# Chapter 2.0
# STORMWATER MANAGEMENT FACILITY DESIGN

## Summary of Chapter 2.0

This chapter provides procedures for selecting and designing facilities that provide stormwater pollution reduction, flow control, and/or disposal benefits. It includes:



**To Use This Chapter:**

1) Use **Chapter 1.0** to determine the pollution reduction, flow control, and destination/ disposal requirements for the project.
2) Select stormwater management facilities from **Section 2.9: Facility Design Criteria** to meet pollution reduction, flow control, and/or disposal requirements for the project.
3) Size facilities using the **simplified approach**, **presumptive approach**, or **performance approach** presented in this chapter. For simplified approach facilities, use **Form SIM** for sizing. For presumptive approach facilities, use specific sizing criteria presented with each facility type and hydrologic analysis methods listed in **Section 2.3**. Integrate the facilities into the project's overall site plan.
4) Prepare drawings and specifications for each stormwater management facility in accordance with the design criteria in **Section 2.9: Facility Design Criteria**.
5) Consult **Chapter 3.0** for the operations and maintenance requirements for each stormwater management facility.

## 2.1 INTRODUCTION & APPLICABILITY

Facilities presented in this chapter receive credit for pollution reduction, flow control, disposal, or in some cases a combination of the three. Three methodologies are included in this chapter for the sizing and design of stormwater management facilities: the simplified, presumptive, and performance approach. Each design approach has limitations on applicability. See **Exhibit 2-1** for a list of the facility types, their applicable design methodologies, and stormwater management credits given.

**Exhibit 2-1: Stormwater Management Facility Application Table**

| Stormwater Management Facility Type | Credit Given with Associated Design Approach | | |
|---|---|---|---|
| | Pollution Reduction | Flow Control | Destination/ Disposal |
| Ecoroof & roof garden | Simplified | Simplified | NA |
| Pervious pavement | Simplified | Simplified | Performance |
| Contained planter | Simplified | Simplified | NA |
| Tree credit | Simplified | Simplified | NA |
| Infiltration planter | Simplified[1] | Simplified | Presumptive[3] |
| Flow-through planter | Simplified[1] | Simplified | NA |
| Vegetated swale | Simplified[1] | Simplified | Presumptive[3] |
| Grassy swale < 15,000 sq-ft impervious area | Simplified[1] | Simplified | Presumptive[3] |
| Grassy swale > 15,000 sq-ft impervious area | Presumptive | NA | Presumptive[3] |
| Street swales | Simplified[1] | Simplified | Presumptive[3] |
| Vegetated filter | Simplified[1] | Simplified | Presumptive[3] |
| Vegetated infil. basin | Simplified[1] | Simplified | Presumptive[3] |
| Sand filter | Simplified[1] | Simplified | Presumptive[3] |
| Wet pond | Presumptive | NA | NA |
| Extended wet det. pond | Presumptive | Presumptive | NA |
| Dry detention pond | Presumptive[4] | Presumptive | NA |
| Treatment wetland | Presumptive | Presumptive | NA |
| Manufactured treatment technology | Presumptive[5] | NA | NA |
| Structural det. facility | NA | Presumptive | NA |
| Spill control manhole | Presumptive[2] | NA | NA |
| Rainwater harvesting | Performance | Performance | NA |
| Private soakage trench | Presumptive | Presumptive | Presumptive |
| Public infiltration sump system | Presumptive[6] | Presumptive | Presumptive |
| Private drywell | NA | Presumptive | Presumptive |

**Exhibit 2-1 Notes**:
[1] The performance approach may be used to downsize these simplified approach facilities when flow control is not required (**See Section 1.6.2**).
[2] Spill control manholes receive credit for oil removal only; additional pollution reduction facilities will be required to meet basic TSS removal requirements.
[3] The surface infiltration facility design criteria presented in **Section 2.2.2** must be used to receive disposal credit.
[4] Vegetated or grassy swales must be integrated into the bottom of dry detention ponds to receive pollution reduction credit.
[5] Manufactured treatment technologies must be pre-approved by BES to receive presumptive approach credit for pollution reduction.
[6] Public infiltration sump systems (sedimentation manhole and infiltration sump) will only receive credit for pollution reduction if used in residential low-use streets (< 1,000 average daily trips).

## 2.2 DESIGN METHODOLOGIES

### 2.2.1 Simplified Approach

The simplified approach is a relatively easy process for selecting and designing pollution reduction and flow control facilities, intended to save the project developer and the City time and expense. Combination facilities can be more practical to build than separate pollution reduction and flow control facilities. Facilities sized using the simplified approach retain stormwater near the ground surface, which provides a number of benefits, including pollution reduction, groundwater recharge and protection, peak flow reduction, and volume reduction. Rather than detaining stormwater and releasing it off-site at increased post-developed volumes, these facilities help infiltrate or retain water on-site. In areas with surface drainageways and streams, on-site retention lessens the "flashy" high- and low-flow impacts created by development in watershed basins. Stream erosion and temperature impacts are also decreased. In combination sewer areas, on-site retention facilities decrease the rate and volume of stormwater that flows through the system, decreasing the risk of combined sewer overflows and basement flooding. Overall, these facilities help mimic the natural hydrologic cycle by slowing and infiltrating stormwater.

### Simplified Approach Sizing

Facilities designed in accordance with the simplified approach are presumed to comply with the City's pollution reduction and flow control requirements (see **Chapter 1.0**). As sized with **Form SIM** sizing factors, the simplified approach facilities do not sufficiently dispose of large storm events. Additional facilities, designed using the presumptive or performance approach, are required that meet the disposal requirements of this manual (See **Section 1.4**).

BES staff conducted a technical process to determine facility designs and sizes that would be effective on development sites. The process included a review of technical literature, review of BES monitoring data, calculations, and theoretical analysis. Sizing factors for the simplified approaches (shown on **Form SIM** below) were developed as a simple and quick tool to use for site planning and to accelerate permit review and approval. Generalized assumptions were used that may result in conservative sizing for some development sites. Manual users have the option to use the sizing factors as given on Form SIM, or follow the performance approach and submit an alternative facility size, along with supporting engineering calculations for BES review and consideration. The performance approach may be used to downsize facilities in circumstances when flow control is not required (see **Section 1.6.2**).

**Appendix D**: *Simplified Approach Sizing Calculations* provides information about how facility sizing factors were developed, and guidance on how the same methodology can be used to develop alternative facility sizes. An approved hydrologic analysis method (**Section 2.3**), such as a Santa Barbara Urban Hydrograph (SBUH) based approach or continuous simulation model, must be used to generate flow rates and volumes for design analysis. When facilities are downsized to meet pollution reduction requirements only, flows above the pollution reduction design flow must be routed around the facility with an approved diversion structure (**Section 2.5**) unless approved otherwise by BES.

The first three facility types on Form SIM (ecoroofs and roof gardens, contained planter boxes, and tree credits) and pervious pavements are impervious area reduction or mitigation techniques, and should be used first during the site planning and design stage to reduce the overall square-footage of impervious area that requires stormwater management. These facilities intercept rainfall, and are not generally designed to receive stormwater runoff. The second group of facilities listed on Form SIM (infiltration and flow-through planter boxes, vegetated and grassy swales, vegetated filter strips and infiltration basins, and sand filters) is designed to receive stormwater runoff from impervious surfaces.

## Simplified Approach Submittal Requirements

Applicants using the simplified approach shall submit **Form SIM** as part of their permit application, along with construction drawings and details. **Page 2 of Form SIM** can be used to claim stormwater management credit for planting new trees and retaining existing tree canopy on-site. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects that utilize simplified approach facilities must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

## Form SIM: Simplified Approach for Stormwater Management

The city has produced this form to assist with a quick and simple approach to manage stormwater on-site.
Facilities sized with this form are presumed to comply with pollution reduction and flow control requirements.
Stormwater disposal requirements per Section 1.4 must still be met.

**New or Redeveloped Impervious Site Area** _____ **Box 1**
**(do not include roof areas that will be infiltrated on-site with drywells or soakage trenches)**

**INSTRUCTIONS**

1. Enter square footage of new or redeveloped impervious site area in Box 1 at the top of this form.
2. Select impervious area reduction techniques from rows 1-3 to reduce the site's resulting stormwater management requirement. Tree credit can be calculated using the tree credit worksheet on the next page.
3. Select desired stormwater management facilities from rows 4-10. In Column 1, enter the square footage of impervious area that will flow into each facility type.
4. Multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the facility surface area needed to manage runoff from the impervious area.
5. Total Column 1 (Rows 1-10) and enter the resulting "Impervious Area Managed" in Box 2.
6. Subtract Box 2 from Box 1 and enter the result in Box 3. When this number reaches 0, stormwater pollution reduction and flow control requirements have been met. Submit this form with the application for permit.
7. If Box 3 is greater than 0 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from Chapter 2.0 of the Stormwater Management Manual to manage stormwater from these remaining impervious surfaces.

| | Column 1 | Column 2 | Column 3 |
|---|---|---|---|
| **Impervious Area Reduction Technique** | **Impervious Area Managed = Facility Surface Area** | | |
| 1) Eco-Roof / Roof Garden | _____ sf | | |
| 2) Contained Planter | _____ sf | | |
| 3) Tree Credit (See Next Page) | _____ sf | | |

Note: Pervious Pavement areas do not need to be included in Box 1

| **Stormwater Management Facility** | **Impervious Area Managed** | | **Sizing Factor** | | **Facility Surface Area** | **Unit** |
|---|---|---|---|---|---|---|
| 4) Infiltration Planter | _____ sf | x | 0.06 | = | | sf |
| 5) Flow-Through Planter | _____ sf | x | 0.06 | = | | sf |
| 6) Vegetated Swale | _____ sf | x | 0.09 | = | | sf |
| 7) Grassy Swale | _____ sf | x | 0.12 | = | | sf |
| 8) Vegetated Filter Strip | _____ sf | x | 0.2 | = | | sf |
| 9) Vegetated Infil. Basin | _____ sf | x | 0.09 | = | | sf |
| 10) Sand Filter | _____ sf | x | 0.07 | = | | sf |

**For drywell and soakage trench sizing and design requirements, see Section 2.9.**

**Total Impervious Area Managed** _____ **Box 2**

**Box 1 - Box 2** _____ **Box 3**

## Form SIM (Page 2): Tree Credit Worksheet

See **Tree Credits** in Section 2.9 for more information regarding the use of trees to meet stormwater management requirements.

### New Evergreen Trees

To receive stormwater management credit, new evergreen trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree height (at the time of planting) to receive credit is 6 feet.

Enter number of new evergreen trees that meet qualification requirements in Box A ____ **Box A**

Multiply Box A by 200 and enter result in Box B ____ **Box B**

### New Deciduous Trees

To receive stormwater management credit, new deciduous trees must be planted within 25 feet of ground-level impervious surfaces. New trees cannot be credited against rooftop surfaces. Minimum tree caliper (at the time of planting) to receive credit is 2 inches.

Enter number of new deciduous trees that meet qualification requirements in Box C ____ **Box C**

Multiply Box C by 100 and enter result in Box D ____ **Box D**

### Existing Tree Canopy

To receive stormwater management credit, existing tree canopy must be preserved during and after construction. Existing tree canopy must be within 25 feet of ground-level impervious surfaces. Existing trees cannot be credited against rooftop surfaces. Minimum tree caliper to receive credit is 4 inches. No credit will be given to existing tree canopy located within environmental zones. Tree canopy is measured around the tree's drip line.

Enter square-footage of existing tree canopy that meets qualification requirements in Box E ____ **Box E**

Multiply Box E by 0.5 and enter the result in Box F ____ **Box F**

### Total Tree Credit

Add boxes B, D, and F and enter the result in Box G ____ **Box G**

**For sites with less than 1,000 square-feet of new or redeveloped impervious area:**
The amount in Box G is to be entered as "Tree Credit" on Form SIM. ** Stop Here **

**For sites with more than 1,000 square-feet of new or redeveloped impervious area:**
Multiply Box 1 of Form SIM by 0.1 and enter the result in Box H ____ **Box H**

Enter the lesser of Box G and H in Box I. ____ **Box I**
This is the amount to be entered as "Tree Credit" on Form SIM. **Stop Here**

### 2.2.2 Presumptive Approach

Facilities that utilize this design approach are classified as "presumptive," *presumed* to be in compliance with the City's pollution reduction, flow control, and/or disposal requirements if the presented sizing and design requirements are followed.

There are a few key differences between the presumptive and simplified approach sizing methodologies. Stormwater management goals that require the presumptive approach to be used for a particular facility type do not lend themselves well to simplified sizing. More detailed hydrologic calculations must be performed to adequately design the facility to achieve the desired goal. Another difference is that the presumptive approach presents sizing methodologies that meet the requirements of one particular goal (pollution reduction, flow control, or disposal), rather than multiple goals. See **Exhibit 2-1** for the table that specifies the design approaches that are applicable to each management goal, for each facility type.

### Presumptive Approach Submittal Requirements

In addition to detailed construction drawings and specifications shown on permit drawings, all applicants using the presumptive approach for stormwater management are required to submit a detailed stormwater report. This report shall include a general description of the stormwater facility and how it is intended to function. It shall include detailed hydraulic calculations, as summarized in **Exhibit 2-2**. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be provided. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

# Exhibit 2-2:
# Checklist of Calculations to be Included in Stormwater Report

**Stormwater Facility Type**
**A**= Grassy Swale
**B**= Wet Pond
**C**= Extended Wet Detention Pond
**D**= Dry Detention Pond
**E**= Constructed Treatment Wetland
**F**= Detention Tank, Vault, or Pipe
**G**= Manufactured Treatment Technology or Spill Control Manhole

| Parameter or Calculated Value to be Included in the Stormwater Report | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| **Site Variables:** | | | | | | | |
| Site soil type (A, B, C, or D) | x | x | x | x | x | x | x |
| Contributing area (acres) | x | x | x | x | x | x | x |
| Pre-developed curve number CN | | | x | x | x | x | |
| Pre-developed time of concentration T of C (minutes) | | | x | x | x | x | |
| Post-developed curve number CN | x | x | x | x | x | x | x |
| Post-developed time of concentration T of C (minutes) | x | x | x | x | x | x | x |
| Distance from ground surface to max. height of seasonal groundwater (feet) | x | x | x | x | x | x | x |
| **Hydrographs:** | | | | | | | |
| Pre-developed hydrographs for the 2, 5, 10, 25, and 100-year storms, including peak rates and total volumes | | | x | x | x | x | |
| Post-developed hydrographs for the 2, 5, 10, 25, and 100-year storms, including peak rates and total volumes (only if routed through the facility) | | | x | x | x | x | |
| Post-developed hydrographs for the 2, 5, 10, 25, and 100-year storms after being routed through the facility, including peak rates and total volumes | | | x | x | x | x | |
| **Facility Geometry:** | | | | | | | |
| Table showing area and volume of the facility every 6" in elevation | | x | x | x | x | x | |
| Side slopes (h: v or %) | x | x | x | x | x | | |
| Longitudinal slope (h: v or %) | x | | | | x | | |
| Bottom width and length (feet) | x | x | x | x | x | | |
| Overall width and length (feet) | x | x | x | x | x | | |
| **Hydraulic Controls:** | | | | | | | |
| Orifice or weir descriptions, sizes, and elevations, including by-pass facilities | | | x | x | x | x | |
| Elevation, size, and type of overflow spillway or pipe | x | x | x | x | x | x | x |
| **Calculated Values:** | | | | | | | |
| Pollution reduction flow rate | x | | | | | | x |
| Pollution reduction permanent pool volume and elevation | | x | x | | x | | |
| Forebay volume and elevation | | x | x | x | x | | |
| Hydraulic residence time for the pollution control storm | x | | | | x | | |
| Storm routing data showing the peak water surface elevation in the facility for the 2, 5, 10, 25, and 100-year storms (only if routed through the facility) | x | x | | | | | x |
| Detailed storm routing data for the 2, 5, 10, 25, and 100-year storms, showing inflow rate, outflow rate, and water surface elevation in the facility every 10 minutes throughout the storm. | | | x | x | x | x | |

## SURFACE INFILTRATION DESIGN APPROACH FOR DISPOSAL

Where soil conditions allow for percolation near the ground surface, surface infiltration facilities can be used to dispose of stormwater from large storm events. The infiltration of stormwater near the ground surface helps increase the separation to groundwater, providing a greater filtration layer and decreasing the risk of groundwater contamination. It also serves to mimic the predevelopment hydrologic cycle, decreasing downstream impacts by recharging groundwater and increasing evapotranspiration.

Examples of surface infiltration facilities that can be designed under this approach include vegetated, grassy, and street swales, infiltration planters, and vegetated infiltration basins. While the design procedure in this section accounts for complete on-site infiltration of stormwater, facilities sized per the simplified approach are not sized adequately to meet destination/ disposal standards and must include an overflow to an acceptable disposal point. Surface infiltration facilities are not classified as underground injection controls (UICs) by DEQ, and therefore do not need to be registered.

### Surface Infiltration Design Approach to Meet Disposal Standards

1) Determine the preliminary facility size by calculating the runoff volume generated by the 10-year storm (3.4 inches of rainfall over 24 hours, NRCS Type 1A rainfall distribution). The SBUH method can be used to determine this volume, or the volume can be approximated by the following formula:

   Runoff Volume (cubic feet) = 0.28 feet * Impervious Area (square-feet)

   The facility will need to be capable of containing this volume of runoff through a combination of above ground storage and below ground storage within voids in a subsurface rock trench.

2) Surface infiltration facilities require infiltration tests during the design phase of the project. For public facilities, double-ring infiltrometer tests shall be conducted, in accordance with ASTM D3385-94, with BES review and approval. For private facilities, the falling head infiltration test procedure specified in **Section 2.4.2** shall be used. The minimum acceptable infiltration rate for surface infiltration facilities to meet disposal standards is 2 inches per hour. A clogging factor of 4 is then applied to the resulting infiltration rate to be used in the design of the facility.

3) The design infiltration rate (measured infiltration rate divided by 4) is then used to check the facility drawdown time. When full, the facility drawdown time shall not exceed 30 hours.

4) The wet seasonal high water table must be determined, and a minimum 4-foot clearance to bottom of facility must be maintained.

5) The 100-year storm inundation area shall be determined and must show that structures will not be flooded and that property damage and safety risks will be avoided.

6) Minimum setbacks from surface infiltration facilities to structures are shown in **Exhibit 2-4**.

7) All areas to be used as surface infiltration facilities shall be back-filled with a suitable sandy loam planting and filtration medium. Minimum depth shall correspond to each facility type's specification. The borrow source of this medium, which may be the same or a different location from the facility area itself, must be tested as follows:

   If the borrow area is virgin, undisturbed soil, one test is required per 200 square-feet of borrow area. The test consists of "grab" samples at 1-foot depth intervals to the bottom of the borrow area. All samples at the testing location are then mixed, and the resulting sample is laboratory tested to meet the following criteria:

   USDA minimum textural analysis requirements: A textural analysis is required from the site-stockpiled topsoil. If topsoil is imported, a textural analysis shall be performed for each location where the topsoil was excavated.

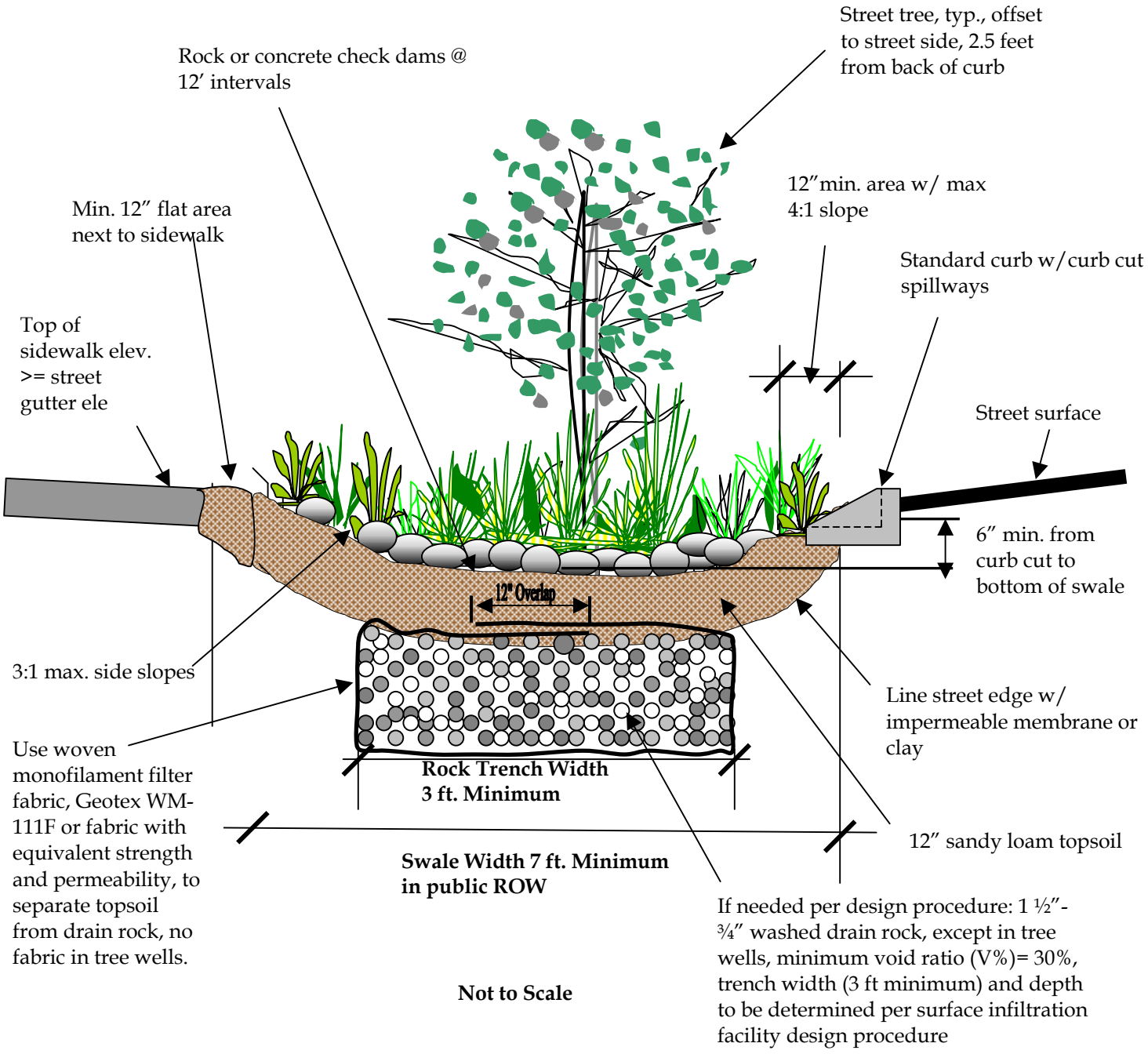
   Requirements:
   Sand 35 – 60%
   Silt 30 – 55% (Loam)
   Clay 10 – 25%

   The soil shall be a uniform mix, free of stones, stumps, roots, or other similar objects larger than two inches.

