site by site basis under staff discretion.

- **New tree sizing**: New trees on private property must be at least 1.5 caliper inches at the time of planting, and new coniferous trees must be at least 5 feet tall to receive credit.

- **New tree setbacks:** New trees shall be planted within 25 feet of impervious surfaces. One hundred square feet of credit is given for new broadleaf trees, and 200 square feet of credit is given for new coniferous trees. (See minimum tree sizes below.)

- **Existing tree sizing and setbacks:** Credit also applies to existing trees kept on a site if the trunk is within 25 feet of impervious surfaces and are at least 1.5-inch caliper or larger. Caliper is the diameter of the tree measured 6 inches above the ground surface or root ball. The tree credit for existing trees is tiered based on caliper (see Exhibit 2-9).

Exhibit 2-9. Stormwater Credit for Existing Trees

Caliper of Existing Tree	Stormwater Credit
1.5 up to 6 inches	200 square feet
6 inches and larger	400 square feet per each 6 caliper inches

- **Tree selection**: The trees selected shall be suitable species for the site conditions and the design intent. Nuisance trees cannot receive stormwater tree credit. BES may require a certified arborists report to verify suitable tree selection and preservation.

- **Planting area:** Minimum planting space necessary for a new tree is determined by City Code and the City Forester. This area should be marked on plans and protected during construction per the City Code.

- **Street and public trees:** 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. New street trees must be at least 1.5 caliper inches for the one- and two-family residential development type, 2 caliper inches for multidwelling residential development type, and 2.5 caliper inches for all other development types. Caliper is the diameter of the tree measured 6 inches above the ground surface or root ball.

- **Other considerations:** Trees planted to meet stormwater facility planting requirements cannot also receive impervious area reduction credit. New or existing trees counting towards environmental zone mitigation cannot receive tree credit.

- **Limitations**: Tree credits may not be allowed if site circumstances or system limitations exist.

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

<u>Submittal Requirements</u>

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, or in the case of existing canopy, after the site grading has been completed. Trees proposed for stormwater credit will need to be included in the required O&M Plan. BES may require a survey and certified arborist report to verify suitable tree selection or tree preservation for any trees designated for stormwater tree credit.

<u>Construction Considerations</u>

Protection of existing trees during construction shall meet City Code requirements unless the City Forester approves exemptions to this requirement. The applicant will have to provide documentation required by the Forester to ensure the tree will remain healthy after construction and for the life of the tree.

Maintenance

- Trees shall be maintained and protected on the site after construction and for the life of the development (50 to100 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 BES. Trees that are removed or die shall be replaced within 6 months with like species or alternatives approved by BES.

- Trees may be pruned for safety and arboricultural health 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 .

Citywide Tree Regulatory Improvement Project:
http://www.portlandoregon.gov/bps/46921

Exhibit 2-10. Disconnected downspout.

Facility Description

Directing downspouts to splash blocks is a method of stormwater management that directs roof runoff to vegetated or mulched landscape areas for onsite infiltration. This method can be utilized for small-scale projects on private property that have appropriate site conditions. Roof runoff is directed to existing landscaping where it can spread out and safely soak into the soils and remain on the property. Existing site conditions will determine if this is a suitable method for managing stormwater onsite. Property line and building setbacks as well as surface grade and available landscaped areas for infiltration must be considered. Proposed downspout locations and roof/gutter alignments will impact the feasibility of this option. As such, a preliminary site visit by BES staff is recommended to determine if downspout extensions are a viable option.

Design Requirements

- **Site Suitability**: Downspout extensions are suitable for sites that have well draining soils (≥2 inches/hour) and have an overall slope of 10 percent or less. A maximum of 500 square feet of roof area is allowed to drain to each downspout. For new development or redevelopment, only small-scale projects on private property with less than 1,000 square feet of new impervious area, including garages, additions, and accessory dwelling units, are eligible to use this method. For stormwater retrofits or alterations to existing structures, the structure must be smaller than 5,000 square feet.

- **Setbacks**: Downspouts typically discharge 2 feet from slab on grade and structures with crawl spaces and 6 feet from all foundations with basements. The point of discharge typically are set back 5 feet from property lines and 10 feet from all neighboring structures or buildings and retaining walls over 36 inches in height. Splash blocks are **not** considered part of the downspout extension and are included for erosion control and flow dispersal only. See **Exhibit 2-1** for more information on setbacks.

- **Sizing and grade**: The landscape area utilized for disposal of stormwater must be at least 10 percent of the roof area that drains to each downspout. The grade of the landscape area must gently slope away from the foundation and neighboring properties and allow stormwater to spread out over the required 10 percent infiltration area. Setback requirements must be retained over the entire infiltration area.

- **Materials**: Durable, gutter-grade materials such as aluminum, steel, copper, vinyl, and plastic downspouts can be utilized for extensions. Downspouts need to be secured to the structure and connections securely fastened together with appropriate materials (i.e., sheet metal or similar screws). Flexible downspout extensions are not approvable materials. Rain chains must be securely fastened to the structure and the ground in a vertical alignment and must meet setback standards in order to be approved. Splash blocks, rock, or flagstone must be utilized for erosion control and flow dispersal at the point of discharge. Downspouts can be directed to drain onto grass without additional erosion control measures.

- **Other Considerations**: Downspouts must not be directed to drain onto or over impervious areas, including walkways, driveways, and patios or onto neighboring properties, including public sidewalks and streets. Downspouts and gutters may be regraded, piped, redirected in order to convey water to a safe infiltration area. Downspouts need to drain directly to landscape areas intended for infiltration. Landscaped areas above buried oil tanks or adjacent to retaining walls over 36 inches high cannot be utilized as infiltration areas.

Submittal Requirements

An applicant for downspout extension approval must submit a site plan that notes downspout locations and roof drainage areas and that clearly illustrates roof area limitations, setbacks, and infiltration area requirements can be met. All other permit requirements apply, including an O&M Plan that meets the standards of Chapter 3.

Alternate onsite disposal methods such as soakage trenches will be required upon inspection for sites that cannot meet applicable downspout extension setback and landscape requirements.

Construction Consideration

Downspouts need to be located in areas that can accommodate stormwater flows and do not cross walkways or drain onto driveways, patios, or other impervious surfaces. Downspout locations and quantity can be field-fit based on site conditions to meet required standards. The design should consider landscape grade during construction to ensure the finished landscape grade will allow stormwater to drain safely away from building foundations and property lines. Hinged downspout extensions or "flipper" extensions can be utilized for ease of landscape maintenance.

Maintenance

Downspout extension must be included in an O&M Plan that meets the standards of Chapter 3. The property owner should:

- check and clear elbows and bends in downspouts to prevent clogging
- regularly clean gutters and ensure that parts are securely fastened together
- check the grade of landscape and look for erosion at the point of discharge
- maintain landscaping as needed

Exhibit 2-11: 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. Grassy swales are described as a separate facility and require the Performance Approach.