8) Surface infiltration facility 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 surface infiltration facility areas.

9) For surface infiltration facilities, post-construction field infiltration testing will be required. Methods consistent with those used during design of the facilities shall be used. The resulting infiltration rate must show that the facility drawdown time will not exceed 30 hours.

## Exhibit 2-3: Example Cross-Section of Vegetated Street Swale, Modified To Receive Credit for Disposal



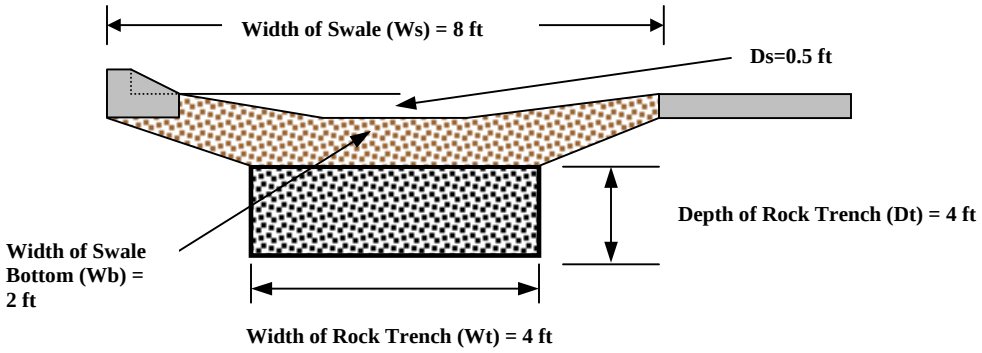
## SURFACE INFILTRATION FACILITY SIZING EXAMPLE

**Facility Type:** Vegetated Street Swale

**Objective:** Find swale dimensions needed to meet stormwater disposal standards.

**Givens:** Design Storm (P) = 10 year, 24 hour storm = 3.4 total inches = **0.28 feet**
Maximum Drawdown Time (Td) = **30 hours**
Infiltration Rate Safety Factor = **4**

**Site Characteristics:**
Impervious Area (Ai) = 200′ x 28′ = **5,600 square feet**
Measured Infiltration Rate (Im), using Double-Ring Infiltrometer Test = 12″/hr = **1′/hr**
Swale width (Ws) = **8 feet**
Swale bottom width (Wb) = **2 feet**
Swale depth (Ds) = **0.5 feet**
Rock trench width (Wt) = **4 feet**
Rock trench depth (Dt) = **4 feet**
Void Ratio of Rock Trench (VR) dimensionless = **0.30**




**Calculations:**
Runoff Volume (Vr) cubic feet = P * Ai = 0.28 * 5,600 = **1,568 cubic feet**
Design Infiltration Rate (Id) feet per hour = Im / 4 = 1 ft/hr / 4 = **0.25 ft/hr**
Swale Storage Volume (Vs) = L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

**Check #1:** Runoff Volume (Vr) must be less than or equal to Swale Storage Volume (Vs)

$$Vr <= Vs$$

$$(0.28 * Ai) <= L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]$$

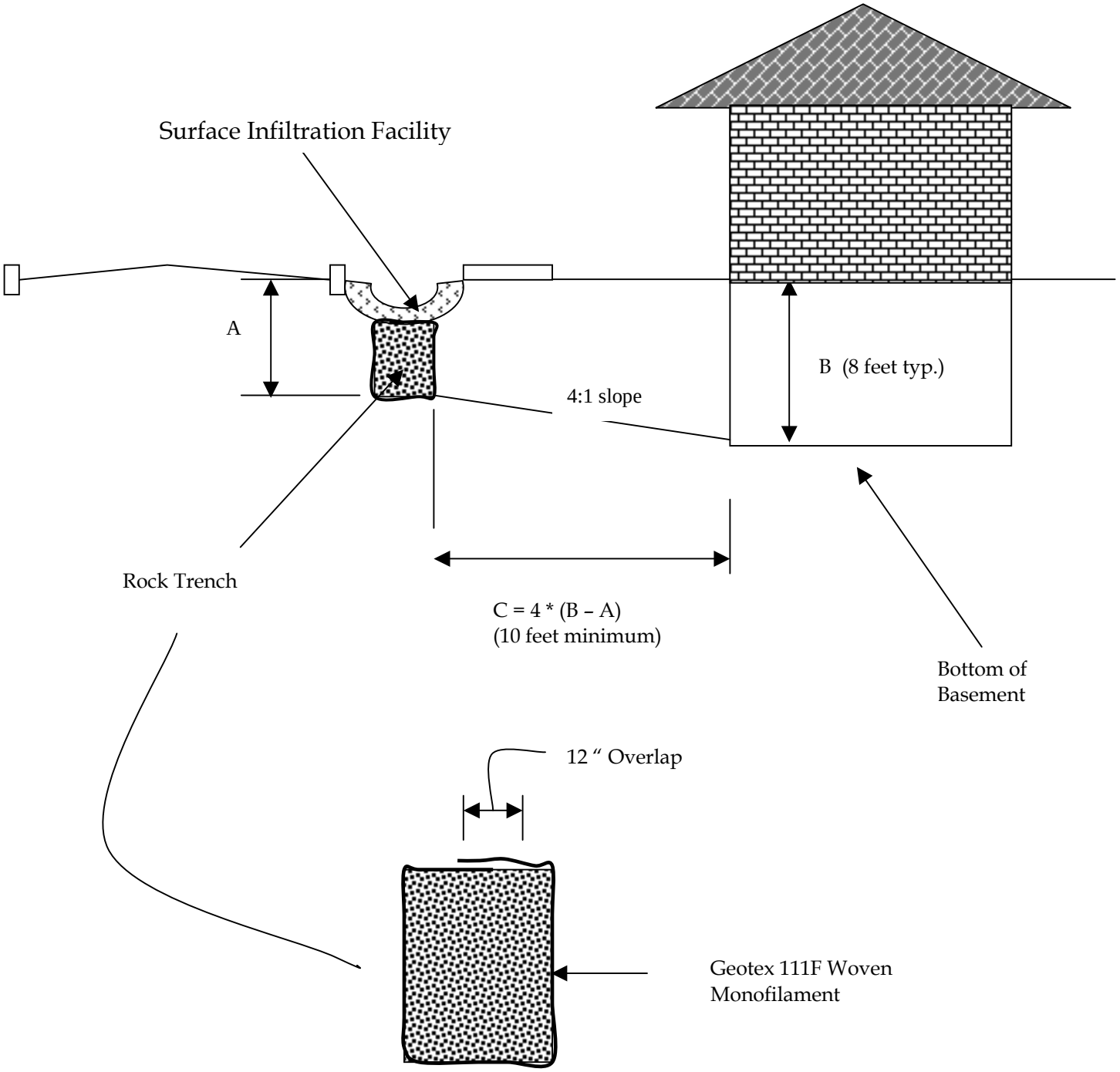
**To find L:** L = (0.28 * Ai) / [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]
**L = (0.28 * 5,600) / [(0.5 * 0.5 * (8 + 2)) + (0.30 * 4 * 4)] = 215 feet**

**Check #2:** Swale drawdown time must not exceed maximum allowable (Td) = 30 hours

$$(0.28 * Ai) / (Id * Wt * L) <= 30 \text{ hours}$$

**(0.28 * 5,600) / (0.25 * 4 * 215) = 7.3 hours < 30 hours, therefore OK**

## Exhibit 2-4: Surface Infiltration Facility Setback Detail



### 2.2.3 Performance Approach

The list of accepted stormwater management facilities is continually changing as new products are developed and more is learned about the performance of facilities already in use. Design professionals may propose facilities other than those included in this manual by using the performance approach. Design professionals may also use the performance approach to show that a facility is capable of reducing a TMDL pollutant of concern (See **Exhibit 1-2**), or to downsize a simplified approach sizing factor when flow control is not required.

The performance approach requires detailed engineering design and calculations, as well as documented evidence of the proposed design's performance. The City will accept the proposed design for meeting pollution reduction requirements if the design professional demonstrates that it:

- Will perform at the required efficiency: 70 percent total suspended solids (TSS) removal from 90% of the average annual runoff (See **Section 1.5**), and is capable of reducing the TMDL pollutant of concern (if applicable). See **Appendix B**: Vendor Submission Guidance for Evaluating Stormwater Treatment Technologies, for definition of 70 percent total suspended solids removal, which is actually a function of influent concentration. Also see Appendix B for required testing protocol, related definitions, and additional requirements. Documented performance is required and shall include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.

- Can be efficiently maintained to perform at the required level, and for public facilities, will not require more costly maintenance than facilities designed using the simplified or presumptive approach.

#### Performance Approach Submittal Requirements

In addition to detailed construction drawings and details to be shown on permit drawings, all applicants using the performance approach for stormwater management are required to submit a detailed stormwater report. This report shall include a description of the stormwater facility, how it is intended to function, and documented evidence of the proposed design's performance. It shall include detailed hydraulic calculations as summarized in **Exhibit 2-2** and must demonstrate the performance criteria listed above. A copy of the operations and maintenance plan (see **Chapter 3.0**) shall also be included. In addition, a geotechnical report may be required by BES to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill the requirements identified in **Section 1.4:** Stormwater Destination/ Disposal.

## 2.3 HYDROLOGIC ANALYSIS REQUIREMENTS

With the exception of pollution reduction and flow control facilities designed using the simplified approach, stormwater management facilities must be designed using hydrologic analysis methods described below. If one of the hydrologic analysis methods discussed below is 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 shall include data necessary to facilitate BES's review. This data is summarized in **Exhibit 2-2**.

### 2.3.1 Pollution Reduction

**Flow Rate-Based Facilities:** With the exception of facilities sized using the simplified approach, BES will use the Rational Method with rainfall intensities presented in **Section 1.5.2** to verify flow rates used to size rate-based pollution reduction facilities. BES has verified these intensities, through a continuous simulation model utilizing Portland rainfall data, to treat 90% 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% 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) are required to use the pre-determined volume of 0.83 inches over 24 hours with a Vb/Vr (volume of basin/ volume of runoff) ratio of 2 to be in presumptive compliance. BES determined this volume, through a continuous simulation model utilizing Portland rainfall data, to provide adequate detention time to treat 90% 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 Santa Barbara Urban Hydrograph (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. An example of this includes the downsizing of simplified approach facilities (such as vegetated swales and infiltration basins) to achieve pollution reduction only. When using SBUH, a 0.83 inch, 24-hour storm with NRCS type 1A rainfall distribution shall be used. The design professional may also use NRCS TR-55, HEC-1, or SWMM to demonstrate treatment of 90% of the average annual runoff volume.

### 2.3.2 Flow Control

With the exception of facilities sized using the simplified approach, BES will use a software program based on the Santa Barbara Urban Hydrograph (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.

### 2.3.3 Destination/ Disposal

The Rational Method must be used to design the infiltration flow rate for public infiltration sumps. If surface infiltration facilities, such as vegetated, grassy, or street swales, vegetated infiltration basins, and infiltration planters are proposed to meet destination/ disposal requirements, the **Surface Infiltration Facility** sizing methodology in Section 2.2.2 must be used to meet presumptive compliance. The surface infiltration facility sizing methodology relies on the determination of the 10-year storm runoff volume, which can be calculated using the simple approximation formula provided, SBUH, NRCS TR-55, HEC-1, or SWMM.

### 2.3.4 Conveyance

Please reference the City of Portland's *Sewer 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-1 or SWMM may be used for projects greater than 100 acres in size.

### 2.3.5 Hydrologic Analysis Method Resources

The **Santa Barbara Urban Hydrograph (SBUH) Method** (**See Appendix C**) may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the simplified approach.

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

The **HEC-1 Method** may be used on medium and large projects. (Refer to the HEC User's Manual.)

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

## 2.4 INFILTRATION TESTING

To size stormwater management facilities, it is often necessary to know the infiltration rate of the soil at the actual facility location. The following general criteria apply to all proposed infiltration facilities:

1) For all surface infiltration facilities being designed to meet disposal standards, a minimum infiltration rate of 2 inches per hour is required. Site-specific facility design may require a much higher infiltration rate.
2) Testing can be classified into three categories, (1) initial feasibility testing, (2) design testing, and (3) post-construction testing. (see **Exhibit 2-5**)
3) Testing shall be conducted or observed by a qualified professional. This professional shall either be a registered professional engineer in the State of Oregon, or a soils scientist or geologist licensed in the State of Oregon.
4) All field-testing must be done in the proposed area of the facility.
5) Testing data shall be documented, including a description of the infiltration testing method.

### 2.4.1 Initial Feasibility Testing

Initial feasibility testing is conducted to determine whether full-scale testing is necessary, and is meant to screen unsuitable sites and reduce testing costs. It involves either one field test per facility (regardless of type or size) or previous testing data, such as the following:

- Pre-approval from the City of Portland Bureau of Development Services Environmental Soils section (Call 503-823-7790 for more information)
- Septic percolation testing on-site, within 200 feet of the proposed facility location and on the same contour
- Previous written geotechnical reporting on the site location as prepared by a qualified geotechnical expert
- NRCS Multnomah County Soil Mapping showing unfeasible conditions such as a hydrologic group "D" soil in a low-lying area
- In the case of public sump systems, pre-approval from BES (Call 503-823-7761 for more information)

If the results of initial feasibility testing as determined by a qualified professional show that an infiltration rate of greater than 0.5 inches per hour is probable, then the design and post-construction testing shall be in accordance with **Exhibit 2-5**. BDS and BES may waive design-testing requirements if it is determined that adequate testing data exist. In the case of infiltration testing, an encased soil boring may be substituted for a test pit, if desired.

## Exhibit 2-5: Infiltration Testing Summary Table

| Type of Facility | Initial Feasibility Testing (Section 2.4.1) | Design Testing (Section 2.4.2) | Post-Construction Testing (Section 2.4.3) |
|---|---|---|---|
| Private Drywell System | Required | One test pit and one falling head test per drywell, unless waived by BDS. | May be required by BDS. (see **private drywell** section for procedure) |
| Private Soakage Trench | Required | One test pit and one falling head test per soakage trench, unless waived by BDS. | Not applicable. |
| Public Infiltration Sump System | Required | Testing of an existing sump in the vicinity, or construction and testing of one sump may be required by BES. | All public infiltration sumps must be field-tested after construction. (see **public infiltration sump** section for procedure) |
| Surface Infiltration Facility | Required | One double-ring infiltrometer test (for public facilities) or one falling head test (for private facilities) per 200 square-feet of facility area | May be required by BDS (if private) or BES (if public). (see **surface infiltration facility** design section for procedure) |

## 2.4.2 Design Testing

Where required, the following **test pit** procedure shall be followed:

1) Excavate a test pit or dig a standard soil boring to a minimum depth of 4 feet below the proposed facility bottom elevation. Also conduct Standard Penetration Testing (SPT) every 2 feet to a depth of 4 feet below the facility bottom.
2) Determine depth to highest seasonal groundwater table (if within 4 feet of proposed bottom) upon initial digging or drilling.
3) Determine USDA or Unified Soil Classification System textures at the proposed bottom and 4 feet below the bottom of the facility.
4) Determine depth to bedrock (if within 4 feet of proposed bottom).
5) The soil description should include all soil horizons.
6) The location of the test pit or boring shall correspond to the facility location; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such.

Where required, the following **falling head infiltration test** procedure shall be followed:

1) Install casing (solid 5-inch diameter, 36-inch length) to 24 inches below proposed facility bottom (see **Exhibit 2-6**).
2) Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing. Upon the tester's discretion, a 2-inch layer of coarse sand or fine gravel may be placed to protect the bottom from scouring and sediment. Fill casing with clean water and allow to pre soak for 24 hours, or until the water has completely infiltrated.
3) Refill casing and monitor water level (measured drop from the top of the casing) for 1 hour. Repeat this procedure (filling the casing each time) three additional times, for a total of four observations. Upon the tester's discretion, the final field rate may either be the average of the four observations or the value of the last observation. The final rate shall be reported in inches per hour.
4) Testing may be done through a boring or open excavation.
5) The location of the test shall correspond to the facility location.
6) Upon completion of the testing, the casings shall be immediately pulled, and the test pit shall be back-filled.

Where required, the **double-ring infiltrometer test** procedure must follow ASTM D3385-94, standard test method for infiltration rate of soils in field using double-ring infiltrometer.

**Note:** For soils west of the Willamette River or similar soil types known as Cascade silt loams (soils with a fragipan that causes a perched water table in winter months), testing must be done between June 1 and October 1.

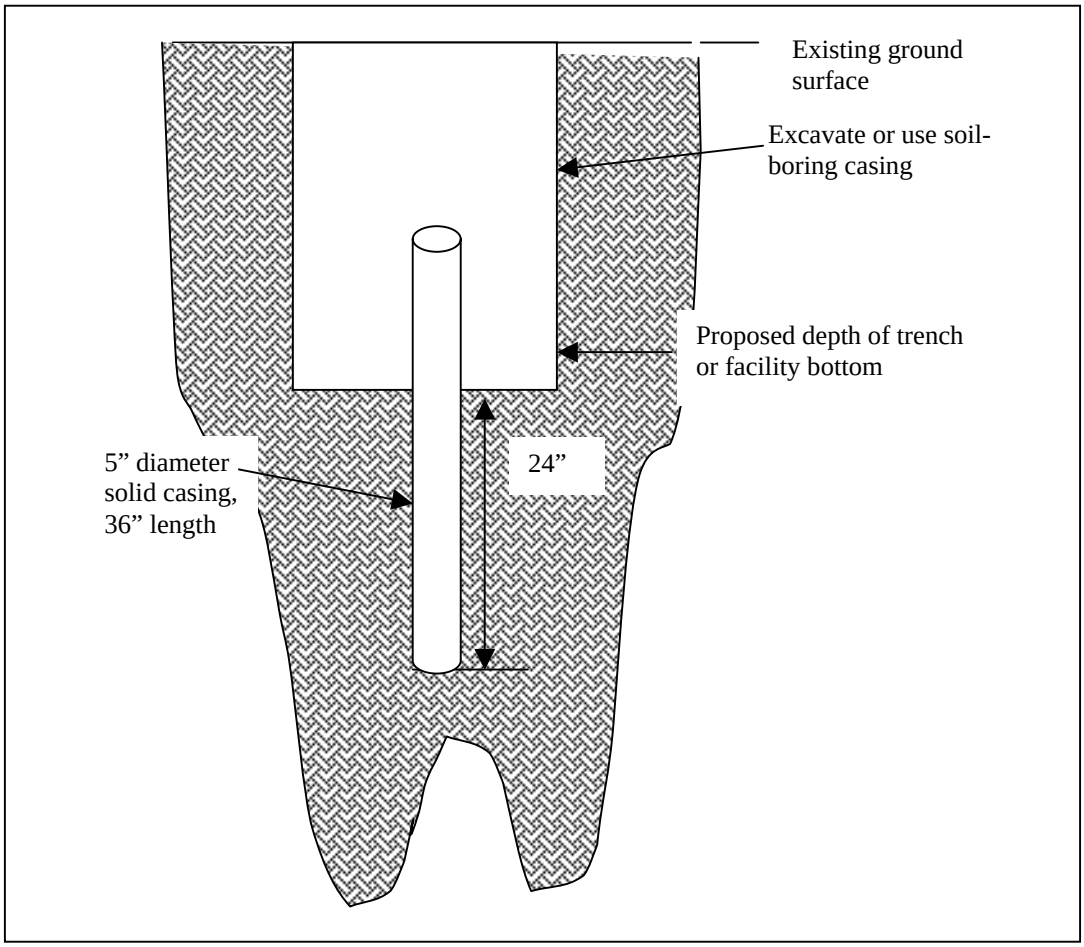
### 2.4.3 Post-Construction Testing

See surface infiltration facility, sump, and drywell design sections for post-construction infiltration testing requirements.

### 2.4.4 Laboratory Testing

Grain-size sieve analysis and hydrometer tests where appropriate may be used to determine USDA soils classification and textural analysis. Visual field inspection by a qualified professional may also be used, provided that it is documented. The use of laboratory testing to establish infiltration rates is prohibited.

## Exhibit 2-6: Falling Head Test Requirements



## 2.5 CONTROL STRUCTURES FOR DETENTION SYSTEMS

This section presents the methods and equations for the design of flow restricting control structures, for use with extended wet detention ponds, dry detention ponds, and structural detention facilities. It includes details and equations for the design of orifices, and equations for rectangular sharp crested weirs and v-notch weirs.

Weir and orifice structures must be enclosed in a catch basin, manhole, or vault, and must be accessible for maintenance.

### 2.5.1 Design Requirements

The following criteria apply to control structure design.

- 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 **Exhibit 2-7**) or on a baffle (see **Exhibit 2-8**).

- The minimum allowable diameter for an orifice used to control flows in a public facility is 2 inches. Private facilities may utilize 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-inch 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 1.6.2**). Where this is not practicable, the applicant must pay the off-site 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.

**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.

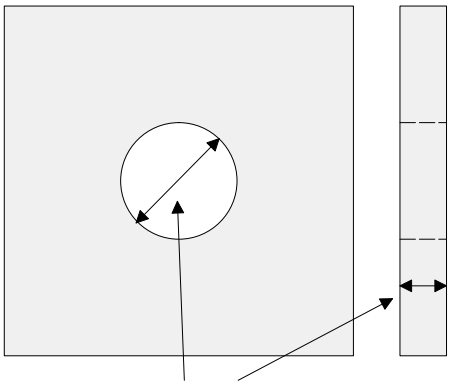
$$d = \sqrt{\frac{36.88\ Q}{\sqrt{h}}}$$

where:

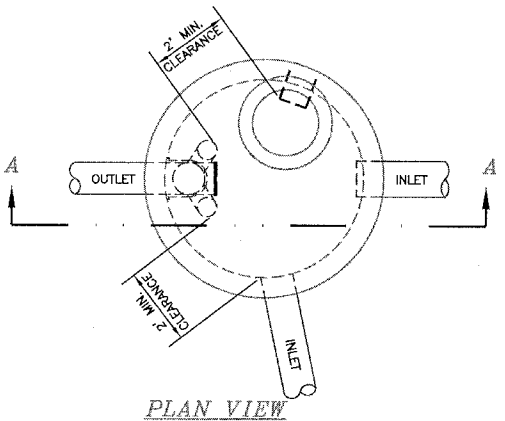
Q = flow, cfs
d = orifice diameter, inches
h = hydraulic head, feet

- Orifices shall be protected within a manhole structure, or by a minimum 18-inch-thick layer of 1½" to 3" evenly graded, washed rock. Orifice holes shall be externally protected by stainless steel or galvanized wire screen (hardware cloth) with a mesh of 3/4" 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 (see diagram).




- If less than 3", the orifice 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.




PLAN VIEW

NOTES:

1. EXCEPT AS SHOWN OR NOTED, UNITS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGER PRE CAST CONCRETE MANHOLE, PER C.O.P. STANDARD PLAN 4–08–1.

2. FOR DETAILS SHOWING GRADE RING, STEPS, MANHOLES, AND TOP SLABS, SEE C.O.P. STANDARD PLAN 4–08–1.

3. PIPE SUPPORTS SHALL ANCHORED AT 3' MAX. SPACING BY 3/8 DIA. STAINLESS STEEL EXPANSION BOLTS EMBEDDED 2" IN WALL.

4. THE RESTRICTOR/SEPARATOR SHALL BE FABRICATED FROM SOLID WALL HDPE PIPE, OR APPROVED EQUAL.

5. OUTLET SHALL BE CONNECTED TO RESTRICTOR PIPE WITH A FLEXIBLE COUPLING.

6. THE VERTICAL RISER STEM OF THE RESTRICTOR/ SEPARATOR SHALL BE THE SAME DIAMETER AS THE HORIZONTAL OUTLET PIPE, WITH A 10" MINIMUM DIAMETER.

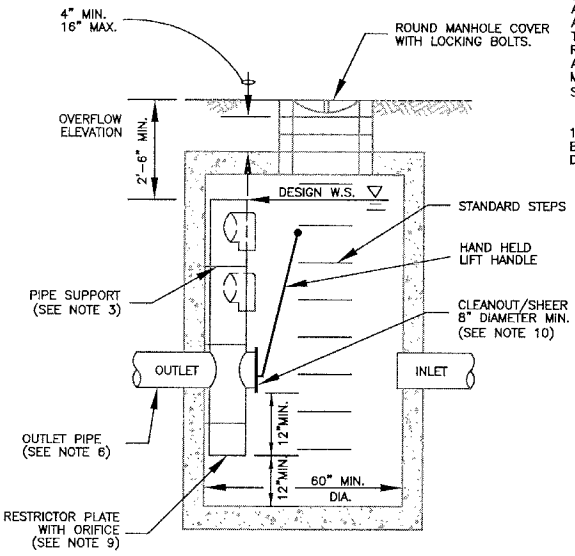
7. FRAME AND STEPS ARE TO BE OFFSET SO THAT:
   A. CLEAN OUT GATE IS VISIBLE FROM TOP
   B. CLIMB–DOWN SPACE IS CLEAR OF RISER AND GATE.
   C. FRAME IS CLEAR OF CURB (IF ANY EXISTS).

8. MULTI–ORIFICE ELBOWS MAY BE LOCATED AS SHOWN OR ALL ON ONE SIDE OF RISER TO ASSURE LADDER CLEARANCE. SIZE OF ELBOWS AND PLACEMENT TO BE CLEARLY LABELED ON THESE PLANS.

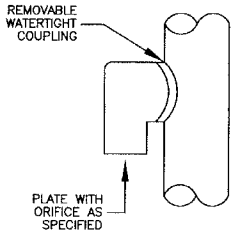
9. RESTRICTOR PLATE WITH ORIFICE AS SPECIFIED ON THESE PLANS. SPECIFIED OPENING TO BE CUT ROUND AND SMOOTH.

10. CLEANOUT/SHEAR GATE: ALUMINUM ALLOY PER B–26–26–32E OR CAST IRON ASTM A48 CLASS 308 AS REQUIRED. LIFT HANDLE EITHER SOLID OR TUBING WITH ADJUSTABLE HOOK AS REQUIRED. NEOPRENE RUBBER GASKET REQUIRED BETWEEN RISER MOUNTING FLANGE AND GATE FLANGE. MATING SURFACES OF LID AND BODY TO BE MACHINED FOR PROPER FIT. FLANGE MOUNTING BOLTS SHALL BE 3/4" DIA. STAINLESS STEEL.

11. GATE SHALL NOT OPEN BEYOND THE CLEAR OPENING BY LIMITED HINGE MOVEMENT, STOP TABS, OR SOME OTHER DEVICE.




SECTION A – A




ELBOW DETAIL

DRAWN BY RRG

NTS

# EXHIBIT 2–7
# ORIFICE LOCATION
# TEE RISER

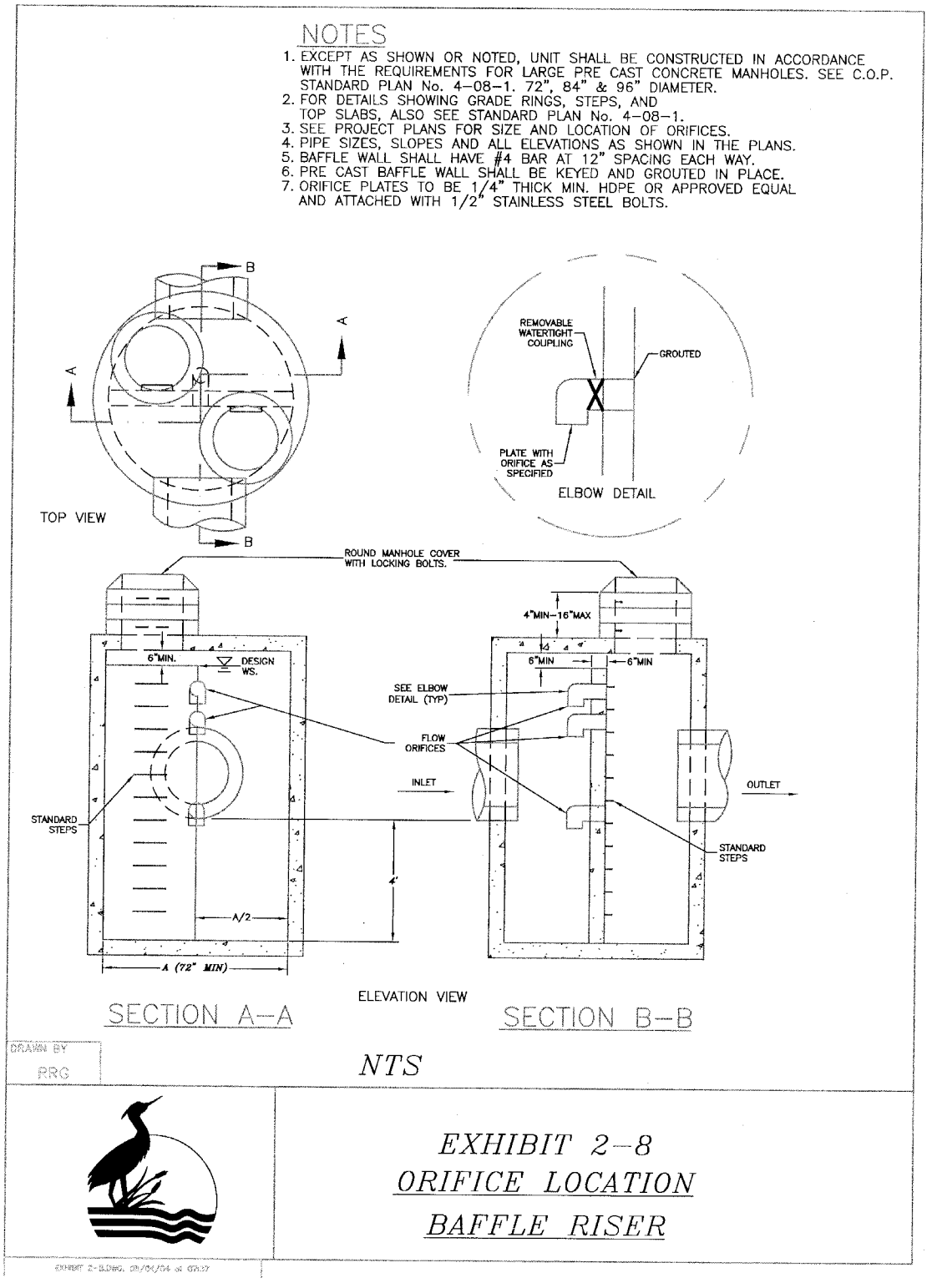
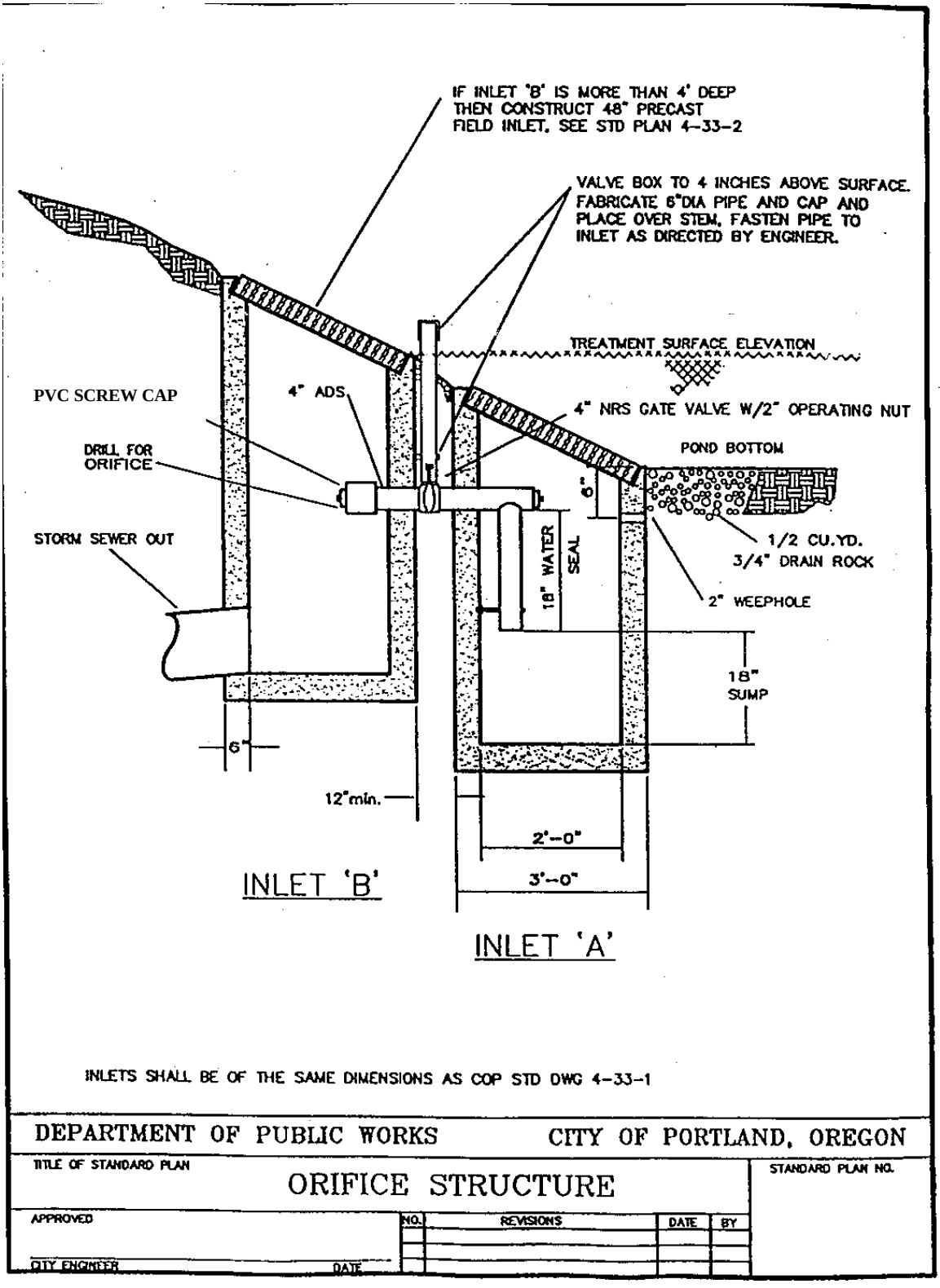

NOTES
1. EXCEPT AS SHOWN OR NOTED, UNIT SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGE PRE CAST CONCRETE MANHOLES. SEE C.O.P. STANDARD PLAN No. 4-08-1. 72", 84" & 96" DIAMETER.
2. FOR DETAILS SHOWING GRADE RINGS, STEPS, AND TOP SLABS, ALSO SEE STANDARD PLAN No. 4-08-1.
3. SEE PROJECT PLANS FOR SIZE AND LOCATION OF ORIFICES.
4. PIPE SIZES, SLOPES AND ALL ELEVATIONS AS SHOWN IN THE PLANS.
5. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
6. PRE CAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
7. ORIFICE PLATES TO BE 1/4" THICK MIN. HDPE OR APPROVED EQUAL AND ATTACHED WITH 1/2" STAINLESS STEEL BOLTS.
B
A
A
B
TOP VIEW
REMOVABLE WATERTIGHT COUPLING
GROUTED
PLATE WITH ORIFICE AS SPECIFIED
ELBOW DETAIL
ROUND MANHOLE COVER WITH LOCKING BOLTS.
6"MIN.
DESIGN W.S.
STANDARD STEPS
A/2
A (72" MIN)
SECTION A-A
4"MIN-16"MAX
6"MIN
6"MIN
SEE ELBOW DETAIL (TYP)
FLOW ORIFICES
INLET
OUTLET
STANDARD STEPS
4'
ELEVATION VIEW
SECTION B-B
DRAWN BY
PRG
NTS
EXHIBIT 2-8
ORIFICE LOCATION
BAFFLE RISER

**Exhibit 2-9:**


IF INLET "B" IS MORE THAN 4' DEEP
THEN CONSTRUCT 48" PRECAST
FIELD INLET, SEE STD PLAN 4-33-2
VALVE BOX TO 4 INCHES ABOVE SURFACE.
FABRICATE 6"DIA PIPE AND CAP AND
PLACE OVER STEM, FASTEN PIPE TO
INLET AS DIRECTED BY ENGINEER.
TREATMENT SURFACE ELEVATION
PVC SCREW CAP
4" ADS
4" NRS GATE VALVE W/2" OPERATING NUT
DRILL FOR
ORIFICE
POND BOTTOM
6"
STORM SEWER OUT
18" WATER
SEAL
1/2 CU.YD.
3/4" DRAIN ROCK
2" WEEPHOLE
18"
SUMP
6"
12"min.
2'-0"
3'-0"
INLET 'B'
INLET 'A'
INLETS SHALL BE OF THE SAME DIMENSIONS AS COP STD DWG 4-33-1
DEPARTMENT OF PUBLIC WORKS
CITY OF PORTLAND, OREGON
TITLE OF STANDARD PLAN
ORIFICE STRUCTURE
STANDARD PLAN NO.
APPROVED
CITY ENGINEER
DATE
NO.
REVISIONS
DATE
BY

**Rectangular Notched Sharp Crested Weir**

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

where:

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

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

**V-Notched Sharp Crested Weir**

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

where:

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

## 2.6 ACCESS FOR OPERATIONS AND MAINTENANCE

Adequate access for operations and maintenance must be provided to all stormwater management facilities and their components. Public facilities shall have access routes at least 8 feet wide, not to exceed 10 percent in slope, and shall be located adjacent to public rights-of-way wherever feasible. Where structural surfaces are needed to support maintenance vehicles, access routes shall be constructed of gravel or other permeable paving surface where possible. Public facility vehicular access routes shall be designed for H-20 loading.

## 2.7 LANDSCAPING REQUIREMENTS

Vegetation is a key element in the performance of many stormwater management facilities. Facility-specific planting requirements are given in **Section 2.9**. These requirements are based on BES experience and/or standard landscape industry methods for design and construction, and are required to be covered by a 2-year warranty period.

At the end of the first year and again at the end of the 2-year warranty period, all plants that do not survive must be replaced. Establishment procedures, such as control of invasive weeds, animal and vandal damage, mulching, re-staking, watering, and mesh or tube protection replacement, shall be implemented to the extent needed to ensure plant survival.

Designers may elect to use BES's Watershed Revegetation Program approach, which allows smaller materials to be planted in larger quantities. If this approach is chosen, the following requirements shall apply:

1) A 5-year warranty period from the time of plant installation shall be provided.
2) Plants must be installed during the dormant season, typically defined as December through March.
3) A survival rate of 75 percent (no replacements) must be achieved for all bare root plants measured in the third and fifth year after installation. If the survival rate falls below this threshold, a number of additional plants, sufficient to meet the 75% survival rate must be installed. The number of additional plants required will be based on the mortality rate of the initial planting.
4) Density of plantings shall be at least one tree and one shrub per 50 square feet of facility area. These plants are bare root (seedlings) and range in size from 10 inches to 24 inches tall.
5) Bareroot seedlings must be dormant in order to harvest from farm sites for planting.
6) All plants must be native from local seed sources and found on the Portland Plant List. A minimum of four different species of trees and shrubs must be used. At least half of the trees must be evergreen. Ground covers must be native

grasses and wildflowers from local seed sources. See **Appendix F** for a list of native plant suppliers.

7) During the period between harvest and installation, the plants must be kept in a temperature-controlled facility. Temperature must be kept between 33 and 36 degrees Fahrenheit, and plant roots must be kept moist at all times. Plants must be planted within 24 hours of removal from the temperature-controlled facility.

Applicants may obtain more information from BES's Watershed Revegetation Program.

Stormwater facilities located in the public street right-of-way are not required to use evergreen trees to meet landscaping requirements.

Where the plant material requirements of this manual and Title 33 differ, the designer shall use the larger quantity and sizes. (In calculating quantities, fractions should be rounded to the higher number.) The Watershed Revegetation Program approach uses smaller plants and may not always satisfy Title 33 requirements.

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.

It is critical that selected plant materials are appropriate for soil, hydrologic, and other facility and site conditions. For facilities located in environmental zones, or BES maintained facilities located outside of the public right-of-way, all plants within the facility area shall be appropriate native species from the **BES recommended plant lists** in **Appendix F** or the latest edition of the Portland Plant List (no nuisance or prohibited plants). The designer may also refer to the Planning Bureau's *Environmental Handbook*.

The design for plantings shall 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 shall be designed to minimize the need for mowing, pruning, and irrigation.

Grass or wildflower seed shall be applied at the rates specified by the suppliers. If plant establishment cannot be achieved with seeding by the time of substantial completion of the stormwater facility portion of the project, the contractor shall plant the area with wildflower sod, plugs, container plants, or other means to complete the specified plantings and protect against erosion before water is allowed to enter the facility.