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 are typically set back 5 feet from property lines and 10 feet from building foundations. There are no setback requirements for lined flow-through swales. See **Exhibit 2-1** for more information on setbacks.
- **Access:** The design must consider safe access for maintenance of the swale.
- **Sizing**: For the Simplified Approach, a sizing factor of 0.09 is required. For the Performance Approach, surface area and depth of facility vary. An approved stormwater sizing calculator allows the designer to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project.
- **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 also slow flow to remove coarse sediment and prevent erosion. They shall be constructed of durable, nontoxic 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 and perpendicular to flow parth of stormwater. 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- to 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 the growing medium must be separated by filter fabric (if required; see **Exhibit 2-3** for geotextile specifications), or a 2- to 3-inch layer of ¾ to 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 blended topsoil is specified in Appendix F.3. In all cases, the blended topsoil 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.3** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibits 2-12 through 2-15**.

<u>Private Property</u>

Exhibit 2-12: 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 2-13: 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 2-14: 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 2-15: 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 compaction or sedimentation to preserve infiltration capacity during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration swale areas.

Exhibit 2-16: North East Siskiyou Street curb extension.

Facility Description

Stormwater curb extensions comprise retrofitting a section of paved roadway with a vegetated swale behind a secondary curb that "extends" into the roadway. This new vegetated area manages stormwater runoff and often utilizes existing street inlets for routing water into and out of the facility. Curb extensions have been typically used in retrofit situations to manage runoff from developed rights-of-way. A change in curb alignment into the roadway allows for stormwater to efficiently flow into the facility. Curb extensions can also provide a location for a stormwater facility since available space behind an existing curb line is more likely to be constrained or inadequate in size. The presence of utilities, potential loss of on street parking spaces, and the narrowing of the road width are all considerations in curb extension placement and design.

Curb extensions can also improve auto, pedestrian, and bicycle safety. Extensions narrow the crossing distance for pedestrians, improve sight-lines, and provide a visual presence in the roadway to slow cars approaching intersections.

Stormwater curb extensions effectively intercept stormwater from the street gutter and send it into gently sloping or flat bottomed facilities. Within the facilities, vegetation and check dams slow the stormwater down, filter it, and in many cases allow it to infiltrate into the ground. In locations where soils do not drain well, curb extensions can overflow to an approved discharge point such as a storm sewer, sump, or open channel drainage way, such as a creek or stream.

General Guidelines

Local Service Streets (as defined by the Portland Bureau of Transportation) typically accommodate curb extensions and the design considerations outlined below are directed primarily for this application. Curb extensions can also be accommodated on higher classification streets using similar design considerations. However, significantly more scrutiny and review are required to ensure vehicle and pedestrian safety, safety for maintenance crews, and adequate sizing of the facility for those situations. Additional considerations for higher classification streets may include analysis for future transportation system demands. These demands may call for future travel lanes, bike lanes, or turn lanes that would potentially conflict with a curb extension. Other facilities such as planter boxes within the planting strip behind the curb may be more appropriate for high traffic areas.

Curb extensions should be designed for optimal collection of stormwater to fit into the existing streetscape to the maximum extent practicable. Designers should take into consideration the impact to adjacent property owners and preserving existing desirable amenities within the right-of-way such as on street parking, walkways, landscaping, street trees, and utilities.

- Since curb extensions occupy space typically used for on-street parking, a technique for mitigating impacts to adjacent property owners is centering surface stormwater facilities between property owners. Even though this may not be the most efficient location for collection of stormwater, it reduces the impact to one property by spreading it over two. This technique can allow for at least one on-street parking space to be retained on each property frontage. In general, projects should avoid removing parking entirely along frontages without driveways or off-street parking areas.

- For mid-block curb extension applications, it is acceptable for stormwater to flow into a facility and then back out (such facilities are referred to as a "flow-through" facilities). When a stormwater curb extension is combined with pedestrian ramps at corners, stormwater should be collected within the facility to the maximum extent practicable. This may include the installation of underdrains and/or overflow inlets within the stormwater facilities. Stormwater must not flow across the base of the pedestrian ramps when exiting the facility.

- The development potential of adjacent property should be considered to the maximum extent practical when placing facilities. For example, an undeveloped or underdeveloped lot might require a driveway at a future time, which could conflict with a surface stormwater facility. The BDS should be contacted to determine if a development inquiry or building permit exists for adjacent properties.

Street Design Requirements and Considerations

- A curb extension in an existing right-of-way is considered to be an alteration. As a result, the federal law requires that such a curb extension project improve adjacent corners that do not have pedestrian ramps. See City Standard Drawing P-548 in the *City of Portland Standard Construction Specifications*.

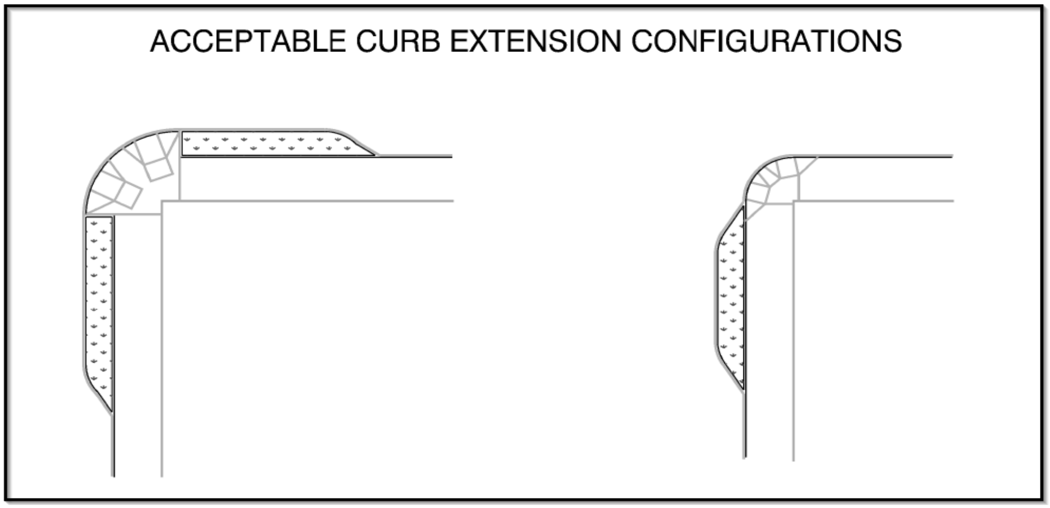
- For corner applications, stormwater curb extensions must be placed at the Point of Curvature (PC) or the Point of Tangency of a corner radius or as close to the corner ramp as possible without blocking the pedestrian ramp. Where a curb extension cannot be placed at or very close to the PC of a corner radius, stormwater curb extensions must be moved back approximately 18 feet to allow for a legal parking space.

- Stormwater curb extensions proposed on both sides of a street corner must be incorporated into a full curb extension including the corner ramps (See Exhibit 2-17). Subject to BES approval, a single stormwater curb extension can be placed on one side of a corner without requiring that the corner ramp be incorporated into the extension. The specific geometry requirements for a full corner curb extension are determined by Portland Bureau of Transportation (PBOT) traffic engineers according to site conditions.

- Corners with pedestrian ramps must be constructed (see Exhibit 2-17) in a Pedestrian District or City Walkway per the City's Transportation System Plan. If there is a safety benefit to shortening the crossing distance for pedestrians, and/or if the street is a designated Safe Route to School and on higher classification streets, these requirements will be conveyed by transportation staff.