### Landscaping Submittal Requirements

The design must include elements that ensure landscape plant survival and overall stormwater facility functional success. Construction specifications and/or drawings need to include the following elements:

- Irrigation system to be used for the establishment period and permanent long-term. Note that public stormwater management facilities shall be designed so permanent long-term irrigation systems are not needed.

- Landscape plan showing the location of landscape elements, including size and species of all proposed plantings, and existing plants and trees to be preserved.

- Plant list/table, including scientific name, size at time of planting, quantity, type of container, evergreen or deciduous, appropriate planting season, native or non-native to region, and other information in accordance with the facility-specific planting section and landscape industry standards.

- Topsoil stockpile location, including source of topsoil, if imported. Include erosion protection per the City's *Erosion Control Manual*. Soil analysis for all topsoil to be used within the facility area. (Soil analysis is not required for single-family residential sites.)

## 2.8 OUTFALL DESIGN

Outfalls shall be located above the downstream mean low water level, except as approved by the City. **Exhibit 2-10** shows a typical outfall layout. Concrete endwalls will be required for all exposed outfall pipes greater than 12 inches in diameter (See **Exhibit 2-13**). Publicly accessible outfalls greater than 18 inches in diameter shall include grated protection in accordance with **Exhibit 2-14**. All outfalls shall be provided with a rock splash pad or other approved erosion control/energy dissipation measures. Rock protection at outfalls from small diameter pipes shall be as follows:

**RIP-RAP PAD DIMENSIONS FOR SMALL OUTFALLS**
2″ Pipe: 12″ wide x 24″ long x 2″ deep, Average Stone Size = 1″
4″ Pipe: 24″ wide x 36″ long x 4″ deep, Average Stone Size = 2″
6″ Pipe: 36″ wide x 48″ long x 6″ deep, Average Stone Size = 4″

Rock protection at outfalls from pipes greater than 6 inches shall be designed in accordance with **Exhibit 2-11,** unless otherwise approved by the City. **Exhibit 2-12**

shows riprap class selection. All rock protection areas shall be inter-planted with willow stakes or other approved plantings, every two feet on-center, to increase stability, reduce erosion, provide shading, and improve aesthetics.

Engineered energy dissipaters, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 feet per second (fps). These shall be designed by a professional engineer using published references such as *Hydraulic Design of Energy Dissipaters for Culverts and Channels* (U.S. Department of Transportation, Federal Highway Administration) and other references. The construction plan submittal shall identify the design reference.

Outfalls to drainageways and rivers are often located in environmental zones. Environmental review may be required as per City Code Title 33.

Drainageways and rivers may have steep slopes or banks and may have unstable landforms (i.e. slump). Geotechnical investigation to determine the stability of the stream or river bank, as reviewed and approved by BES or BDS, may be required for approval.

**Exhibit 2-10: Typical Outfall Layout With Energy Dissipation**

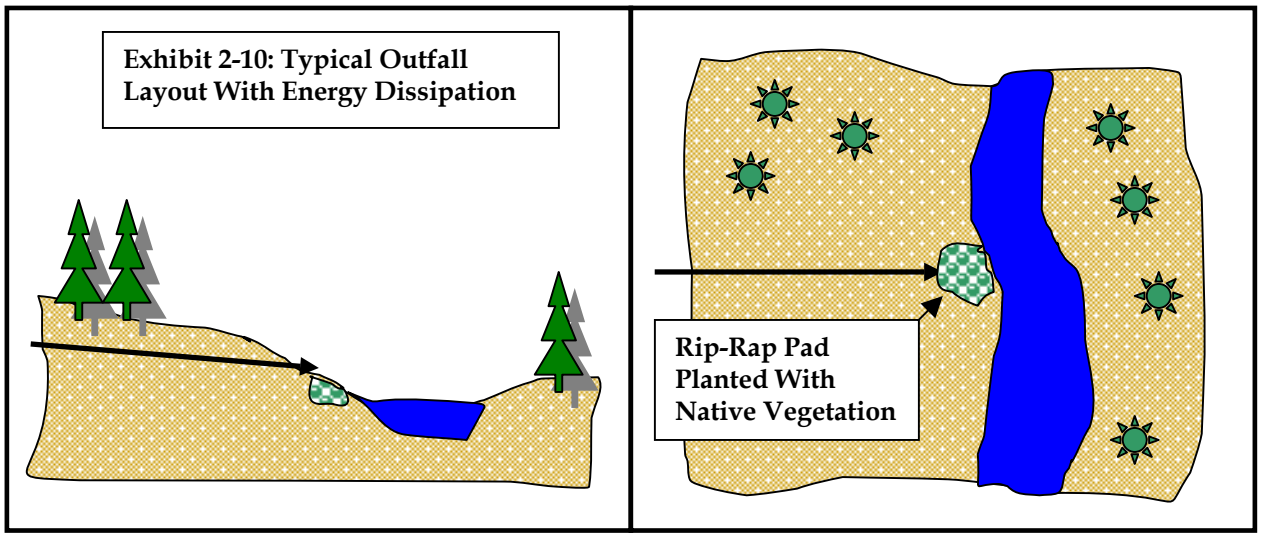


**Exhibit 2-11**
**ROCK PROTECTION AT OUTFALLS FOR PIPES GREATER THAN 6 INCHES IN DIAMETER**

| Discharge Velocity at Design Flow (fps) | | | REQUIRED PROTECTION Minimum Dimensions | | | | |
|---|---|---|---|---|---|---|---|
| | | | Type | Depth* | Width | Length** | Height |
| 0 | To | 5 | Riprap* | 2 x (max stone size) | Diameter + 6 ft. | As calculated | Crown + 1 ft. |
| 6 | To | 10 | Riprap* | 2 x (max stone size) | Diameter + 6 ft. or 3x dia. which-ever is greater | As calculated | Crown + 1 ft. |
| 11 | To | 20 | Gabion or Riprap* | 2 x (max stone size) | Diameter + 6 ft. or 4x dia. which-ever is greater | As calculated | Crown +1 ft. |
| Over 20 | | | Engineered Energy Dissipater Required | | | | |

* Riprap size shall be determined using the following formulae*** and the *City of Portland Standard Construction Specifications*, Chapter 610.2.04 Broken Stone

V = Average velocity (ft/s)
Do = Pipe diameter (ft)
ds = Riprap diameter (ft)
Lsp = Apron length (ft)
depth = Thickness (ft)
Fo = $V/(g*Do)^{0.5}$

*Riprap size ds=0.25*Do*Fo (6" minimum)
Depth=2*ds (1 foot minimum)
**Apron length Lsp= Do(8+17*Log Fo)

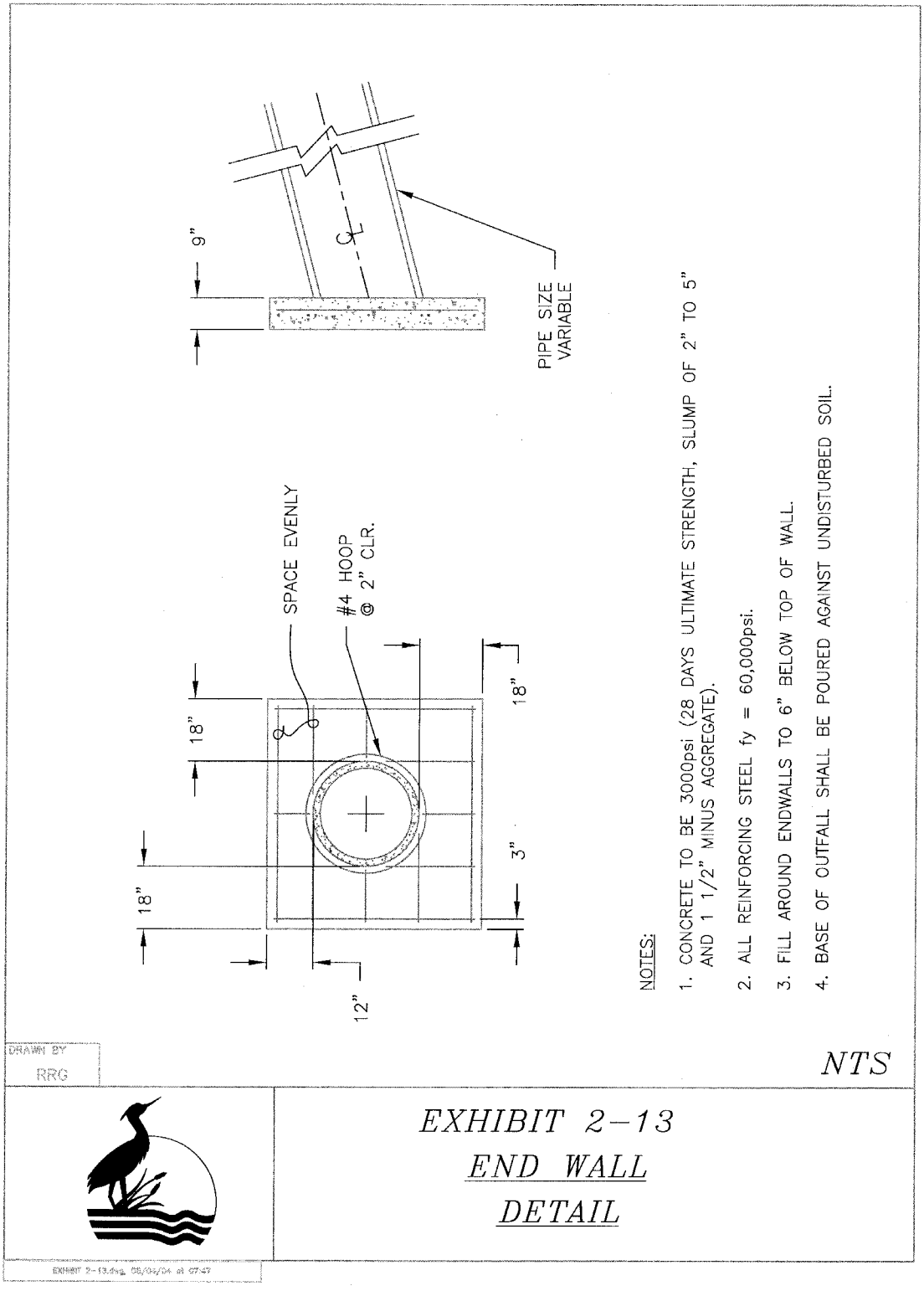
g = 32.2 $ft/s^2$

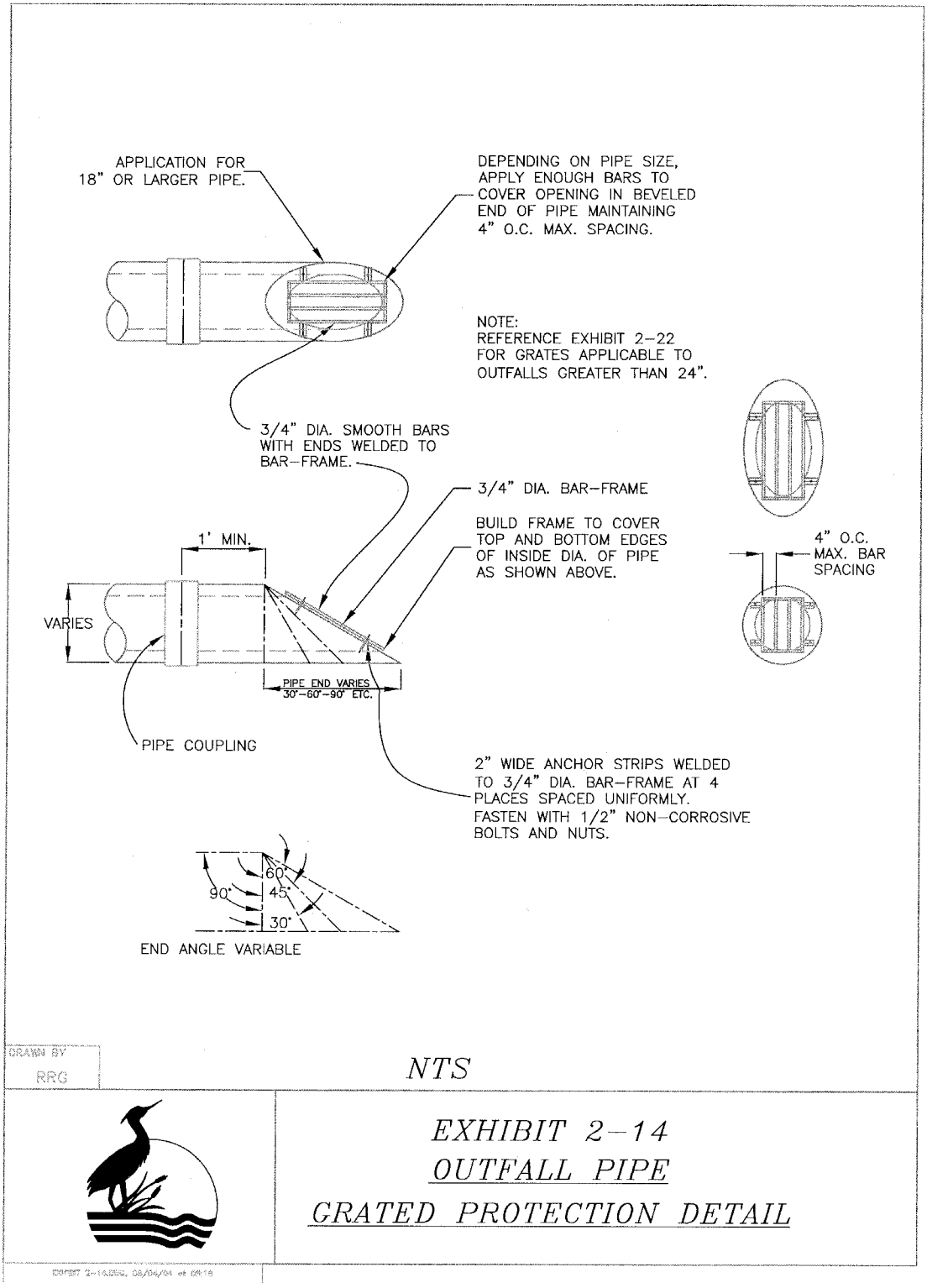
***US Army Corps of Engineers design formulas from *Erosion and Riprap Requirements at Culvert and Storm Outlets*, January 1970

**Exhibit 2-12: RIPRAP CLASS SELECTION**

| Weight (lbs) | Spherical Size (inches) | % by Weight | Average Stone Size (inches) |
|---|---|---|---|
| | | | |
| **Class 50** | | | 6.3 |
| 30 – 50 | 8.5 – 10 | 20 | |
| 15 – 30 | 6.7 – 8.5 | 30 | |
| 2 – 15 | 3.5 – 6.7 | 40 | |
| 0 – 2 | 0 – 3.5 | 10 | |
| | | | |
| **Class 100** | | | 7.6 |
| 60 – 100 | 10.6 – 12.8 | 20 | |
| 25 – 60 | 8.0 – 10.6 | 30 | |
| 2 – 25 | 3.5 – 8.0 | 40 | |
| 0 – 2 | 0 – 3.5 | 10 | |
| | | | |
| **Class 250** | | | 11.3 |
| 200 – 250 | 15.0 – 18.0 | 20 | |
| 100 – 200 | 12.0 – 15.0 | 30 | |
| 10 – 100 | 6.0 – 12.0 | 40 | |
| 0 – 10 | 0 – 6.0 | 10 | |
| | | | |
| **Class 700** | | | 15.2 |
| 500 – 700 | 21.5 – 24.0 | 20 | |
| 200 – 500 | 15.9 – 21.5 | 30 | |
| 20 – 200 | 7.4 – 15.9 | 40 | |
| 0 – 20 | 0 – 7.4 | 10 | |
| | | | |
| **Class 2000** | | | 21.7 |
| 1400 – 2000 | 30.4 – 34.0 | 20 | |
| 700 – 1400 | 24.0 – 30.4 | 30 | |
| 40 – 700 | 9.3 – 24.0 | 40 | |
| 0 – 40 | 0 – 9.3 | 10 | |

**Reference:** Erosion and Riprap Requirements at Culverts and Storm-Drain Outlets
U.S. Army Engineers, Jan 1970


9"
PIPE SIZE
VARIABLE
SPACE EVENLY
#4 HOOP
@ 2" CLR.
18"
18"
18"
3"
12"
NOTES:
1. CONCRETE TO BE 3000psi (28 DAYS ULTIMATE STRENGTH, SLUMP OF 2" TO 5" AND 1 1/2" MINUS AGGREGATE).
2. ALL REINFORCING STEEL fy = 60,000psi.
3. FILL AROUND ENDWALLS TO 6" BELOW TOP OF WALL.
4. BASE OF OUTFALL SHALL BE POURED AGAINST UNDISTURBED SOIL.
NTS
DRAWN BY
RRG
EXHIBIT 2-13
END WALL
DETAIL

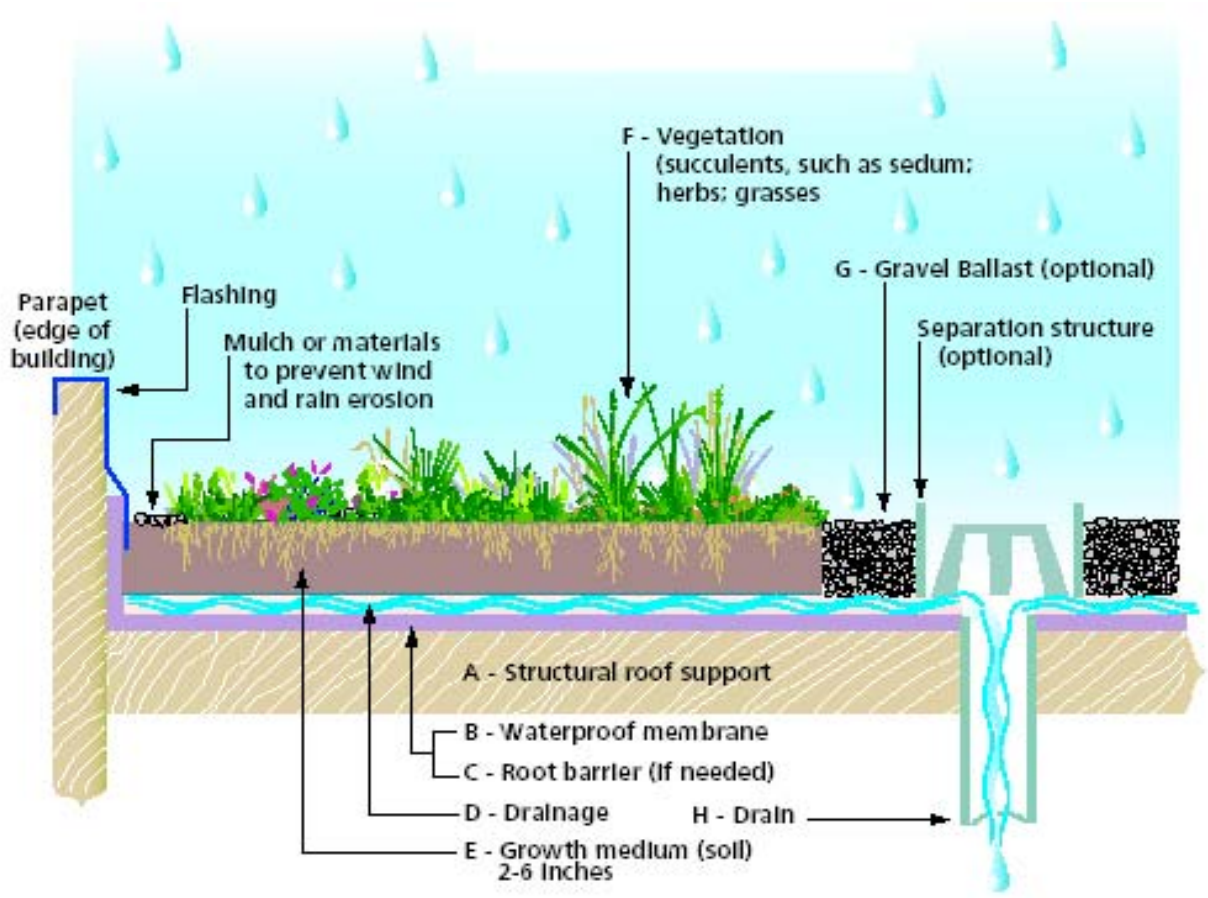

APPLICATION FOR
18" OR LARGER PIPE.
DEPENDING ON PIPE SIZE,
APPLY ENOUGH BARS TO
COVER OPENING IN BEVELED
END OF PIPE MAINTAINING
4" O.C. MAX. SPACING.
NOTE:
REFERENCE EXHIBIT 2-22
FOR GRATES APPLICABLE TO
OUTFALLS GREATER THAN 24".
3/4" DIA. SMOOTH BARS
WITH ENDS WELDED TO
BAR-FRAME.
3/4" DIA. BAR-FRAME
BUILD FRAME TO COVER
TOP AND BOTTOM EDGES
OF INSIDE DIA. OF PIPE
AS SHOWN ABOVE.
1' MIN.
VARIES
PIPE END VARIES
30°-60°-90° ETC.
PIPE COUPLING
4" O.C.
MAX. BAR
SPACING
2" WIDE ANCHOR STRIPS WELDED
TO 3/4" DIA. BAR-FRAME AT 4
PLACES SPACED UNIFORMLY.
FASTEN WITH 1/2" NON-CORROSIVE
BOLTS AND NUTS.
60°
90°
45°
30°
END ANGLE VARIABLE
DRAWN BY
RRG
NTS
EXHIBIT 2-14
OUTFALL PIPE
GRATED PROTECTION DETAIL

## 2.9 FACILITY DESIGN CRITERIA

**Stormwater Management Design Criteria For:**

**Ecoroof & roof garden**
**Pervious pavement**
**Contained planter**
**Tree credit**
**Infiltration planter**
**Flow-through planter**
**Vegetated swale**
**Grassy swale**
**Street swales**
**Vegetated filter**
**Vegetated infiltration basin**
**Sand filter**
**Wet, extended wet detention, and dry detention pond**
**Constructed treatment wetland**
**Manufactured treatment technology**
**Structural detention facility**
**Spill control manhole**
**Rainwater harvesting**
**Private soakage trench**
**Public infiltration sump system**
**Private drywell**

# Ecoroof & Roof Garden




| **Stormwater Management Goals Achieved** | **Acceptable Sizing Methodologies** |
|---|---|
| √ Impervious Area Reduction | SIM |
| √ Pollution Reduction | SIM |
| √ Flow Control | SIM |
| Destination/ Disposal | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** This facility is an impervious surface reduction technique. Its applicability is limited to rooftops or decks above building structures.