- For midblock applications, locate stormwater curb extensions at the wing of a driveway or at least 18 feet from a driveway wing to either remove or allow for parking.

Exhibit 2-17. Acceptable Curb Extension Configurations.

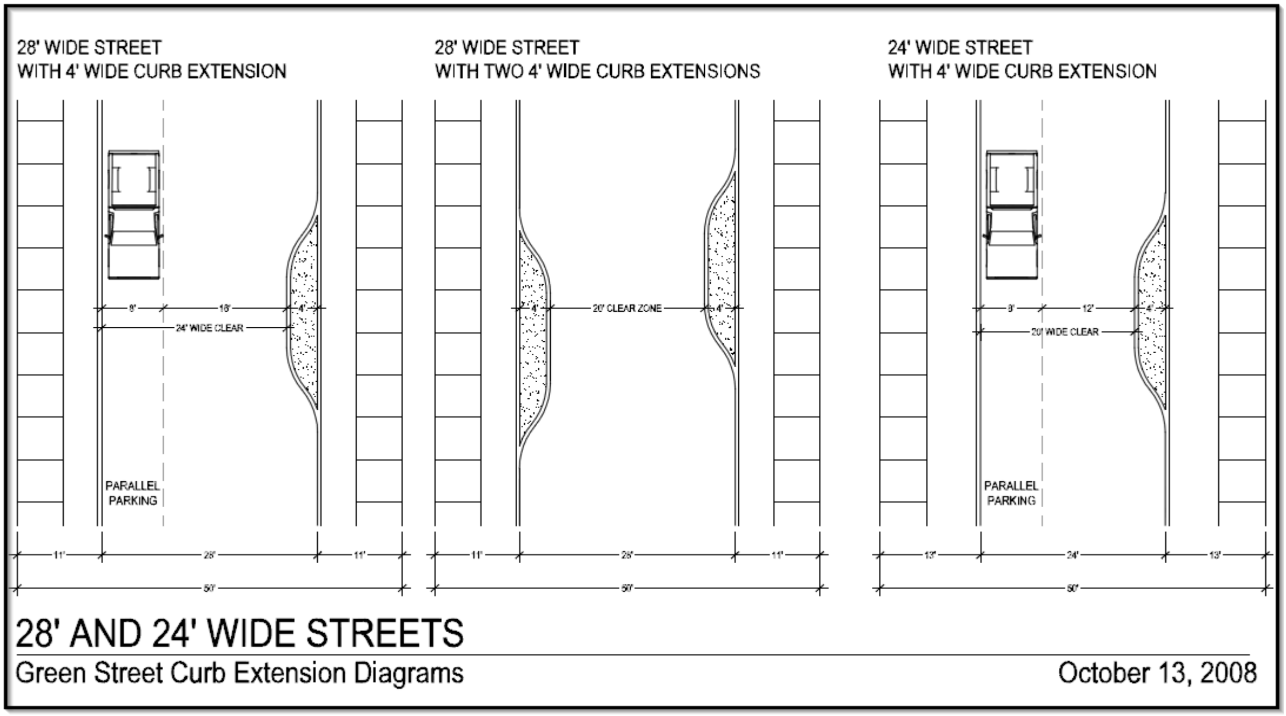


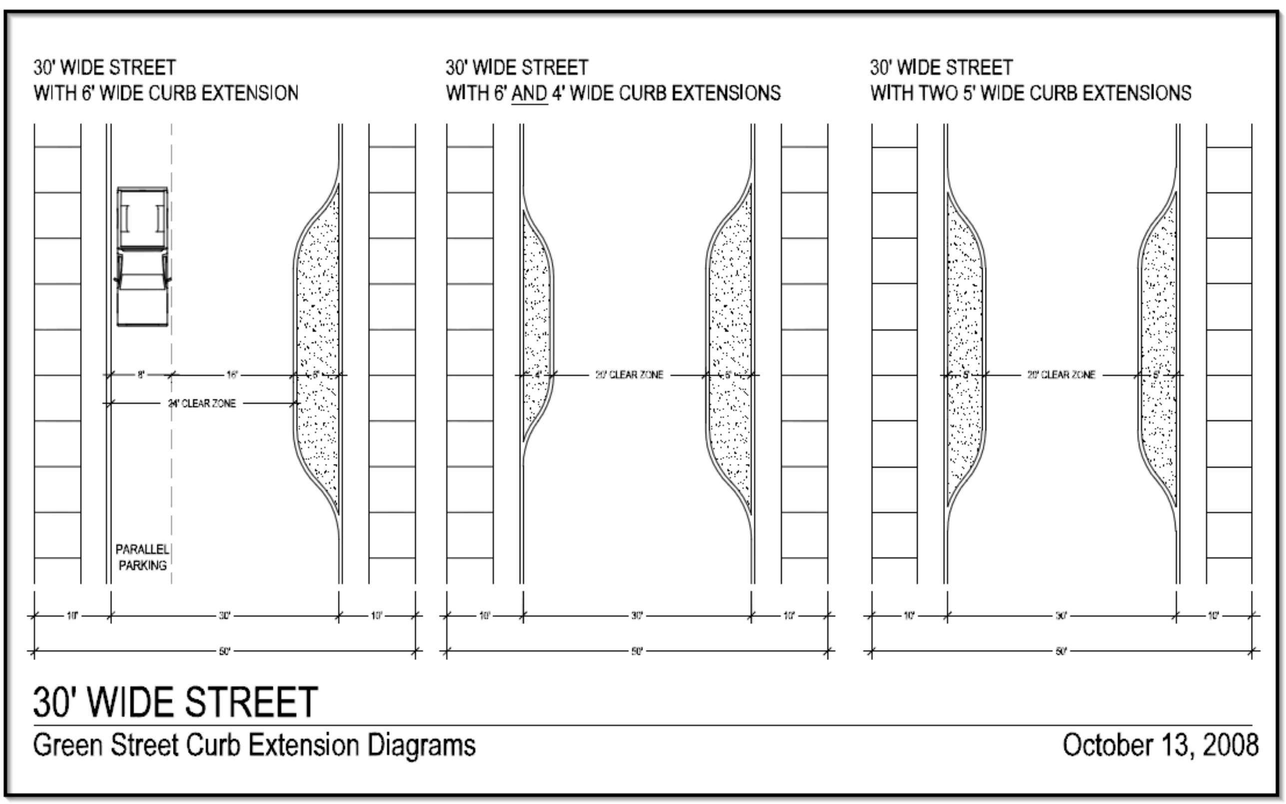
- The presence of existing fire hydrants and mature street trees will impact placement of curb extensions. Consequently, coordination with the Portland Water Bureau and Portland Parks and Recreation is necessary.

- A thickened curb and gutter per *City of Portland Standard Construction Specification* Drawing P-540 must be used along the street side of all surface stormwater facilities in the public right-of-way.

- Typical curb extensions vary in width from 4 to 6 feet as measured from the face of the existing curb to the street-facing face of a new curb. The actual width of the curb extension varies depending on many factors, including but not limited to existing street width, on-street parking, bike lanes, traffic engineering considerations, and conflicts with utilities, such as water lines. A distance of 20 feet between curbs on opposite sides of the street must be maintained on all local, two-way residential streets per Portland Fire Bureau requirements, unless specific exceptions are approved (See Exhibit 2-18).

Exhibit 2-18. Street Widths for Curb Extensions.





Note: 32 feet and wider streets may have up to 6 feet curb extensions on one or both sides of the street.

- In addition to PBOT and Fire Bureau requirements, existing utility locations may also impact allowable curb extension width. It may be necessary to reduce the width of a curb extension to avoid a utility conflict.

- Curb extensions must be designed with a wheel stop at the inlet/outlet of a facility when adjacent to on-street parking. Significant damage to both the facility and a vehicle can occur if a vehicle enters the curb opening of a curb extension. See **Appendix G.3**.

- To prevent odor issues in combined sewer areas, beehive inlets located within a curb extension stormwater facility should be piped to manholes or daisy-chained with street inlets and not piped directly to a main-line combined sewer. If a connection to the sewer cannot be avoided, an approved method must be used to prevent the escape of sewer gas. Refer to the BES *Sewer and Drainage Facilities Design Manual.*

- The "Green Street Site Assessment Checklist" (**Appendix G.4**.) should be used for field checks and applicable details.

- Generally, a minimum length of 30 feet is required to accommodate a mid-block curb extension ranging from 4 to 6 feet in width. Any linear length shorter than this should not be considered for a curb extension.

- Existing sidewalks with a vertical or horizontal displacement greater than or equal to ½ inch must be repaired at locations where new construction meets old as shown on the *City of Portland Standard Construction Specifications* Drawing P-554. Many existing sidewalks are old and not able to withstand even minimal adjacent disturbance or construction loads. Since the adjacent property owner is responsible under City Code for sidewalk maintenance and repair, the sidewalk must be restored to a condition as good as the condition that existed before construction. Replacement of fragile sidewalks beyond the minimal requirements allowed by P-554 should be evaluated during the design process by PBOT staff.

Stormwater 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 and requirements.

- **Setbacks**: Infiltration curb extensions are typically set back 10 feet from building foundations. There are no setback requirements for lined flow-through curb extensions. See **Exhibit 2-1** for more information on setbacks.

- **Sizing**: Surface area and depth of facility vary. An approved stormwater sizing calculator allows the designer to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project. See **Appendix G.3** for stormwater curb extension geometry and typical sections.

- **Dimensions and slopes**: The minimum curb extension width is 4 feet, and the length will vary. They may vary in depth from 6 to 9 inches measured from the top of the street curb. Maximum longitudinal slope is 6 percent.

- **Check dams**: Check dams may be required perpendicular to the flow line to encourage water to pool and infiltrate into the ground.

- **Gravel drain rock:** Drain rock may be required below the growing medium of a curb extension. Refer to **Appendix G.3** for specific details.

- **Piping:** 8-inch ASTM 3034 SDR 35 PVC pipe and 4-nch perforated pipe are required. Refer to the BES *Sewer and Drainage Facilities Design Manual*.

- **Growing medium**: For curb extensions, the blended topsoil is specified in **Appendix F.3**. The blended topsoil must be 18 inches deep unless otherwise specified.

- **Vegetation:** The entire facility area must be planted with vegetation. The facility area is equivalent to the total area of the facility, including bottom and side slopes, as developed in the sizing calculations. Curb extensions should be planted so they do not block traffic sight lines or require mowing. See **Appendix F.4** for suggested plant material appropriate for private property and the public right-of-way. See **Appendix G.3** for typical details and planting templates.

- **Liners:** Full or partial liners may be required for protecting adjacent water facilities/utilities. In addition, they may be required on higher classification streets, in locations with hazardous materials or topography considerations, and in wellhead protection areas. Other methods may be considered where impervious or waterproof facilities are required, such as single-pour concrete forms.

Exhibit 2-19: 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 are typically set back 5 feet from property lines and 10 feet 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. See **Exhibit 2-1** for more information on setbacks.

- **Access:** Design must consider safe access for maintenance of the planter.

- **Sizing**: For the Simplified Approach, a sizing factor of 0.06 is required. For the Performance Approach, surface area and depth of facility vary. An approved stormwater sizing calculator allows the designer to size the planter with respect to native infiltration rates and other unique site conditions of the project.

- **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. For planters that require an impervious bottom, a single-pour concrete solution is preferred. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

- **Waterproofing (if required):** Flow-through facilities that require an impervious bottom can achieved through either a waterproof liner (geomembrane) or a single-pour concrete box. If lined, there are many liner options, and installation varies. Liners should be installed to the high water mark. Liner shall be 30 to 40-mil PVC or HDPE as appropriate or approved 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- to 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 a 2- to 3-inch layer of ¾- to ¼-inch washed, crushed rock or by filter fabric (see **Exhibit 2-3** for geotextile specifications). Green streets require ¾ inch No. 4 open graded aggregate 3 inches in depth.

- **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 blended topsoil is specified in **Appendix F.3**. In all cases, the blended topsoil 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.3** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibit 2-20**.

Exhibit 2-20: Planter Vegetation - ZONE A
Private and Public Property

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 overapplied.

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 compaction and sedimentation to preserve infiltration capacity during construction. No vehicular or foot traffic, except that specifically used to construct the facility, should be allowed within 10 feet of infiltration planter areas.

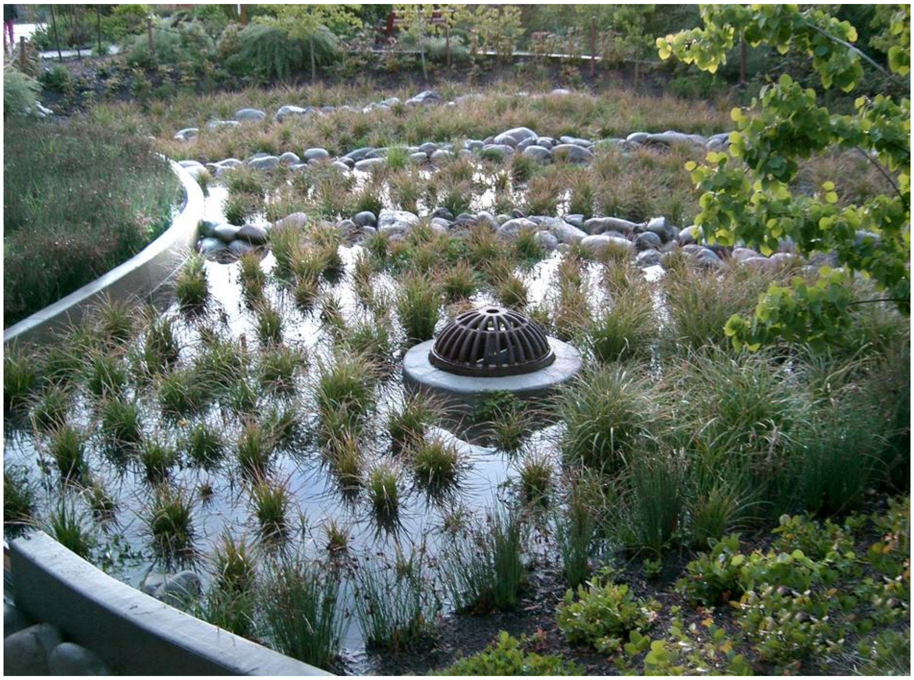


Exhibit 2-21: Glencoe School Infiltration Basin. See **Appendix G.1,** SW-140**,** for typical basin details.