# Ecoroof & Roof Garden


**Ecoroof Description:** An ecoroof is a lightweight roof system of waterproofing material with a thin soil/vegetation protective cover. The ecoroof can be used in place of a traditional roof as a way to limit impervious site area. The ecoroof captures and depending on the season, evapotranspirates 10 to 100 percent of the precipitation. Ecoroofs attempt to mimic pre-developed ground cover hydrology, reducing post-developed peak runoff rates to near pre-developed rates. Ecoroofs help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in warm seasons. An underdrain system and overflow to an approved conveyance and destination/disposal method per **Section 1.4** will be required.


# Ecoroof & Roof Garden

**Roof Garden Description:** A roof garden is a heavy weight roof system of waterproofing material with a thick soil/vegetation protective cover. The roof garden can be used in place of a traditional roof to limit impervious site area. The roof garden captures and then evapotranspirates 50 to 100% of precipitation, depending on the season. Roof gardens attempt to mimic pre-developed hydrology, therefore reducing post-developed peak runoff rates to near pre-developed rates. They help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in warm seasons. Roof gardens should not be used on slopes greater than 10%. A drain system and overflow to an approved conveyance and destination/disposal method per **Section 1.4** will be required.

**Design Requirements:**

**General Specifications:** Good quality waterproofing material must be used on the roof surface. Soil of adequate fertility and drainage capacity at depths of 2-6 inches, and weight of 10 to 30 pounds per square foot, shall be applied. The building structure must be shown to be adequate to hold the additional weight. Vegetation shall be self-sustaining plants, without the need for fertilizers or pesticides. Soil coverage to prevent erosion shall be established immediately upon installation by using mulch, vegetation mats, or other approved protection method. Ninety-percent plant coverage shall be achieved within 2 years. Temporary irrigation to establish plants is recommended. A permanent irrigation system using potable water may be used, but an alternative means of irrigation, such as air conditioning condensate or other non-potable sources is recommended. Alternative sources should be analyzed to determine if the source has chemicals that might harm or kill the vegetation. Maximum roof slope shall be 25%, unless the applicant can provide documentation for runoff control on steeper slopes.

A. **Structural Roof Support:** The structural roof support must be sufficient to hold the additional weight of the ecoroof. For retrofit projects, check with an architect, structural engineer, or roof consultant to determine the condition of the existing building structure and what might be needed to support an ecoroof. This might include additional decking, roof trusses, joists, columns, and/or foundations. Generally, the building structure must be adequate to hold an additional 10 to 25 pounds per square-foot (psf) saturated weight, depending on the vegetation and growth medium that will be used. (This is in addition to snow load requirements.) An existing rock ballast roof may be structurally sufficient to hold a 10-12 psf ecoroof. (Ballast typically weighs 10-12 psf.)

   **For New Construction** the project architects and structural engineers shall address the structural requirements of the ecoroof during the design process.

Greater flexibility and options are available for new buildings than for re-roofing. The procedures for the remaining components (B through H) are the same for both re-roofing and new construction.

**B. Waterproof Membrane (Impermeable Material):** Waterproof membranes are made of various materials, such as modified asphalts (bitumens), synthetic rubber (EPDM), hypolan (CPSE), and reinforced PVC. Some of the materials come in sheets or rolls and some are in liquid form. They have different strengths and functional characteristics. Some of these products require root inhibitors (refer to C) and other materials to protect the membrane. Numerous companies manufacture waterproofing materials appropriate for ecoroofs.

**Protection Boards or Materials:** These materials protect the waterproof membrane from damage during construction and over the life of the system, usually made of soft fibrous materials.

**C. Root Barrier (If needed):** Root barriers are made of dense materials that inhibit root penetration. The need for a root barrier depends on the waterproof membrane selected. Modified asphalts usually require a root barrier, while synthetic rubber (EPDM) and reinforced PVC generally do not. Check with the manufacturer to determine if a root barrier is required for a particular product. Note: membranes impregnated with pesticides are not allowed. Manufacturers must provide BES with evidence that membranes impregnated with copper will not leach out at concentrations of concern.

**D. Drainage Layer (If needed):** There are numerous ways to provide drainage. Products range from manufactured perforated plastic sheets to a thin layer of gravel. Some ecoroof designs do not require any drainage layer other than the growth medium itself, depending on roof slope and size (for example, pitched roofs and small flat roofs).

**E. Growth Medium (Soil):** The growth medium is generally 2 to 6-inches thick and well drained. It weighs from 10 to 25 pounds per square-foot when saturated. A simple mix of one-fourth topsoil, one-fourth compost, and one-half pumice perlite may be sufficient for many applications. Some companies have their own growth medium specifications. Other components could include digested fiber, expanded clay or shale, or coir.

**F. Vegetation:** Ecoroof and roof garden vegetation should have the following attributes:

- Drought-tolerant, requiring little or no irrigation after establishment

- A growth pattern that allows the plant to thoroughly cover the soil. At least 90% of the overall surface shall be covered.
- Self-sustaining, without the need for fertilizers, pesticides, or herbicides
- Able to withstand heat, cold, and high winds
- Very low-maintenance, needing little or no mowing or trimming
- Perennial or self-sowing
- Fire resistant

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

***Link to Ecoroof Landscaping Plan Example**
***Link to Ecoroof and Roof Garden Recommended Plants**

**Installation:** Four methods (or combinations of them) are generally used to install the vegetation: vegetation mats, plugs/ potted plants, sprigs, and seeds.

1. **Vegetation mats** are sod-like, pre-germinated mats that achieve immediate full plant coverage. They provide immediate erosion control, do not need mulch, and minimize weed intrusion. They also need minimal maintenance during the establishment period and little ongoing watering and weeding.
2. **Plugs or potted plants** may provide more design flexibility than mats. However, they take longer to achieve full coverage, are more prone to erosion, need more watering during establishment, require mulching and more weeding.
3. **Sprigs** are hand-broadcast. They require more weeding, erosion control, and watering than mats.
4. **Seeds** can be either hand-broadcast or hydraseeded. Like sprigs, they require more weeding, erosion control, and watering than mats.

G. **Gravel Ballast (If needed):** 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 requiring periodic maintenance. In many cases, very little, if any, ballast is needed. In some situations a header or separation board may be placed between the gravel ballast and adjacent elements (such as soil or drains). If a root barrier is used, it must extend under the gravel ballast and growth medium, and up the side of the vertical elements.

# Ecoroof & Roof Garden

**H. Drain:** As with a conventional roof, an ecoroof must safely drain runoff from the roof to an approved stormwater destination. See **Section 1.4** for stormwater destinations.

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from roof lines
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification, including weight
4) Filter fabric specification
5) Drainage layer specification
6) Waterproof membrane specification, including root barriers
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Planting and irrigation plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Roof Structure | Call for inspection |
| Waterproof membrane | Call for inspection |
| Drainage layer/ plumbing & pipes | Call for inspection |
| Growing medium, plantings & irrigation | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to ecoroof and roof garden O&M form**

**Additional photos and drawings:**

*** Link to ecoroof and roof garden photos**
*** Link to ecoroof and roof garden drawings**

# Ecoroof & Roof Garden

**FAR Bonus for Ecoroofs and Roof Gardens in the Central City:**

Under City Code Chapter 33.510.210: Floor Area and Height Bonus Options, Option #10 provides an ecoroof bonus option in the Central City. The option is provided below:

10. Ecoroof bonus option. Ecoroofs are encouraged in the Central City because they reduce stormwater run-off, counter the increased heat of urban areas, and provide habitat for birds. An ecoroof is a rooftop stormwater facility that has been certified by the Bureau of Environmental Services (BES). Proposals that include ecoroofs receive bonus floor area. A proposal may not earn bonus floor area for both the ecoroof option and the rooftop gardens option; only one of these options may be used.

    a. Bonus. Proposals that include ecoroofs receive bonus floor area as follows:

        (1) Where the total area of ecoroof is at least 10 percent but less than 30 percent of the building's footprint, each square foot of ecoroof earns one square foot of additional floor area.
        (2) Where the total area of ecoroof is at least 30 percent but less than 60 percent of the building's footprint, each square foot of ecoroof earns two square feet of additional floor area.
        (3) Where the total area of ecoroof is at least 60 percent of the building's footprint, each square foot of ecoroof earns three square feet of additional floor area.

    b. The applicant must submit a letter from BES with the application for land use review. The letter must certify that the ecoroof is approved and must specify the area of the ecoroof.

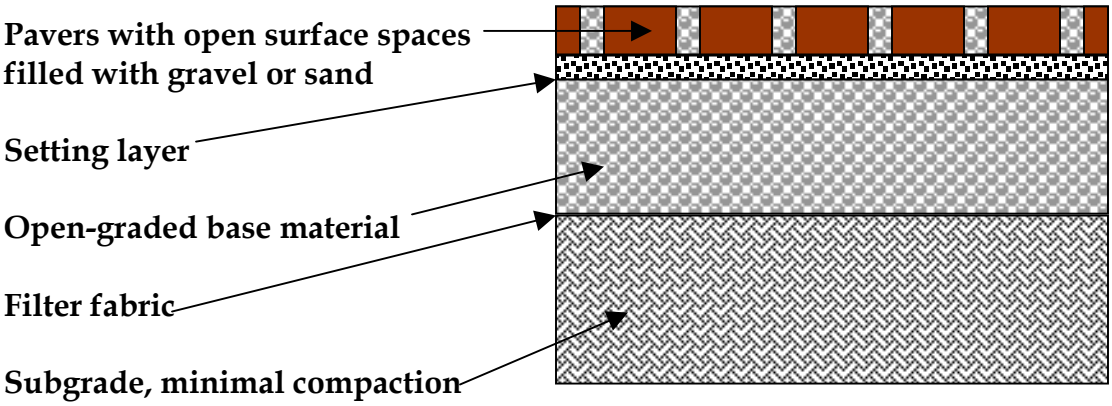
c. The property owner must execute a covenant with the City ensuring installation, preservation, maintenance, and replacement, if necessary, of the ecoroof. The covenant must comply with the requirements of 33.700.060.

The City is currently exploring options to expand the FAR bonus to other districts.

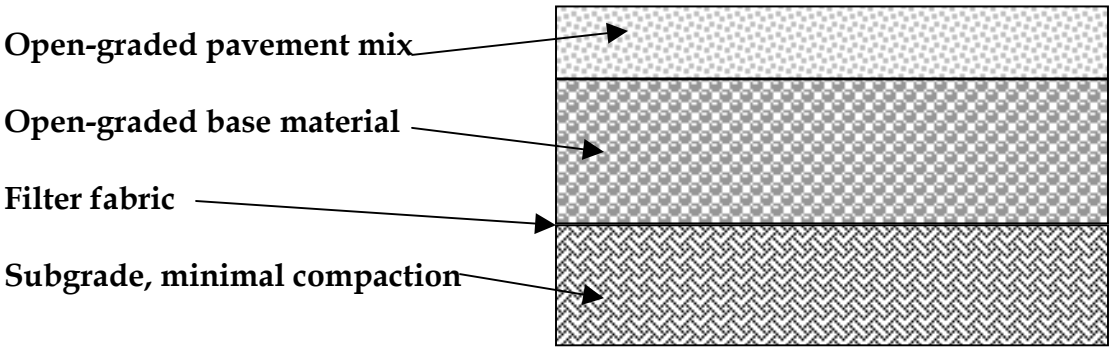
# Ecoroof & Roof Garden

# Pervious Pavement

## Pervious Concrete Block or "Paver" Systems




## Pervious (Open Graded) Concrete and Asphalt Mixes




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Impervious Area Reduction | |
| √ Pollution Reduction…….... | SIMP |
| √ Flow Control…… | SIMP |
| √ Destination/ Disposal…… | PERF |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** This facility is an impervious surface reduction technique. It is applicable for use in parking lots, driveways, and in some cases streets.

# Pervious Pavement



**Description:** There are many types of pervious pavement on the market today. Numerous products and design approaches are available, including special asphalt paving; manufactured products of concrete, plastic, and gravel; paving stones; and brick. It may be used for walkways, patios, plazas, driveways, parking lots, and some portions of streets, subject to compliance with building codes and PDOT and BES Administrative Rules. To receive credit, the material must be installed and maintained to manufacturer's specifications. These materials may not be allowed in certain areas (see **Chapter 4.0** for restrictions). A professional engineer, registered in the state of Oregon must design pervious pavement systems that will be supporting vehicular traffic. For EPA's "Porous Pavement Phase I Design and Operational Criteria" (EPA-600/2-80-135), go to: **http://www.epa.gov/ednnrmrl/repository/abstrac2/abstra2.htm.** For BES's report on pervious pavement demonstration projects, vendors, and other resources, go to: **http://www.portlandonline.com/bes/index.cfm?&a=41626** .

**Design Considerations:** When designing pervious pavement systems, the infiltration rate of the native soil is a key element in determining the depth of base rock for the storage of stormwater, or for determining whether an underdrain system is appropriate. Traffic loading and design speed are important considerations in determining which type of pervious pavement is applicable. Pedestrian ADA accessibility, aesthetics, and maintainability are also important considerations, depending on pavement use.

**Construction Considerations:** Installation procedures are vital to the success of pervious pavement projects, particularly pervious asphalt and concrete pavement mixes. The subgrade cannot be overly compacted with the inclusion of fine particulates or the void ratio critical to providing storage for large storm events will be lost. Weather conditions at the time of installation can affect the final product. Extremely high or low temperatures should be avoided during construction of pervious asphalt and concrete pavements.

# Pervious Pavement

**Design Requirements:**

**Soil Suitability:** Pervious pavement systems are appropriate for all soil types, but will require underdrain systems to an approved stormwater disposal point (per **Section 1.4**) for soils that do not infiltrate well (less than 2 inches per hour, generally NRCS soil types C and D). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the base rock and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.), unless an underdrain system is used.

**Dimensions and Slopes:** Minimum/ maximum dimensions and other specifications are product-specific and shall comply with manufacturer's recommendations. Slopes shall be less than 10% in all cases.

**Setbacks:** Not applicable.

**Sizing:** Pervious pavement systems are not considered to be impervious surfaces, and therefore do not trigger pollution reduction and flow control requirements. A high-flow overflow or underdrain system must be provided to an approved destination point per **Section 1.4**, unless the performance approach is used by a professional engineer to design the system for complete stormwater disposal.

**Limitations:** Pervious pavements shall not be used on sites with a likelihood of high oil and grease concentrations. These site uses include vehicle wrecking or impound yards, fast food establishments, automotive repair and sales, and parking lots that receive a high number of average daily trips (> 1,000).

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Pervious pavement materials and installation procedure specifications
4) Subgrade and base course specifications
5) Filter fabric specification (if applicable)
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

# Pervious Pavement

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Subgrade | Call for inspection |
| Filter fabric (if applicable) | |
| Underdrain piping (if applicable) | Call for inspection |
| Base rock | |
| Pervious pavement installation | Call for inspection |

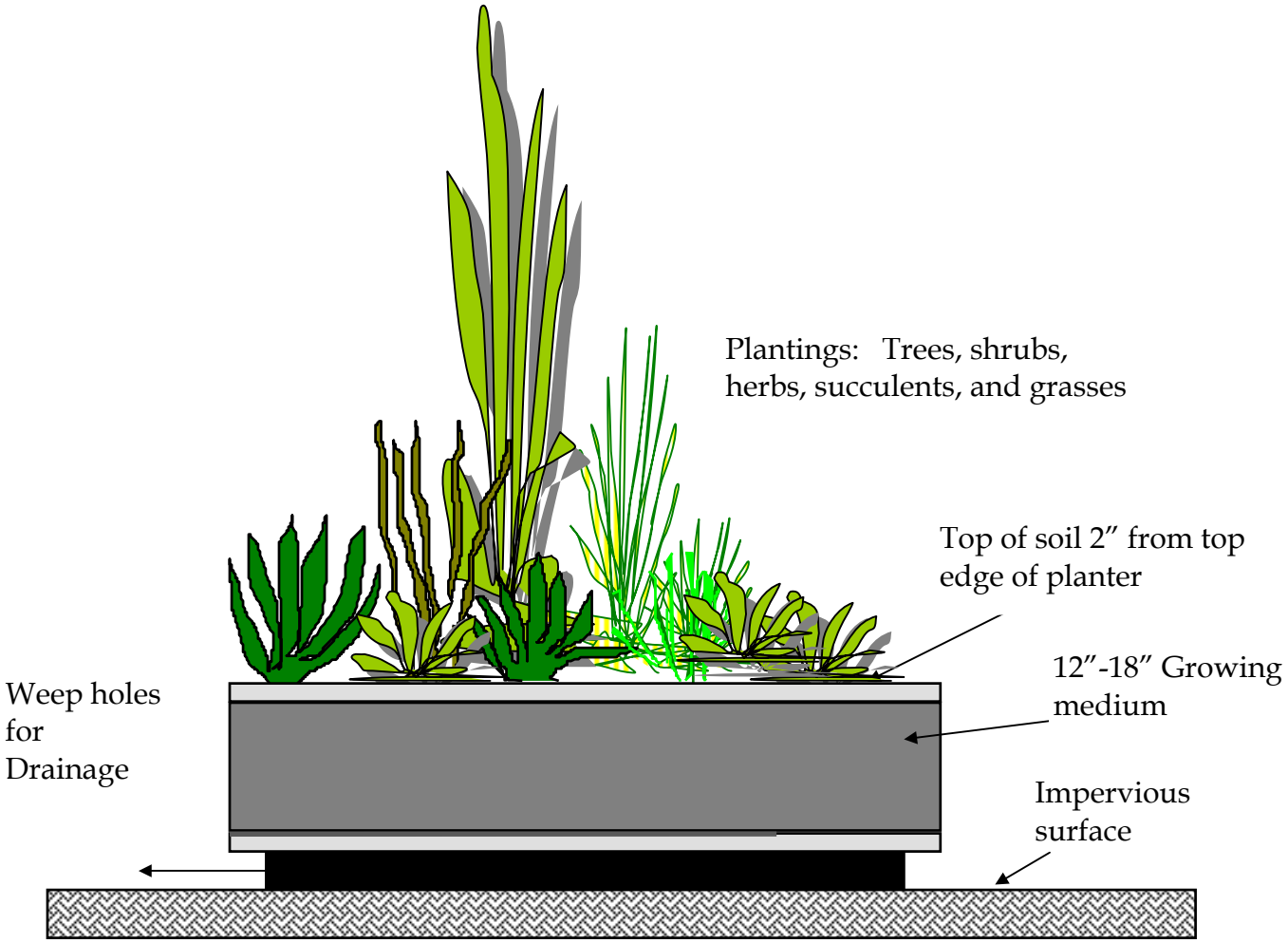
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to pervious pavement O&M form**

**Additional photos and drawings:**

*** Link to pervious pavement photos**
*** Link to pervious pavement drawings**
- *** Link to pervious Asphalt drawing**
- *** Link to pervious concrete drawing**
- *** Link to brick drawing**
- *** Link to cobble drawing**
- *** Link to crushed aggregate drawing**
- *** Link to natural stone drawing**
- *** Link to turf block drawing**
- *** Link to unit pavers on sand drawing**

# Contained Planter




**Section Not to Scale**

| **Stormwater Management Goals Achieved** | **Acceptable Sizing Methodologies** |
|---|---|
| √ Impervious Area Reduction | SIM |
| √ Pollution Reduction | SIM |
| √ Flow Control | SIM |
| Destination/ Disposal | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** This facility is an impervious surface reduction technique. It may be placed over sidewalk, parking lot, flat roof, and plaza areas to reduce the effective impervious area.

# Contained Planter


1100 block of bus mall, downtown Portland


Federal Building (1200 block of SW 3rd Ave.)

**Description:** Contained planters are used for planting trees, shrubs, and ground cover to be placed over impervious surface. The planter may be a prefabricated pot of various dimensions or may be constructed in place and have an infinite variety of shapes and sizes. Contained planters accept precipitation only, not stormwater runoff. Planters are placed on impervious surfaces, such as sidewalks, plazas and rooftops. Drainage is allowed through the bottom of the planter.

**Design Considerations:** Plants shall be relatively self-sustaining, with little need for fertilizers or pesticides. Irrigation is optional, although plant viability must be maintained. Trees are encouraged and may receive added stormwater management credit on the tree credit section of Form SIM.