Facility Description

Vegetated infiltration basins are shallow landscaped depressions used to collect and hold stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground. Basins are also referred to as rain gardens. 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:** Basins are typically set back 5 feet from property lines and 10 feet from building foundations. Infiltration basins are typically set back from downstream slopes: a 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. See **Exhibit 2-1** for more information on setbacks.

- **Access:** Design must consider safe access for maintenance of the basin.

- **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. An approved stormwater sizing calculator allows the designer to size stormwater facilities with respect to native infiltration rates and other unique site conditions of the project.

- **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-to 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 a 2-to 3-inch layer of ¾ - to ¼-inch washed, crushed rock or filter fabric (see **Exhibit 2-3** for geotextile specifications). Green streets require ¾ No. 4 open graded aggregate 3 inches in depth.

- **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 blended topsoil is specified in **Appendix F.3**. In all cases, blended topsoil 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.3** for typical details and planting templates. Minimum container size is 1 gallon. Minimum quantities are shown on **Exhibits 2-22 and 2-23**.

Exhibit 2-22: 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 2-23: 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 overapplied.

Construction Considerations

Infiltration basin areas should be clearly marked before site work begins to avoid soil compaction or sedimentation during construction. No vehicular or foot 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, which 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**: Filter strips are typically 5 feet from the property line; 10 feet from buildings; and 50 feet from wetlands, rivers, streams, and creeks. See **Exhibit 2-1** for more information on setbacks.
- **Access:** Design must consider safe access for maintenance of the facility.
- **Sizing**: Where the Simplified Approach is applicable, the filter strip is sized at 20 percent of impervious area treated for a maximum of 500 square feet of impervious area to be managed by the filter strip. 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, nontoxic 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 TSS 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 predevelopment peak runoff rates (as described **Section 1.3.2**).

Design Requirements

- **Soil suitability:** Grassy swales are appropriate for all soil types.
- **Setbacks**: Grassy swales are typically set back 5 feet from centerline of the swale to property lines and 10 feet to building foundations, unless the swale is lined with impermeable fabric. See **Exhibit 2-1** for more information on setbacks.
- **Access:** Design must consider safe access for maintenance of the facility.
- **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
  - a Manning *n* value of 0.25

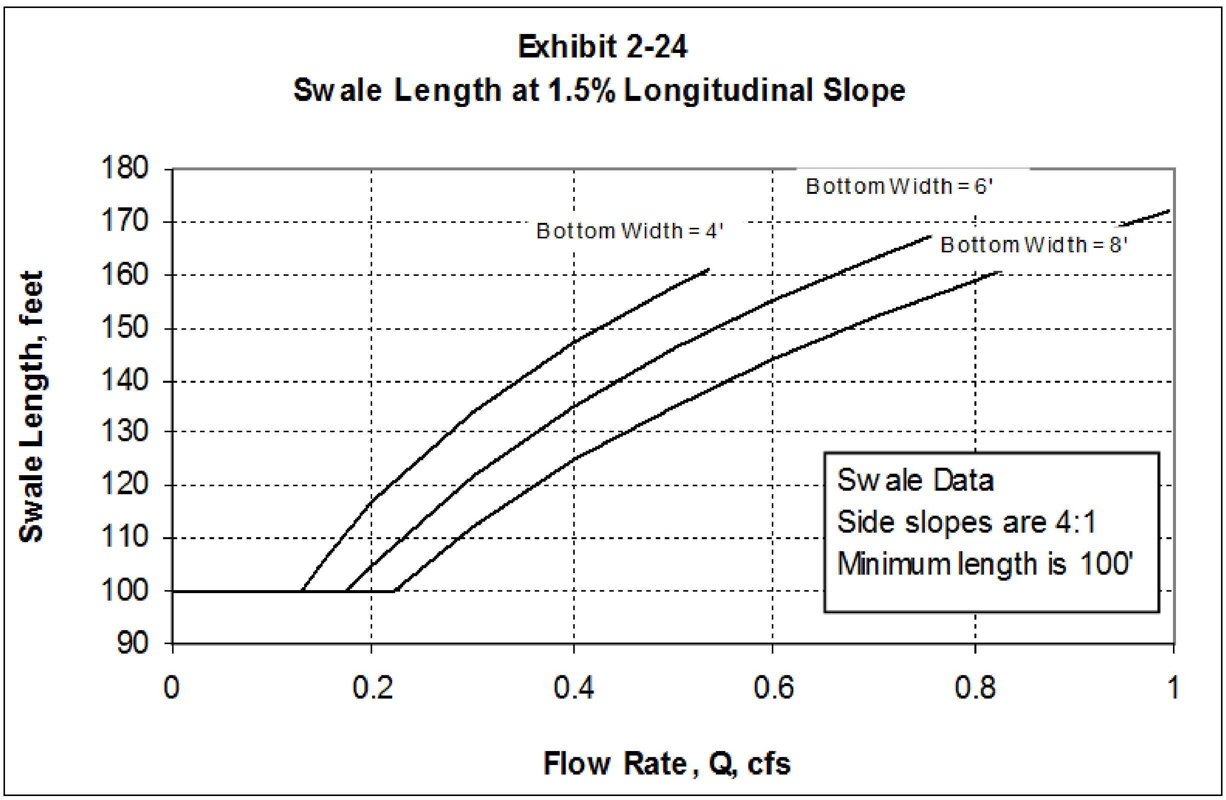
  A minimum of 1 foot of freeboard above the water surface shall be provided for facilities not protected by high-flow storm diversion devices. Swales without high-flow diversion devices shall be sized to safely convey the 25-year storm event, analyzed using the Rational Method (peak 25-year, 5 minute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

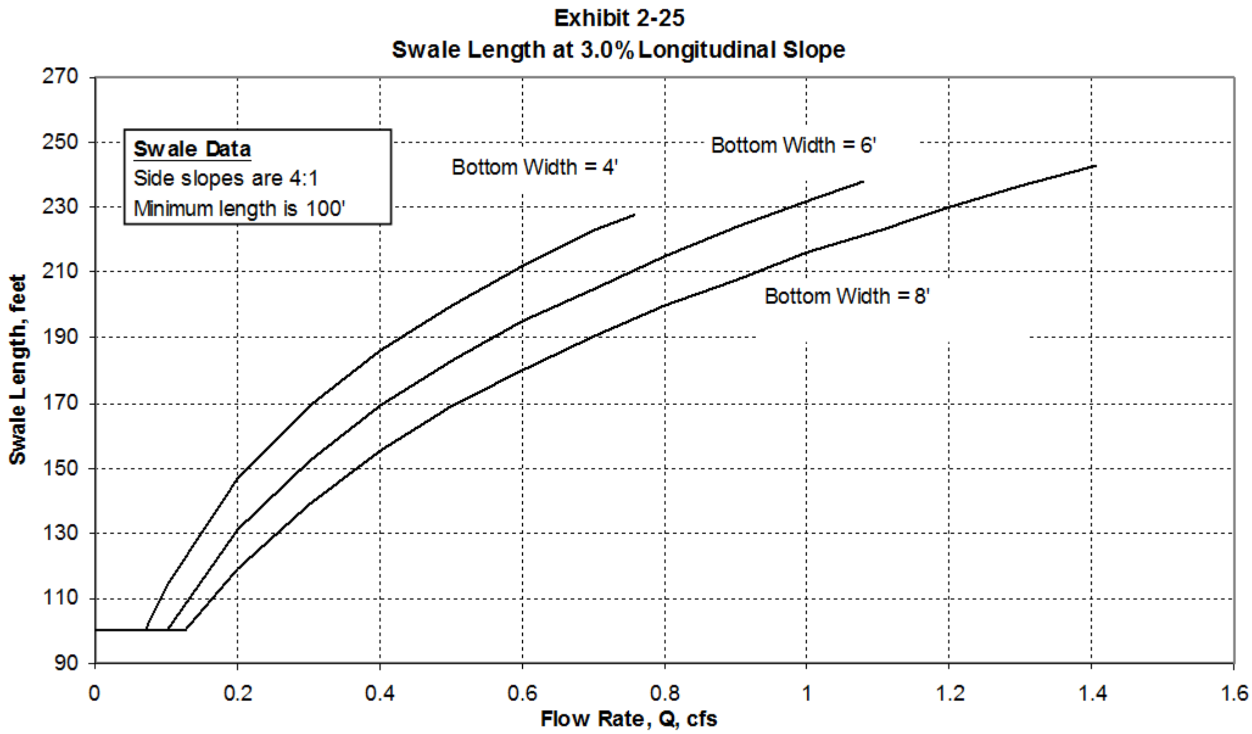
Velocity through the facility shall not exceed 3 feet per second during the high-flow events (i.e., when flows greater than those resulting from the pollution reduction design intensity are not passed around the facility).

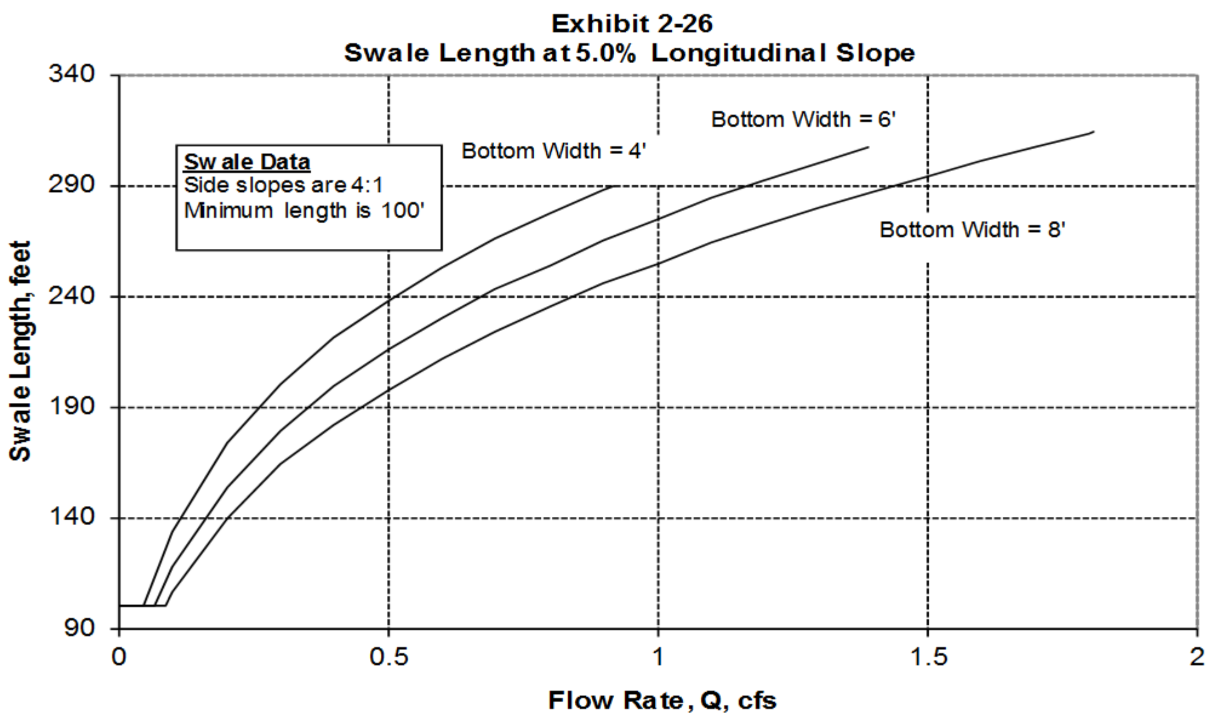
- **Flow spreader**: The grassy swale shall incorporate a flow-spreading device at the inlet. The flow spreader shall provide a uniform flow distribution across the swale bottom. In swales with a bottom width greater than 6 feet, a flow spreader shall be installed at least every 50 feet.

- **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 2-24, 2-25, and **2-26** 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.







- **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:** Blended topsoil shall be used within the top 18 inches of the facility to support plant growth, per specifications in **Appendix F.3.**
- **Vegetation:** Grasses 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 2-27** shows vegetation requirements for grassy swales.

Exhibit 2-27: 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 on trees and shrubs that are appropriate for their zone.

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.

<u>Submittal Requirements</u>

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

<u>Construction Considerations</u>

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

<u>Maintenance</u>

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 TSS removal from 90 percent of the average annual runoff (as described in **Section 1.3.3**) and provide detention of the postdevelopment peak runoff rates to less than predevelopment 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 are typically 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.) See **Exhibit 2-1** for more information on Setbacks.

  - 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 10 percent. 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).

- **Access:** Design must consider safe access for maintenance of the facility.

- **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:

$$\text{Volume} = 2 \times (2{,}276 \times \text{Impervious Acreage})$$

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 postdevelopment 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) = 54,624 cubic feet

- **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 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 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 improvement 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- to 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, cubic feet per second (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, 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

- **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 postdevelopment 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 postdevelopment conditions, using the following formula:

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

where:	L	= Length of bottom of weir, feet
	Q_{100}	= 100-year postdevelopment 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 preapproval 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 2-28 and 2-29**.

Exhibit 2-28: 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 2-29: 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 TSS removal from 90 percent of the average annual runoff (as described in **Section 1.3.3**) and provide detention of the postdevelopment peak runoff rates to less than predevelopment 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 typically have 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. See **Exhibit 2-1** for more information on setbacks.

- **Access:** Design must consider safe access for maintenance of the facility.

- **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. For planters that require an impervious bottom, a single-pour concrete solution is preferred. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

- **Waterproofing (if required):** Flow-through facilities require an impervious bottom, achieved through either a waterproof liner (geomembrane) or a single-pour concrete box. If lined, there are many liner options and installation varies. Liners should be installed to the high water mark. Liner shall be 30 to 40-mil PVC or HDPE as appropriate or approved 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-to 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- to ¼-inch washed, crushed rock. Green streets require ¾ inch No 4 open aggregate 3 inches in depth.