**Design Requirements:**

**Soil Suitability:** Contained planters are appropriate for all soil types, as they are placed over impervious surface. Topsoil shall be used within the top 12 to 18 inches of the facility.

**Setbacks:** Not applicable.

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

**Sizing:** Contained planters are given stormwater management credit for the square-footage of impervious surface that they cover, at a 1 to 1 ratio.

**Landscaping:** Contained planters shall be planted to cover at least 50% of the planter surface.

# Contained Planter

***Link to Planter Recommended Plants**

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material specification
4) Growing medium specification
5) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Structural planter components | |
| Growing medium | |
| Plantings | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

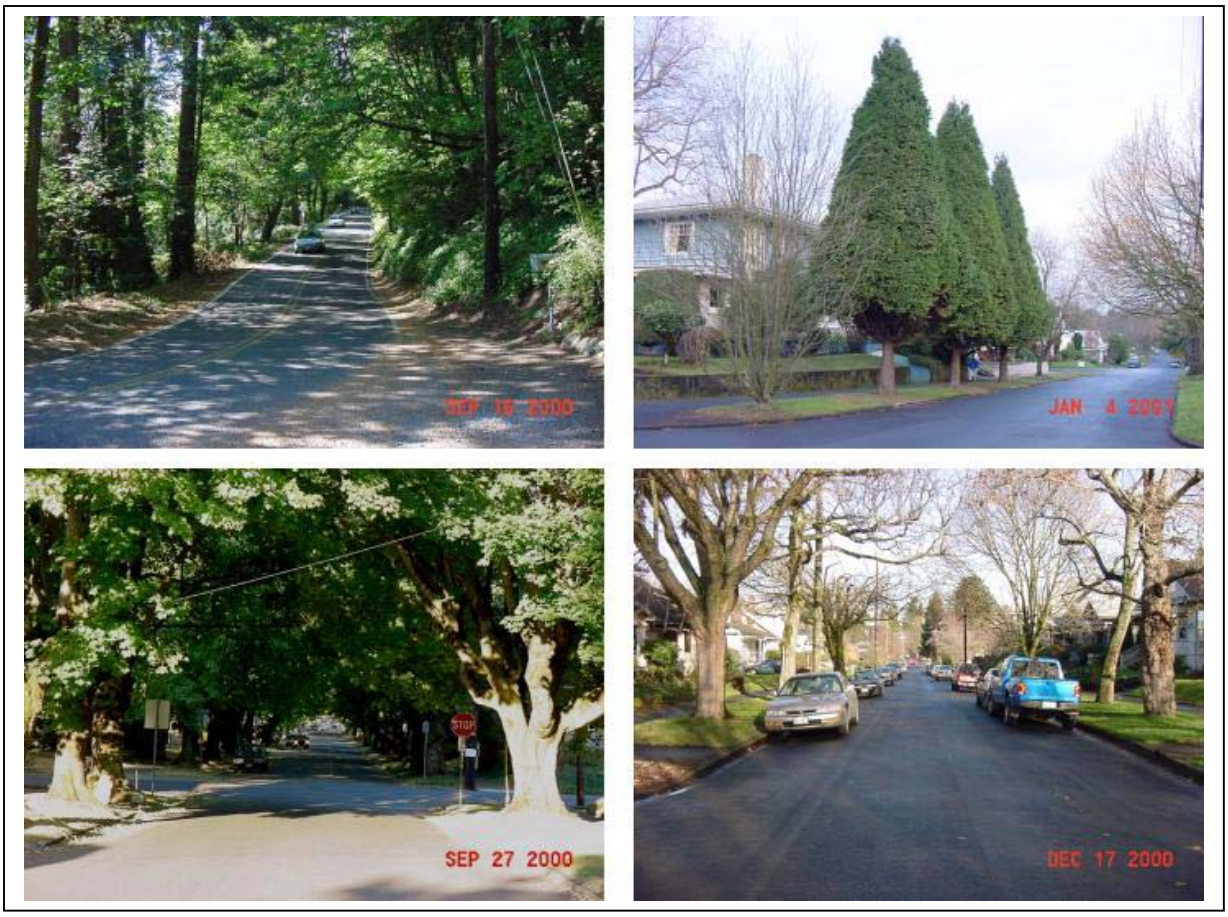
*** Link to contained planter O&M form**

**Additional photos and drawings:**

*** Link to contained planter photos**
*** Link to contained planter drawings**

# Contained Planter

# Tree Credits




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Impervious Area Reduction…….. | SIM |
| √ Pollution Reduction……..…….. | SIM |
| √ Flow Control…….…… | SIM |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** This facility intercepts rainfall and provides shade for impervious surfaces. Trees may only receive credit against the construction of ground-level impervious surfaces.

# Tree Credits

**Description:** Trees intercept precipitation and provide several stormwater management benefits:

- Flow control: Trees hold water on the leaves and branches and allow it to evaporate, retaining flow and dissipating the energy of runoff. These functions are most measurable for storms of less than 0.5 inches over 24 hours, typical of Portland storm events. While 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.

- Pollution reduction/ stormwater cooling: Trees can provide shade over large areas of impervious surface. 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. Cooler air may help prevent stream temperature increases associated with air temperatures.

New trees planted within 25 feet of ground-level impervious surfaces are eligible for stormwater management credit. 100 square feet of credit is given for new deciduous trees, and 200 square feet of credit is given for new evergreen trees (See minimum sizes below). Stormwater management credits also apply to existing trees kept on a site if the trees' canopies are within 25 feet of ground-level impervious surfaces. The credit is the square-footage equal to one-half of the existing tree canopy. No credit will be given for existing trees within an environmental zone. For sites with over 1,000 square-feet of impervious surface to manage, no more than 10% can be mitigated through the use of trees.

# Tree Credits

Trees used for stormwater management credit shall be clearly labeled on permit drawings. A note shall be included on the permit drawings that calls for City inspection after the tree has been planted, or in the case of existing tree canopy, after the site grading has been completed.

**NEW EVERGREEN AND DECIDUOUS TREES:**

Trees shall be maintained and protected on the site after construction and for the life of the development (50-100 years or until any approved redevelopment occurs in the future). During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City. Trees that are removed or die shall be replaced within 6 months with like species. Trees may be pruned for safety purposes only; however, if a tree is planted near a building, pruning to protect the structure is recommended.

The trees selected shall be suitable species for the site conditions and the design intent. Trees should be relatively self-sustaining and long-lived. Native conifers are highly encouraged, as many of these trees naturally grow in harsh/rocky conditions. Long-term irrigation is not required. New deciduous trees must be at least 2 caliper inches and new evergreen trees must be at least 6 feet tall to receive simplified approach credit. Trees planted to meet stormwater facility planting requirements cannot also receive simplified approach credit.

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

**Approved Trees**

The following tree and arborescent shrub* species are approved outright for use as simplified approach tree credits. Other species may be given credit, as approved by BES.

| | | |
|---|---|---|
| Acer macrophyllum | Juniperus occidentalis* | Quercus garryana |
| Alnus rubra | Libocendrus decurrens | Rhamnus purshiana |
| Arbutus menziesii | Pinus contorta | Sequoia sempervirens |
| Castanopsis chrysophylla* | Pinus monticola | Thuja plicata |
| Chamacyparis lawsoniana | Pinus ponderosa | Tsuga heterophylla |

# Tree Credits

| | | |
|---|---|---|
| Cornus nuttallii | Pseudotsuga menziesii | Umbellularia californica |
| Fraxinus latifolia | Quercus chrysolepis* | |

**EXISTING TREES:**

Mature evergreen and deciduous trees can have significant benefits in addition to stormwater management. They already provide habitat for urban wildlife, energy and cost conservation, aesthetics, visual screens, heritage value, windbreaks, and recreation.

The stormwater credit applies to existing trees of 4-inch caliper or larger. Credit is based on one-half of the square footage of the tree canopy, measured within the drip-line. An existing tree for which protection is required by City Title 33 code is not eligible for credits.

Protection during construction shall be in the form of minimizing disruption of the root system. Construction shall not encroach within a space measured 10 feet outside of the drip line to the tree trunk, 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 during the life of the project. During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City. Stormwater management functions of any removed trees shall be replaced on the site with other trees or stormwater management approaches. Trees that die shall be replaced within 6 months. Trees may be pruned for safety purposes only; however, if a tree is near a building, pruning to protect the structure is recommended.

**Checklist of minimal information to be shown on the permit drawings:**

1) Trees to be given stormwater management credit shall be clearly labeled as such, with the size and species included.
2) Approximate setbacks from property lines and structures shall be shown.
3) Temporary irrigation measures shall be shown, if applicable.
4) Form SIM must be submitted, clearly showing that less than 10% of the impervious area is being mitigated for with tree credits if the project impervious area exceeds 1,000 square feet.

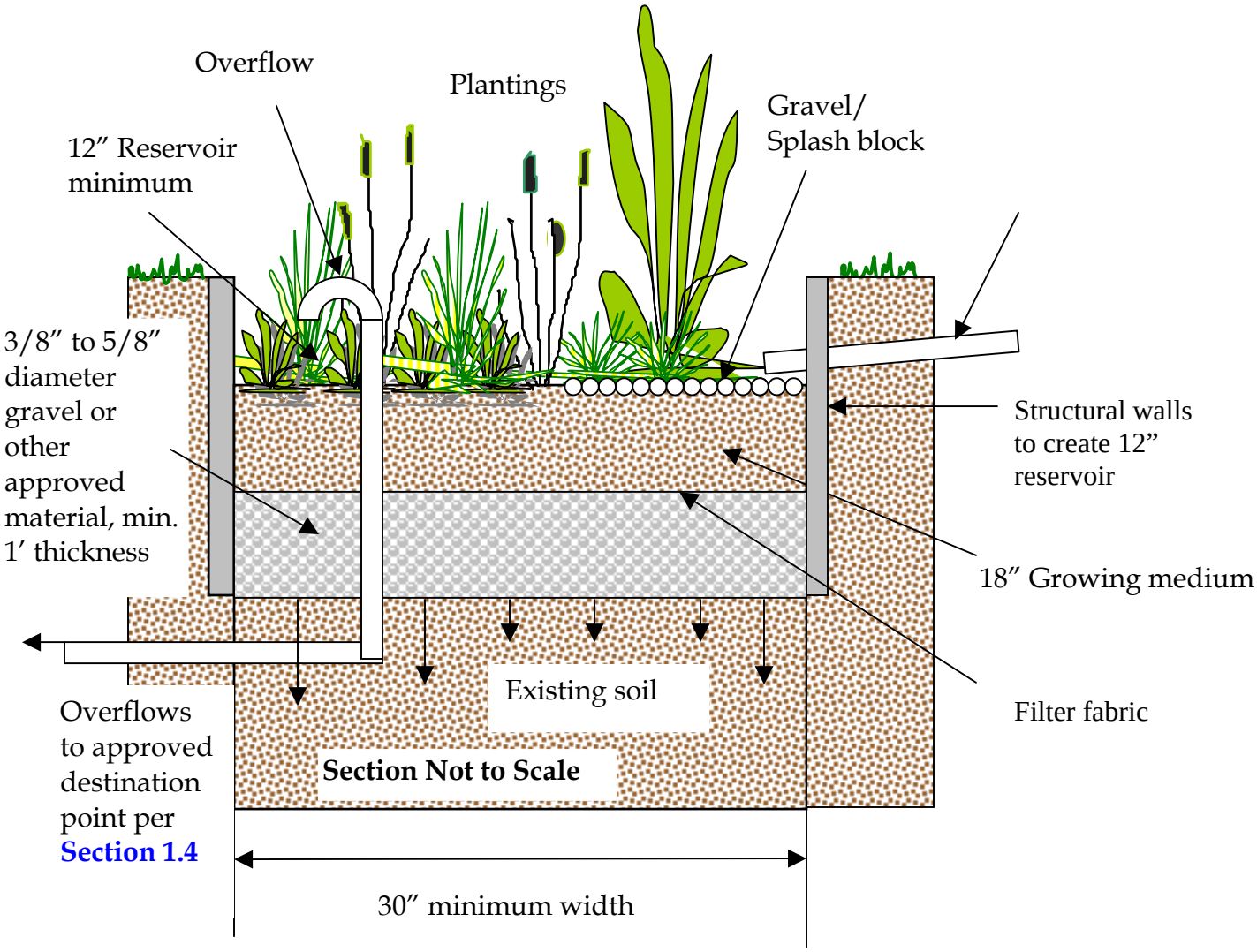
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to new tree O&M form**

**Additional photos:**

*** Link to tree photos**

# Infiltration Planter




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| √ Destination/ Disposal | PRES[2] |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The Performance Approach may be used to downsize the Simplified Approach sizing factor when the only goal is pollution control. **2)** The surface infiltration facility design procedure from **Section 2.2.2** may be used to receive credit for stormwater disposal.
Infiltration planters may be designed to manage runoff from rooftops, and if submerged into the ground, parking lots and streets in many cases.

# Infiltration Planter

**Description:** Infiltration planters are structural landscaped reservoirs used to collect, filter, and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil and infiltrates into the ground. In addition to providing pollution reduction, flow rates and volumes can also be managed with infiltration planters. 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. An overflow to an approved conveyance and disposal method per **Section 1.4** will be required, unless the facility is sized per surface infiltration facility guidelines presented in **Section 2.2.2**.

**Design Considerations:** When designing infiltration planters, the infiltration rate of the native soil is a key element in determining size and viability.

**Construction Considerations:** Infiltration planter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of planter areas.

**Design Requirements:**

**Soil Suitability:** Infiltration planters are appropriate for soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.) Topsoil shall be used within the top 18 inches of the facility.

**Dimensions and Slopes:** Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 30 inches. Planters shall be constructed without slope.

# Infiltration Planter

**Setbacks:** Required setback from property lines is 5 feet, and 10 feet from building foundations. Proposed variances to this standard must request an exception to the building code through BDS.

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

**Sizing:** Individual infiltration planters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution and flow control. A high-flow overflow must be provided, or to receive credit for stormwater destination, the surface infiltration facility design criteria from **Section 2.2.2** must be used. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor. Planters shall be designed to pond water for less than 12 hours after each storm event.

**Landscaping:** Plantings shall be designed at the following quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

| | |
|---|---|
| **4** - Large shrubs/small trees | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants | 1-gallon containers or equivalent |

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

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

***Link to Flow-Through Planter Landscaping Plan Example**
***Link to Planter Recommended Plants**

**Checklist of minimal information to be shown on the permit drawings:**

# Infiltration Planter

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification
5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Planter grading/ excavation | |
| Structural components/ liner | Call for inspection |
| Piping | Call for inspection |
| Drain rock | |
| Filter fabric | |
| Growing medium | |
| Plantings | Call for inspection |

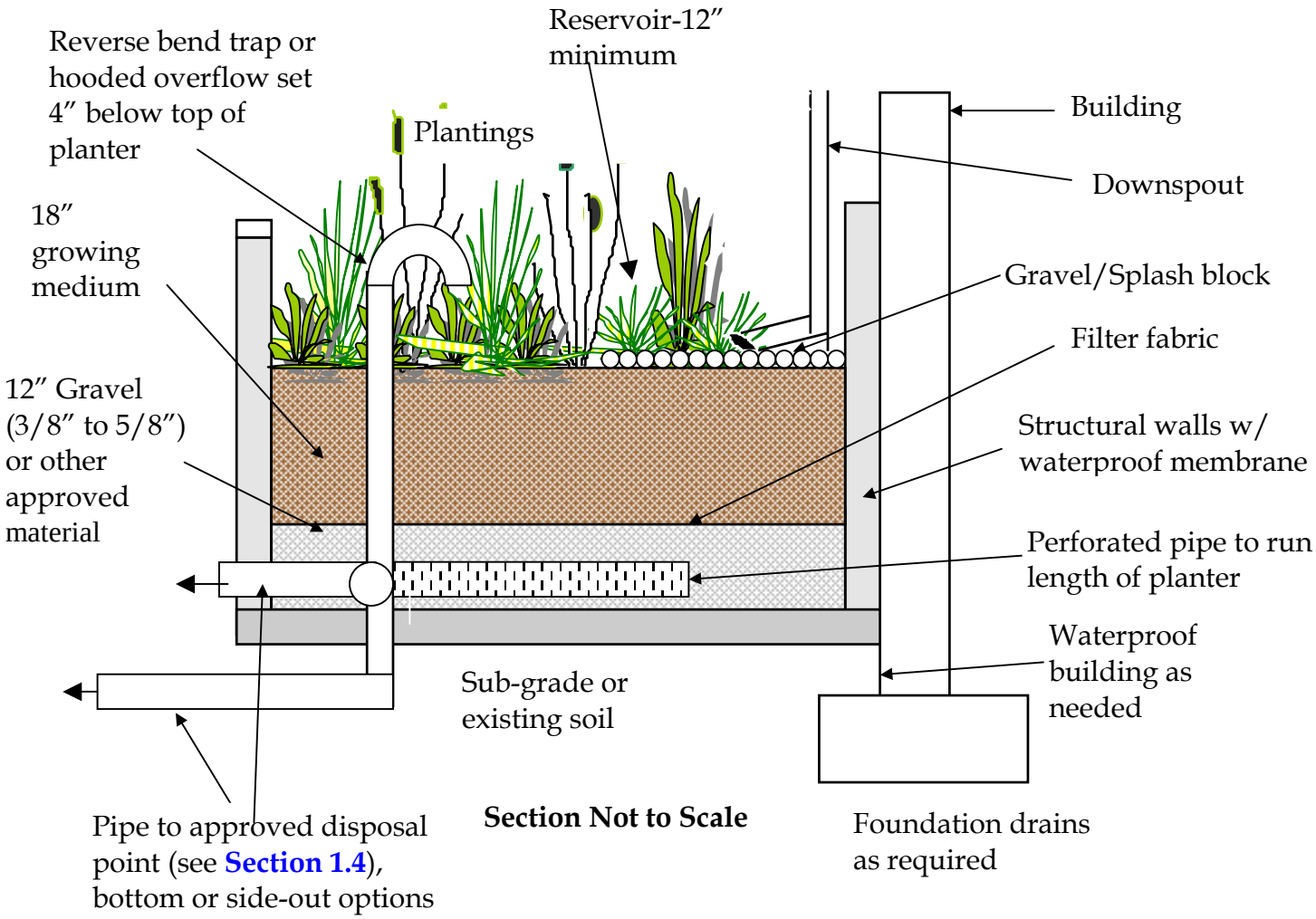
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to infiltration planter O&M form**

**Additional photos and drawings:**

*** Link to infiltration planter photos**
*** Link to infiltration planter drawings**

# Flow-Through Planter




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| Destination/ Disposal | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The Performance Approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Flow-through planters may be designed to manage runoff from rooftops, and if submerged into the ground, parking lots and streets in some cases.

# Flow-Through Planter


**Description:** Flow-through planters are structural landscaped reservoirs used to collect and filter stormwater runoff, allowing pollutants to settle and filter out as the water percolates through the planter soil. In addition to providing pollution reduction, flow rates and volumes can also be managed with flow-through planters. Planters should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. Numerous design variations of shape, wall treatment, and planting scheme can be used to fit the character of a site. Because they include a waterproof lining, flow-through planters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance and destination/ disposal method per **Section 1.4** will be required.

**Design Considerations:** When designing flow-through planters, the structural walls can often times be incorporated with building foundation plans.

**Construction Considerations:** Special attention needs to be paid to the planter waterproofing if constructed adjacent to building structures.

**Design Requirements:**

**Soil Suitability:** Flow-through planters are appropriate for all soil types. Topsoil shall be used within the top 18 inches of the facility.

**Dimensions and Slopes:** Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum planter width is 18 inches. Planter slopes shall be less than 0.5%.

**Setbacks:** Required setback from property lines is 5 feet, unless the planter height is less than 30 inches.

# Flow-Through Planter

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

**Sizing:** Individual flow-through planters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution reduction and flow control. A high-flow overflow must be provided to an approved disposal point per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used to downsize the simplified approach sizing factor. Planters shall be designed to pond water for less than 12 hours after each storm event.

**Landscaping:** Plantings shall be designed at the following minimum quantities per **100** square feet of facility area. Facility area is equivalent to the area of the planter calculated from Form SIM.

| | |
|---|---|
| **4** - Large shrubs/small trees | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants | 1-gallon containers or equivalent |

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

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

***Link to Flow-Through Planter Landscaping Plan Example**
***Link to Planter Recommended Plants**

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Planter wall material and waterproofing membrane specification
4) Growing medium specification

# Flow-Through Planter

5) Drain rock specification
6) Filter fabric specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
8) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Planter grading/ excavation | |
| Structural components/ liner | Call for inspection |
| Piping | Call for inspection |
| Drain rock | |
| Filter fabric | |
| Growing medium | |
| Plantings | Call for inspection |

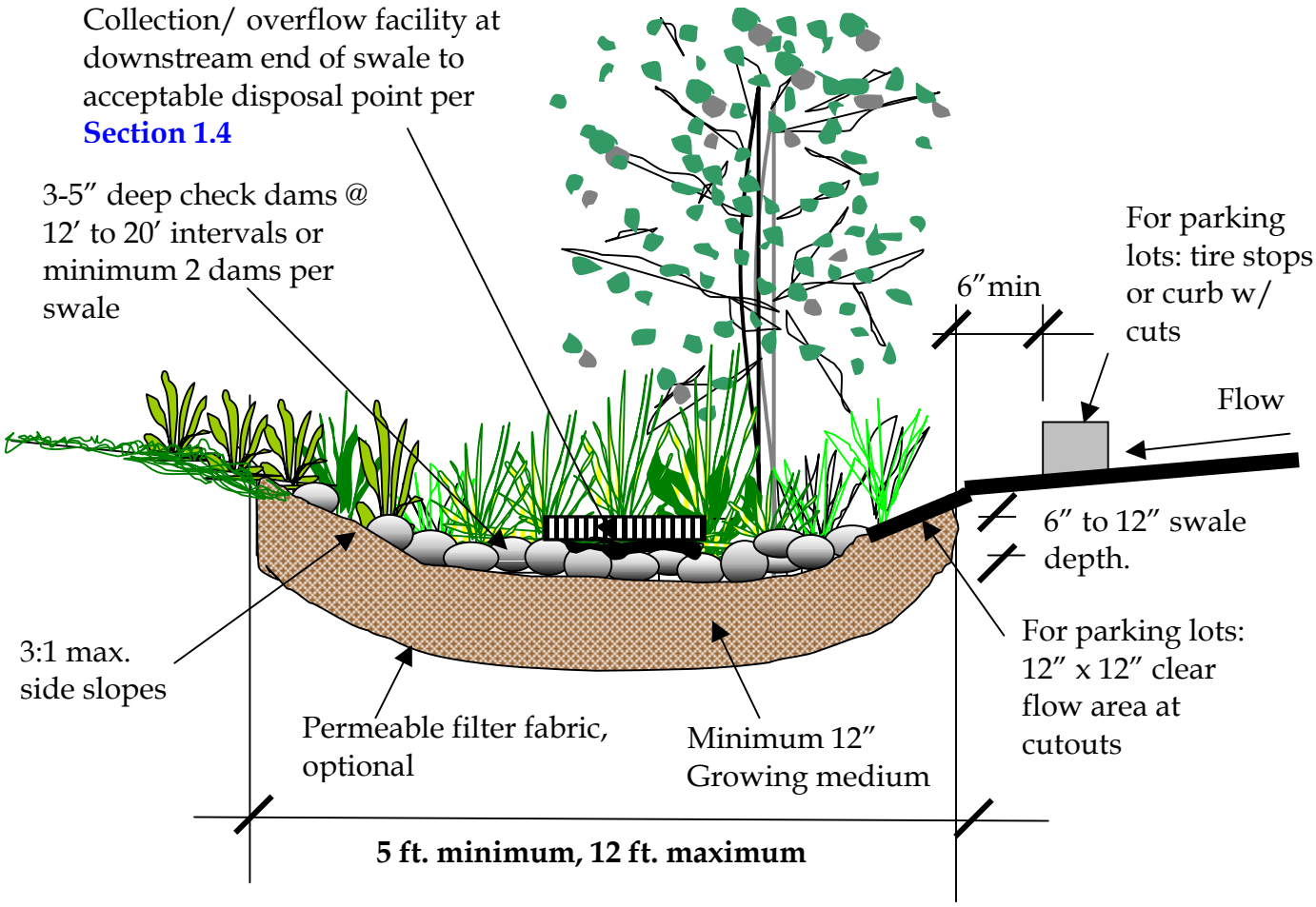
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to flow-through planter O&M form**

**Additional photos and drawings:**

*** Link to flow-through planter photos**
*** Link to flow-through planter drawings**

# Vegetated Swale




**Section Not to Scale**

| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| √ Destination/ Disposal | PRES[2] |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Vegetated swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **2)** The surface infiltration facility design procedure from **Section 2.2.2** may be used to receive credit for stormwater disposal.

# Vegetated Swale

**Description:** Vegetated swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and destination/ disposal method per **Section 1.4** will be required at the end of the swale.

**Design Considerations:** When designing vegetated swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility.

**Construction Considerations:** Vegetated swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

**Design Requirements:**

**Soil Suitability:** Vegetated swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

**Dimensions and Slopes:** Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Maximum longitudinal slope is 6%.

# Vegetated Swale

**Setbacks:** Required setback from centerline of swale to property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric or approved by BES and BDS.

**Sizing:** Vegetated swales sized with the Simplified Approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor.

**Check Dams:** Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrating them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 6 inches in height.

**Landscaping:** Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Minimum plant material quantities per 100 square feet of facility area are as follows:

| | | |
|---|---|---|
| **1** - Evergreen or deciduous tree (planted around the perimeter of the swale): | | |
| | Evergreen trees: | Minimum height: 6 feet |
| | Deciduous trees: | Minimum caliper: 1 ½ inches at 6 inches above base. |
| **4** - Large shrubs/small trees: | | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants: | | 1-gallon containers or equivalent |

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

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

# Vegetated Swale

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Swale grading | Call for inspection |
| Piping | Call for inspection |
| Filter fabric (if applicable) | |
| Growing medium | |
| Plantings | Call for inspection |

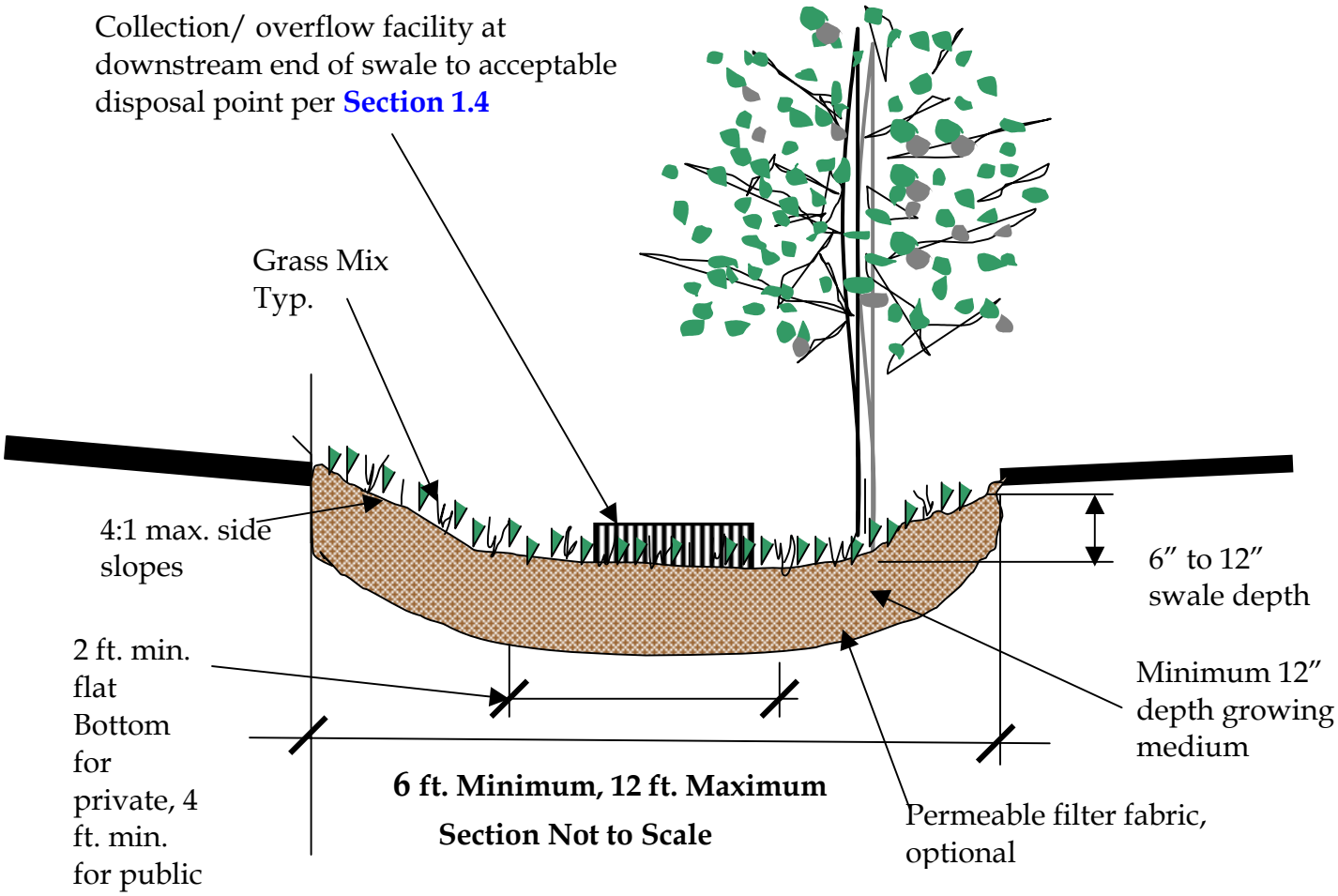
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to vegetated swale O&M form**

**Additional photos and drawings:**

*** Link to vegetated swale photos**
*** Link to vegetated swale drawings**

# Grassy Swale




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction…….. | SIM[1], PRES[2] |
| √ Flow Control…….. | SIM[1] |
| √ Destination/ Disposal…….. | PRES[3] |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Flow and volume control credit will only be given for projects with less than 15,000 square-feet of impervious area to manage. **2)** For projects with more than 15,000 square-feet of impervious area to manage, the presumptive approach must be used to size the swale for pollution reduction, and additional facilities may be required to meet flow control requirements. Grassy swales can be used to manage runoff from parking lots, rooftops, and private streets. For public street runoff, the street swale criteria must be used. **3)** The surface infiltration facility design procedure from Section 2.2.2 may be used to receive credit for stormwater disposal

# Grassy Swale


**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, flow rates and volumes can also be managed for small projects (<15,000 square feet of impervious surface) with grassy swales. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and disposal method per **Section 1.4** will be required at the end of the swale.

**Design Considerations:** When designing grassy swales, slopes and depth should be kept as mild as possible to avoid safety risks and prevent erosion within the facility.

**Construction Considerations:** Grassy swale areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

**Design Requirements:**

**Soil Suitability:** Grassy swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

**Dimensions and Slopes:** Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 4 horizontal to 1 vertical. Minimum flat bottom width is 2 feet for private swales, and 4 feet for public swales. Maximum longitudinal slope is 5%, while minimum slope is 0.5%. Maximum surrounding ground slopes shall be 10%.

# Grassy Swale

**Setbacks:** Required setback from centerline of swale to property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric.

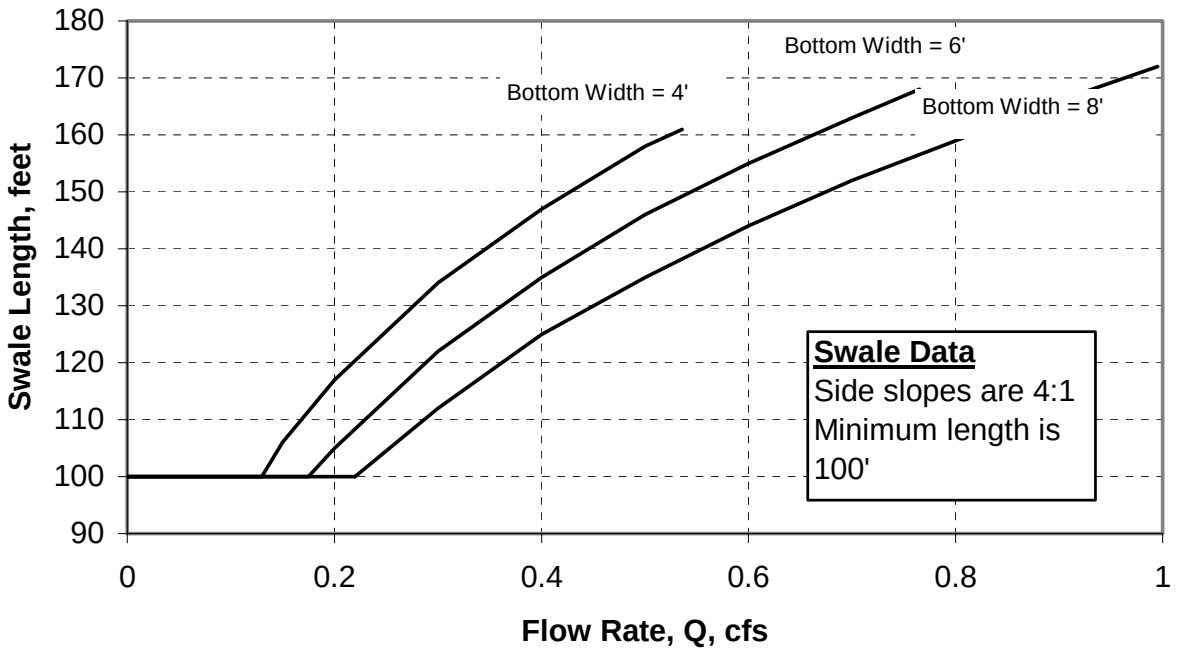
**Sizing:** Grassy swales sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.1 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, or there is more than 15,000 square feet of impervious area to manage, the presumptive approach must be used size the swale for pollution reduction, and additional facilities will be required to meet flow control requirements, where applicable.

**Presumptive Approach Sizing Criteria:**

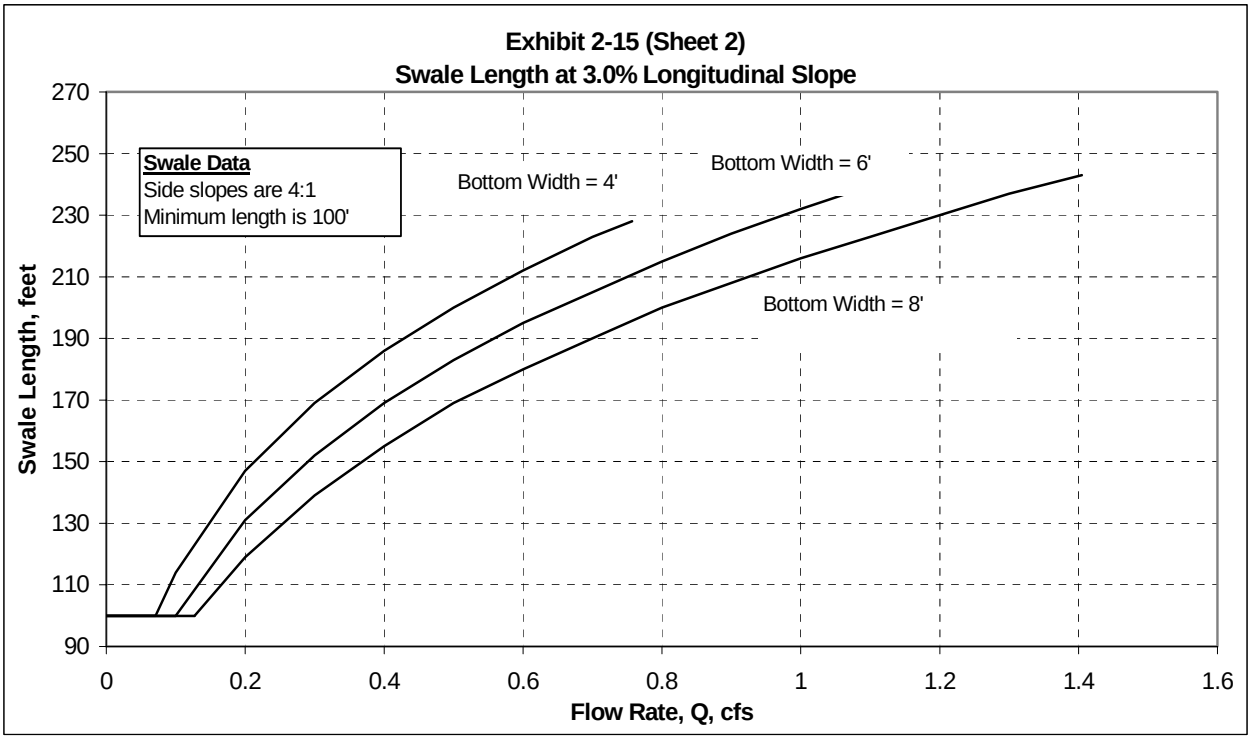
**Exhibit 2-15** shows swale side slopes of 4:1 and lengthwise slopes of 1½ percent, 3 percent, and 5 percent. These charts are based on the City standards shown below and may be used to easily determine swale length, given the peak flow rate and the desired swale bottom width.

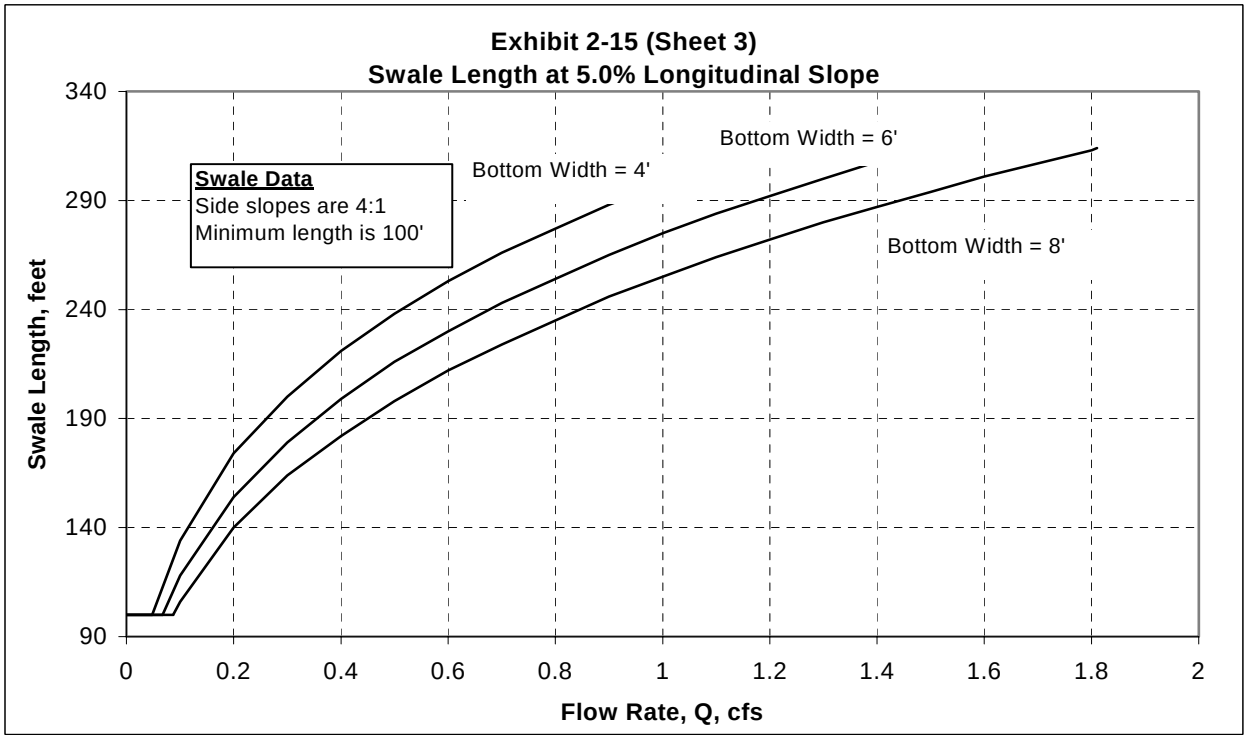
# Grassy Swale

**Exhibit 2-15 (Sheet 1)**
**Swale Length at 1.5% Longitudinal Slope**



# Grassy Swale



# Grassy Swale

1) The swale width and profile shall be designed to convey runoff from the pollution reduction design storm intensity (see **Section 1.5.2**) at:

   - Maximum design depth of 0.33 feet.
   - 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.
   - Minimum longitudinal slope of 0.5 percent, maximum slope of 5 percent. For slopes greater than 5 percent, check dams shall be used (one 6-inch high dam every 10 feet).
   - Designed using a Manning "n" value of 0.25.
   - 4:1 (or flatter) side slopes in the treatment area.
   - Minimum length of 100 feet.

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

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

2) The 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.

3) To minimize flow channelization, the swale bottom shall be smooth, with uniform longitudinal slope, and with a minimum bottom width of 2 feet for private facilities and 4 feet for public facilities. Maximum bottom width shall be 8 feet.

4) Grasses or sod shall be established as soon as possible after the swale is completed, and before water is allowed to enter the facility.

5) 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 allowing water to flow through the swale.

# Grassy Swale

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

**Stormwater Report Requirements For Presumptive Approach**: See **Exhibit 2-2**.

**Landscaping:** Plantings shall be designed at the following quantities per **200** square feet of facility area. Facility area is equivalent to the area of the swale calculated from Form SIM. (Note: Facilities smaller than 200 square feet shall have a minimum of one tree per facility.):

**1** Evergreen or Deciduous tree:

| | |
|---|---|
| Evergreen trees: | Minimum height: 6 feet. |
| Deciduous trees: | Minimum caliper: 1 ½ inches at 6 inches above base. |

Grass: Seed or sod is required to completely cover the grassy swale bottom and side slopes. (Shrubs are optional)

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.

Native wildflowers, grasses, and ground covers used for BES-maintained facilities shall be designed not to 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 will require BES approval.

Environmental zones shall meet requirements established by Title 33 for grass in E-zones.