- **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 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.

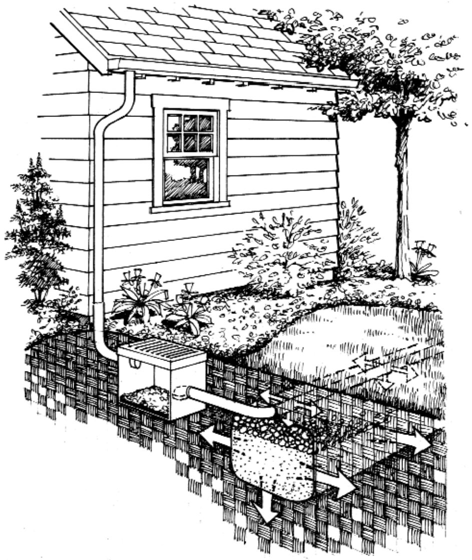


Exhibit 2-30: Soakage Trench illustration. See **Appendix G.1,** SW-180 and SW-181, for typical soakage trench details.

Facility Description

A soakage or infiltration trench is a shallow trench in permeable soil that is backfilled with washed drain rock. 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 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. Additional requirements may be applicable within Wellhead Protection Areas. Complete Wellhead Protection Area requirements can be found online at http://www.portlandoregon.gov/water/29890.

Design Requirements

- The maximum impervious area to be served by a soakage trench is 10,000 square feet.
- Trenches shall not be constructed under current or future impervious surfaces.
- 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.
- **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 groundwater is less than 5 feet.
- **Setbacks:** Soakage trenches typically have 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 typical for slopes 20 percent or greater. See **Exhibit 2-1** for more information on setbacks.

- **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 2-31 shows soakage trench dimensions.

Exhibit 2-31: 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- to 2½-inch round or crushed rock separated from soil by one layer of filter fabric depending on trench type.

- **Filter fabric (if required): 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 BDS approval. Chambers are 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 2-32** shows manufactured chamber technologies dimensions.

Exhibit 2-32: Manufactured Chamber Technologies Dimensions

Soil Type	Area Ratio	Sizing Based on Standard Chamber Size			Design Infiltration Rate (in/hr)
		Length (10)	Width (in)	Height (in)	
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: Manufactured chambers are typically 10 feet on center from all foundations and 5 feet from property lines. See **Exhibit 2-1** for more information on setbacks.

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 the 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.

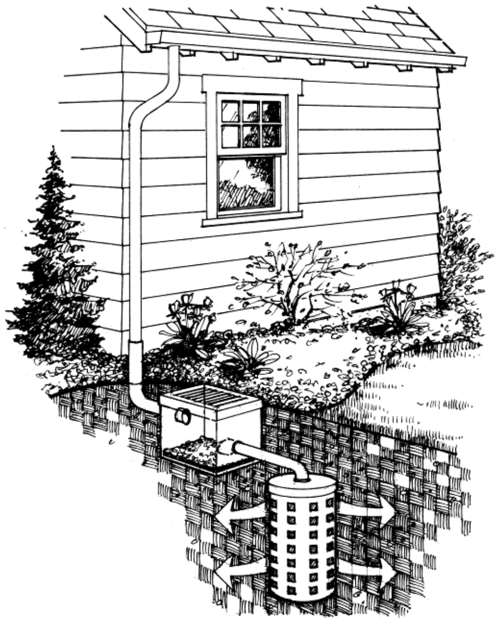


Exhibit 2-33: Drywell illustration. See **Appendix G.1,** SW-170, for typical drywell details.

Facility Description

The typical drywell is a precast concrete ring in 5-foot-tall sections perforated to allow for infiltration. These facilities are vertical in nature and can range from just a few feet in depth to 20 feet in depth (see Exhibit 2-34 for sizing drywells). Drywells require a minimum of 5 feet of vertical separation between the bottom of the drywell and seasonal high groundwater (see Appendix F.1 for determining depth to groundwater). Drywells should not be located in dense silt or clay soils, and may only be located in areas with soils suitable for infiltration (see Design Requirements and Drywell Testing Procedures in the following sections).

Note: Drywells are "Class V Injection Wells" under the federal 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**). Additional requirements may be applicable within designated Wellhead Protection Areas. Complete Wellhead Protection Area requirements can be found at http://www.portlandoregon.gov/water/29890 See **Section 4.3** for areas affected by source control requirements.

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 BES 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 BES. 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 is typically 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. See **Exhibit 2-1** for more information on setbacks.

- **Sizing:** The chart provided in **Exhibit 2-34** 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 2-34: Drywell Sizing Chart

Drywell Sizing: *Once BES 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 these 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 BES approval.

Setbacks: From center: 5 feet to property line, 8 feet to any foundation, and 20 feet to existing cesspools.

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.

City of Portland Groundwater Protection Program
http://www.portlandoregon.gov/water/29890

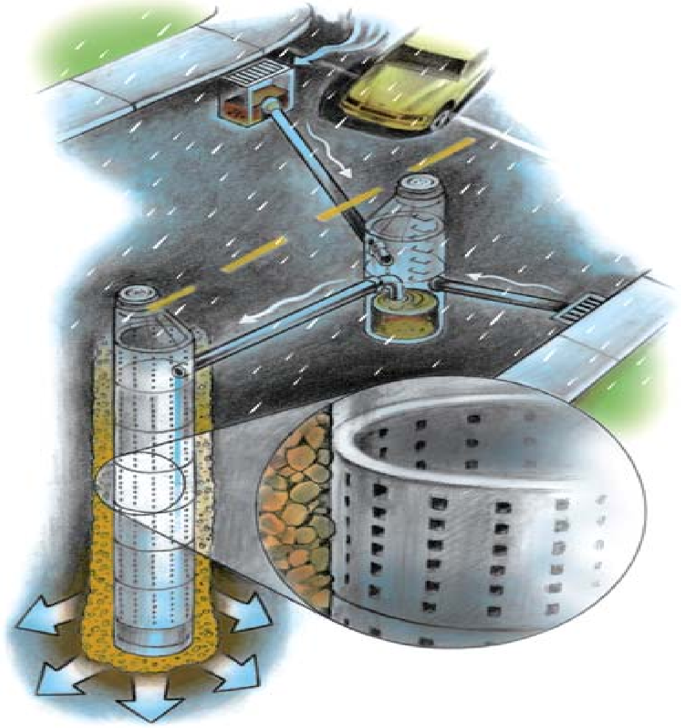


Exhibit 2-36: Sump Illustration. See City of Portland **Standard Plans 4-10 and 4-11** for typical details.

Facility Description

Public infiltration sump systems can be used to provide drainage from City-owned streets by collecting stormwater and infiltrating it into the ground. The use of sumps is dependent on soil type and depth to seasonal groundwater. Sumps are different from drywells in that they are designed using precast 4-foot-diameter concrete rings with perforations, typically 30 feet deep and located in the public right-of-way. Like drywells, sumps require a minimum 5 feet of vertical separation between the bottom of the sump and seasonal high groundwater.

Note: Sumps are "Class V Injection Wells" under the federal 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 a sump. 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 sump 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 pollution reduction benefits. The sedimentation manhole reduces pollution through removal of sediment, oils, and grease. Other types of pollution reduction facilities (e.g., swales or planters) may be used instead of sedimentation manholes. Additional pollution reduction facilities, such as street swales, planters, or filters, must be used in nonresidential 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).
- Additional requirements may be applicable within designated Wellhead Protection Areas. Complete Wellhead Protection Area requirements can be found at http://www.portlandoregon.gov/water/29890.
- 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 5 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 *Sewer and Drainage Facilities Design Manual* for acceptable pipe material types between the sump and sedimentation manhole.

Exhibit 2-37 provides standard sump notes.

Exhibit 2-37: Standard Sump Notes

SUMP NOTES for Plan Set

Design flows reflect a factor of safety of 2.

Design rates for the sump: ______________________________

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 the BES inspector or BES construction office at 503-823-____ 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 the 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 the sump. Introduction of sediment is not acceptable and may result in failure of sump capacity test and reconstruction of the sump.

Fill the sump with water at an initial rate of 300 gallons per minute (gpm), and record water elevation below the sump manhole lid every 5 minutes. When the water surface reaches a constant elevation, increase the flow rate to sump to 600 gpm. Record the water surface elevations every 5 minutes. Continue to increase the flow rate 300 gpm each time water surface elevation stabilizes, until maximum capacity is reached.

Immediately upon completion of the sump test, provide the BES inspector with recorded test data. The 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.

BES Construction Contact information: 503-823-_____________

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.

The City may require the applicant to supply a sump testing table to determine if the sump is performing as designed or if an additional sump may be required.

Exhibit 2-38 shows a sump testing example.

Exhibit 2-38: 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:	$Q=C \times I \times A$
Assume:	Time of concentration = 5 minutes for the street area
Where:	Q = Flow, cfs 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)
	$Q= (0.9) \times (2.86) \times (0.23) = 0.59$ cfs
Apply safety factor of 2:	$Q= 2 \times 0.59$ 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.

O&M 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 "Submission Guidelines for Evaluating Manufactured 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 all documentation required to evaluate if the device meets Portland's pollution reduction standards. This information will be reviewed by BES's Approval Committee, which will decide whether or not the facility can be approved for general use or for use with conditions. The list of approved manufactured stormwater treatment technologies is posted on the BES website.

Manufactured stormwater treatment technologies on BES's approved list must be designed and constructed in accordance with the manufacturer's recommendations.

Manufactured stormwater treatment technologies on BES's approved list for general use may not be capable of meeting specific 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.

Manufactured stormwater treatment technologies not on the approved list can be submitted using the Performance Approach.

Submittal Requirements

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

- 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

Exhibit 2-39: 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 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 2-40 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.

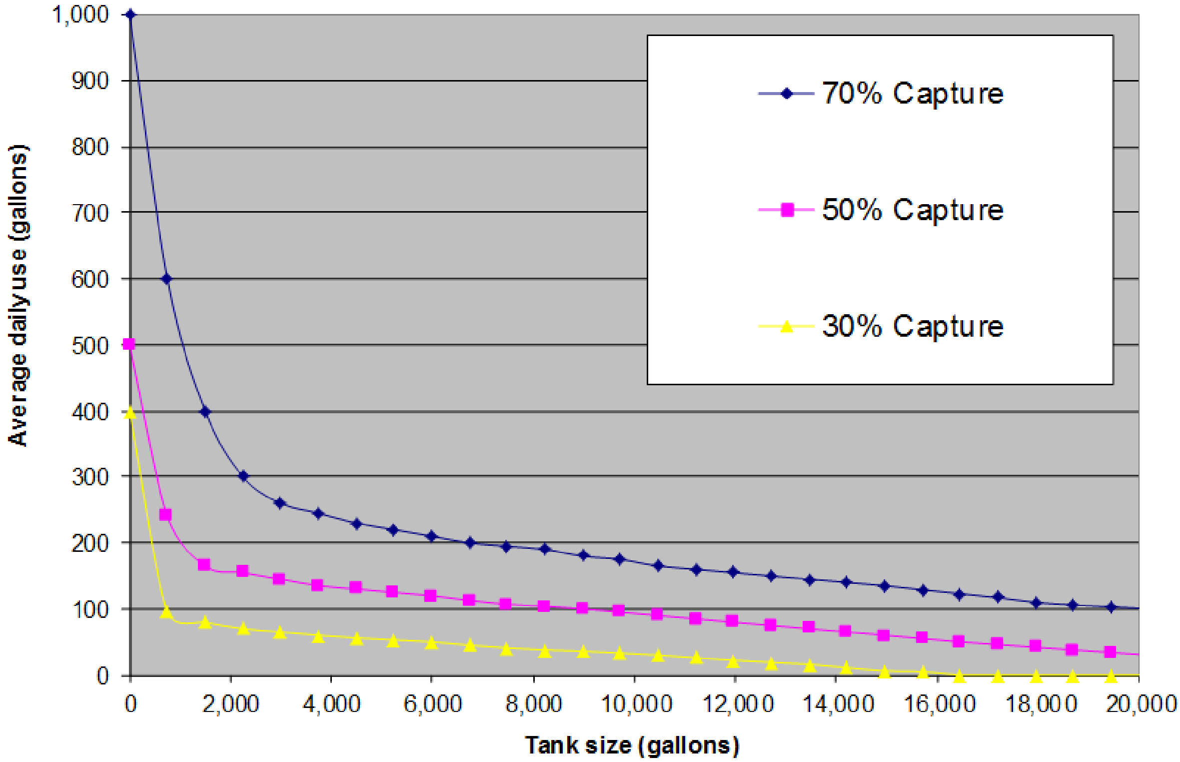
For example, if the stormwater management goal is 50 percent reduction of the annual release volume, the pink line shows that the average daily use would need to be approximately 160 gallons per day if a 2,000-gallon tank were used. A larger tank would need a smaller average daily use rate to achieve 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 2-40: Rainwater Harvesting: 5,000 Square-Foot Impervious Surface
Average Annual Stormwater Runoff Capture Rates



Resources

The BDS website provides more information on reuse guidelines for interior use: **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. Maintenance is required to periodically remove sediment (See **Chapter 3** for O&M requirements).

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,** Operations 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 that follow).

Materials and Structural Stability:

- For public facilities, pipe materials and joints shall conform to the City of Portland *Sewer and Drainage Facilities 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 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 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 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, 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. Source controls do not meet flow control or pollution reduction requirements, and additional stormwater management facilities must be used to meet those requirements.

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.

- 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.)

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 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 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. See **Chapter 3** for O&M requirements, including 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. Source controls are required in areas designated for high-risk activities (i.e., fuel islands, hazardous materials storage/handling, wash pads, trash compactors, vehicular/equipment maintenance). High-risk areas are required to be hydrologically separated from the surrounding impervious area, and the approved discharge location is most often the sanitary system. Proposals installed per the requirements of this manual must be approved by BES and the 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 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 the 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. 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. 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.

Design Requirements

- 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.
- 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.
- Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification.
- Engineered calculations are required, using the Rational Method ($Q=C\times I\times A$).

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 BMPs the facility has implemented. See **Chapter 3** for O&M requirements, including BMPs.

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.