***Link to Grassy Swale Recommended Seed Mixes**

**Checklist of minimal information to be shown on the permit drawings:**

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

# Grassy Swale

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Swale grading | Call for inspection |
| Piping | Call for inspection |
| Filter fabric (if applicable) | |
| Growing medium | |
| Plantings/ seeding/ sod | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

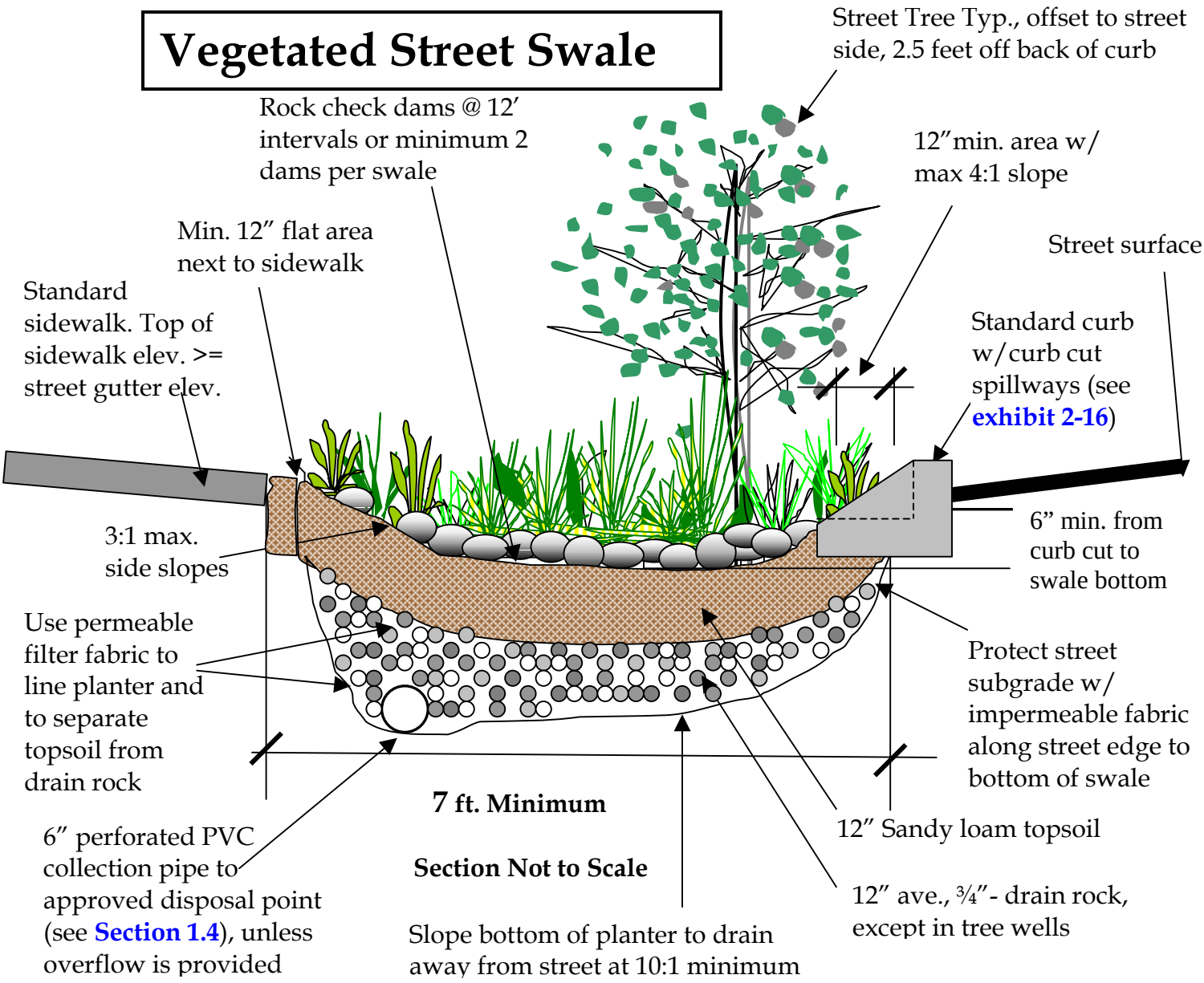
*** Link to grassy swale O&M form**

**Additional photos and drawings:**

*** Link to grassy swale photos**
*** Link to grassy swale drawings**

# Street Swales

## Vegetated Street Swale




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM |
| √ Flow Control | SIM |
| √ Destination/ Disposal | PRES[1] |

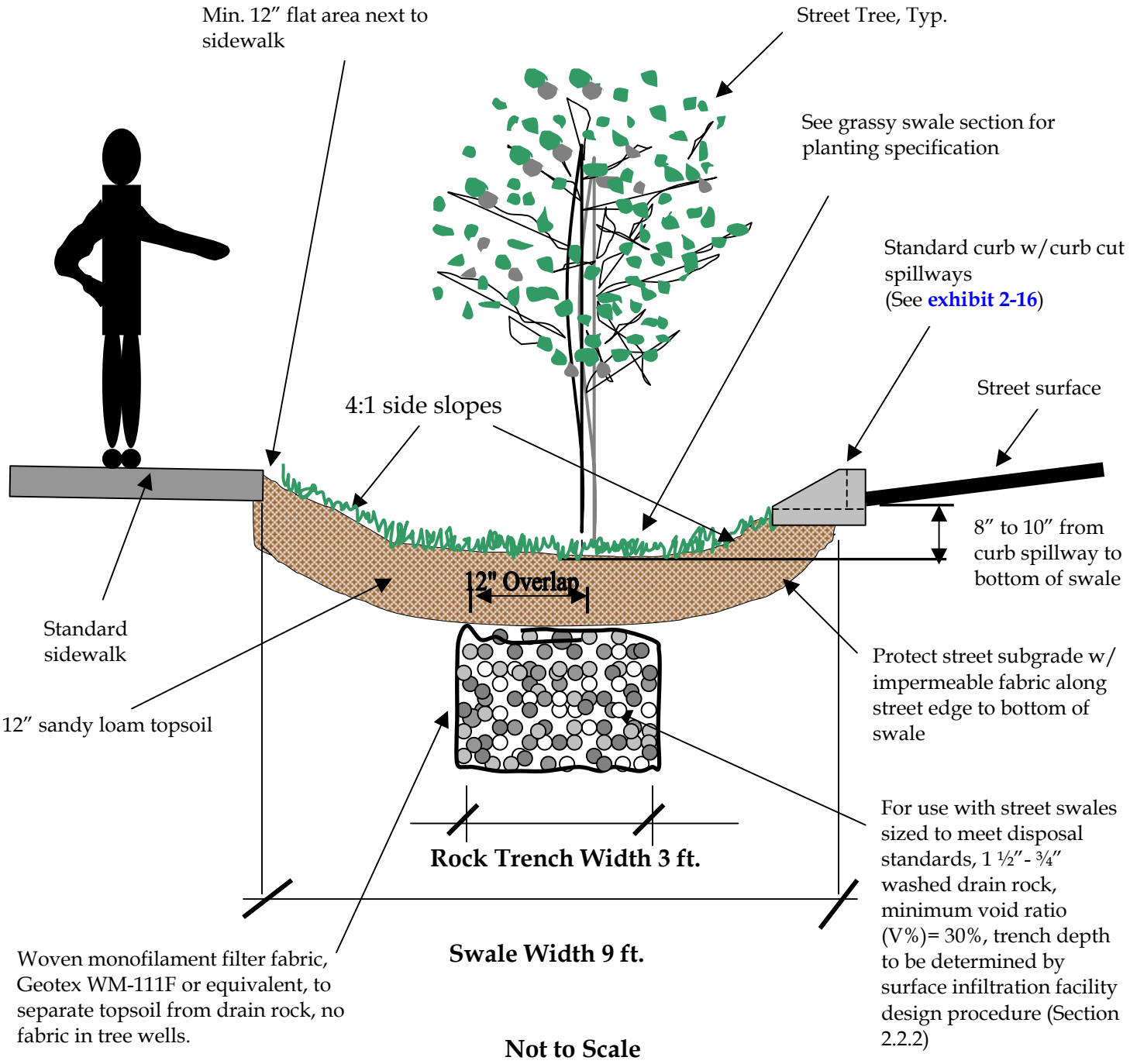
This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The surface infiltration facility sizing criteria from **Section 2.2.2** may be used to size the street swale for complete stormwater infiltration. This facility may be used on private property or in the public right-of-way.

# Street Swales

## Grassy Street Swale




**Note:** Overflow to an approved disposal point is required, unless swale is sized in accordance with surface infiltration facility design procedure presented in **Section 2.2.2**.

# Street Swales

**Description:** Street construction poses particular challenges related to stormwater management design. Lack of available space is often the most difficult hurdle in locating stormwater pollution reduction and flow control facilities in or near allocated rights-of-way. BES and the Portland Office of Transportation have developed specific street swale designs that incorporate pollution reduction and flow control into the cross-section of the street. For more information and ideas about stormwater friendly street designs, Metro has developed three handbooks: "Creating Livable Streets," "Green Streets," and "Trees for Green Streets." These handbooks can be purchased from Metro at: **www.metro-region.org.**

Street swales are long narrow landscaped depressions used to collect and convey stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or flows from one bay to the next through the facility. In addition to providing pollution reduction, flow rates and volumes can also be managed with street swales, as check dams are provided every 12 to 20 feet to slow and pool water. Swales should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. An approved conveyance and disposal method per **Section 1.4** will be required at the end of the swale, unless the swale is designed per the surface infiltration facility criteria presented in **Section 2.2.2**.

**Design Considerations:** When designing street swales, slopes and depth should be kept as mild as possible to avoid safety risks, improve aesthetics, and prevent erosion within the facility. All applicable PDOT, BDS, and Urban Forestry requirements for other street elements (curbs, sidewalks, trees, etc.) must be met.

**Construction Considerations:** Street swale areas should be clearly marked before site work begins to avoid soil disturbance and compaction during construction.

# Street Swales

No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of swale areas.

**Design Requirements:**

**Soil Suitability:** Street swales are appropriate for all soil types. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

**Dimensions and Slopes:** Facility storage depth may vary from 6 to 12 inches. Maximum side slopes are 3 horizontal to 1 vertical for vegetated swales, and 4 horizontal to 1 vertical for grassy swales (to accommodate for mowing). Minimum flat bottom width is 2 feet. Maximum longitudinal slope is 6%.

**Setbacks:** Required setback from building foundations is 10 feet unless lined with impermeable fabric.

**Sizing:** To meet pollution reduction and flow control requirements, the square-footage of street swales is to be determined using vegetated or grassy swale sizing criteria (shown on **Form SIM**), depending on which surface treatment is being used. The minimum width for street swales is 7 feet for vegetated, and 9 feet for grassy. Street swales sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the swale to an approved disposal point, per **Section 1.4**.

**Check Dams:** Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or soil by integrated them into the grading of the swale. Check dams shall be 12 inches in length, by the width of the swale, by 3 to 5 inches in height.

**Landscaping:** Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the swale, including bottom and side slopes, as calculated from Form SIM. Turf grass may be used to cover the entire swale surface area. If plantings are chosen to landscape the swale, the minimum plant material quantities per 100 square feet of facility area shall be as follows:

| | |
|---|---|
| **4** - Large shrubs/small trees: | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants: | 1-gallon containers or equivalent |

# Street Swales

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be avoided, facilities shall be designed to require mowing no more than once annually.

**Recommended street trees in or near street swales:**

| **With overhead power lines** | **Without overhead power lines** |
|---|---|
| Carpinus caroliniana | Acer campestre 'Evelyn' |
| Cercis Canadensis | Betula jacquemontii |
| Fraxinus pennsylvanica 'Johnson' | Celtis occidentalis |
| Gleditsia triacanthos 'Impcole' | Gleditsia triacanthos 'Skycole' |
| Koelreuteria paniculata | Nyssa sylvatica |
| Prunus virginiana 'Canada Red' | Quercus shumardii |

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All curb cut details and stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

# Street Swales

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Swale grading | Call for inspection |
| Curbs / curb cuts | Call for inspection |
| Piping (if applicable) | Call for inspection |
| Filter fabric (if applicable) | |
| Growing medium | |
| Plantings | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

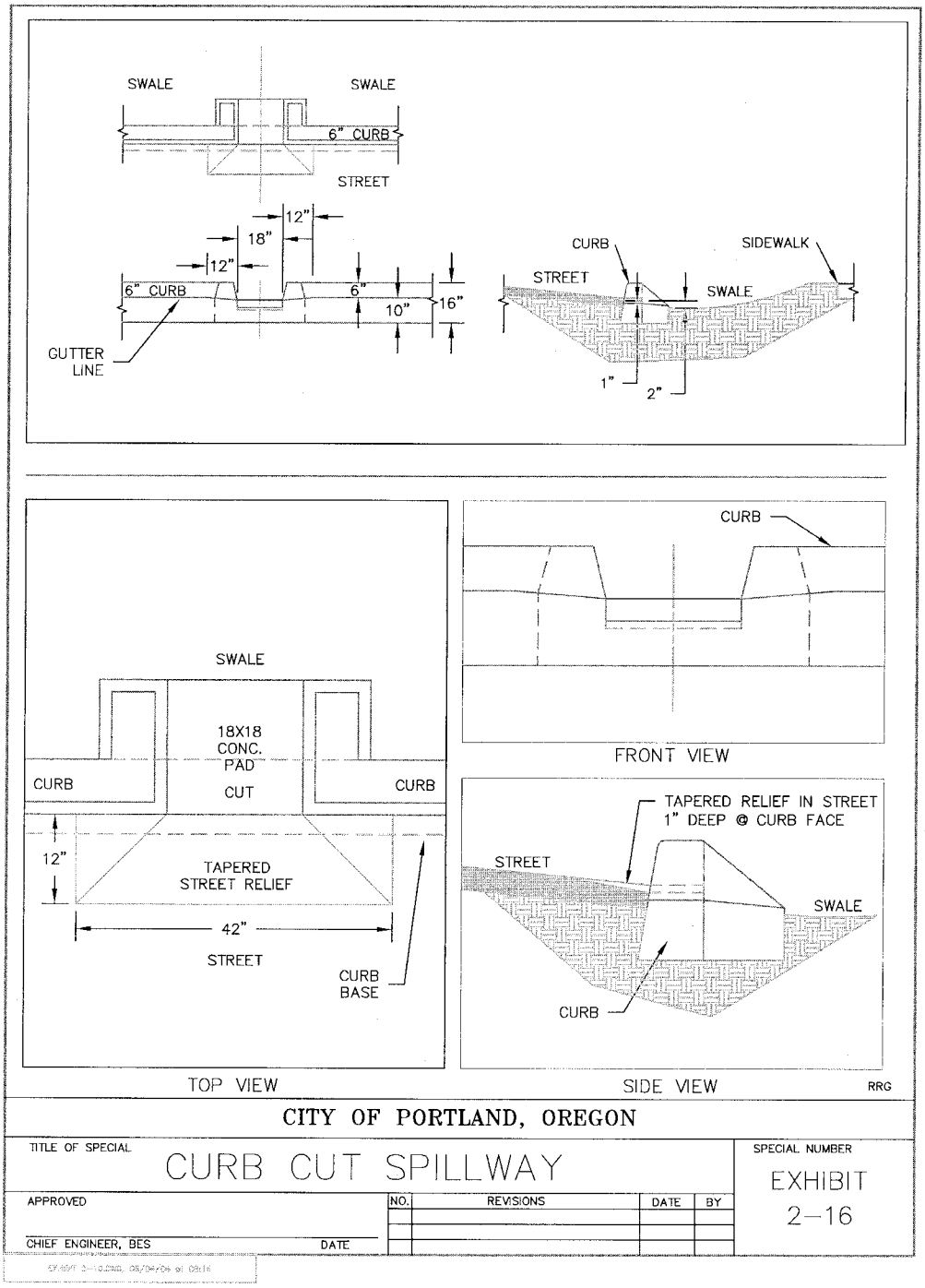
*** Link to vegetated and grassy swale O&M form**

**Additional photos and drawings:**

*** Link to street swale photos**

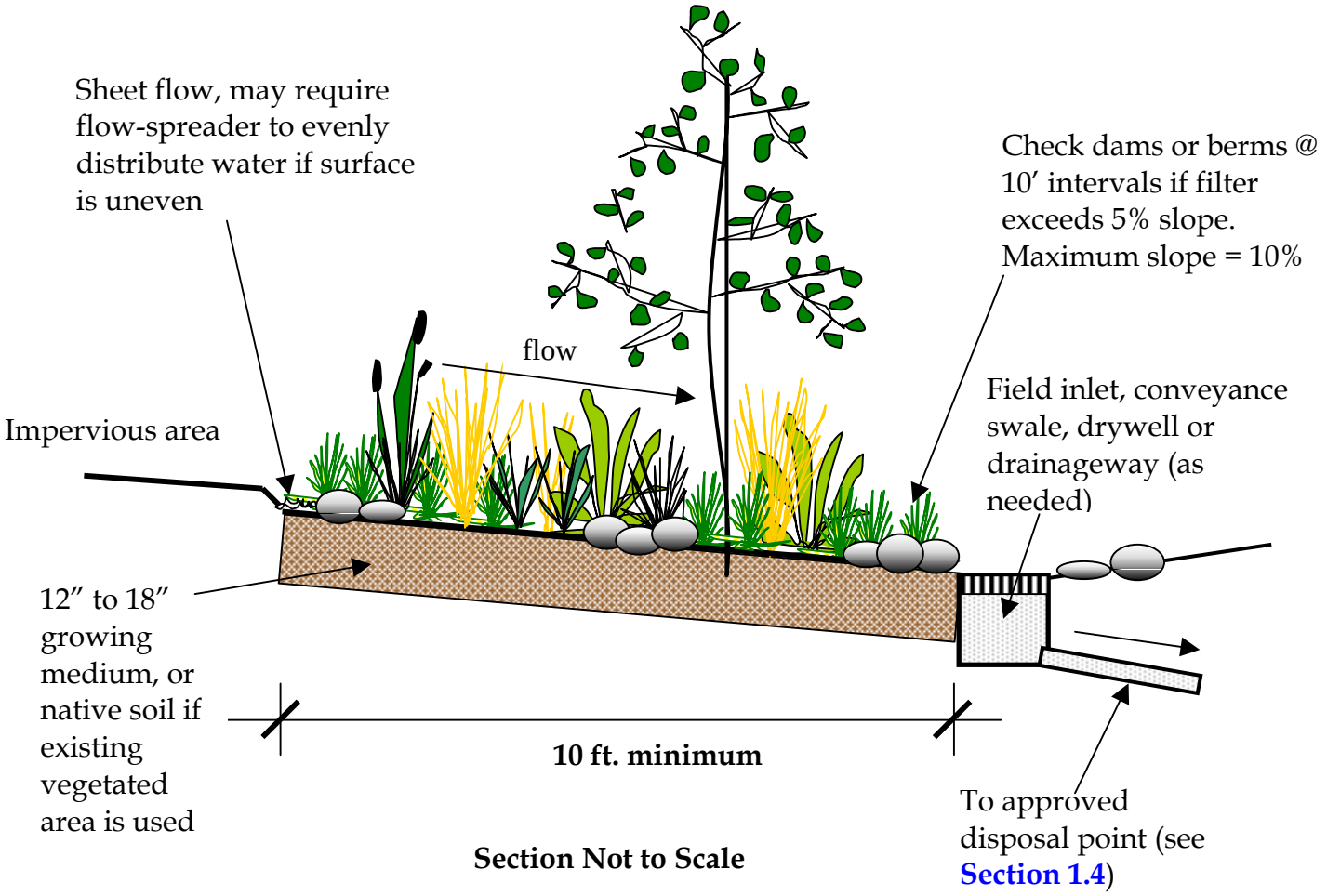
*** Link to street swale drawings**

# Street Swales



# Street Swales

# Vegetated Filter




**Section Not to Scale**

| **Stormwater Management Goals Achieved** | **Acceptable Sizing Methodologies** |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| √ Destination/ Disposal[2] | PRES[2] |

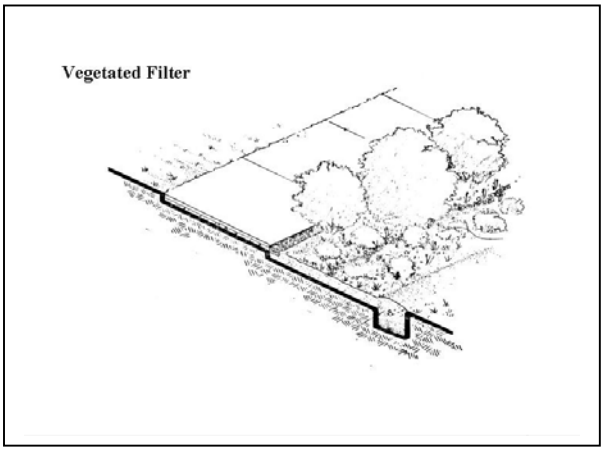
This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The Performance Approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Vegetated filters can be used to manage stormwater from rooftops, pathways, parking lots, and potentially streets (with flow spreaders or if the runoff is left as unconcentrated sheet flow). **2)** Where soils infiltrate sufficiently per BDS, stormwater disposal credit may be given for projects with less than 500 square feet of impervious surfaces to manage.

# Vegetated Filter


SW Community Center (6820 SW 45th Ave.)




**Description:** Vegetated filter strips, or vegetated filters, are gently sloping areas used to filter, slow, and infiltrate stormwater flows. Stormwater enters the filter as sheet flow from an impervious surface or is converted to sheet flow using a flow spreader. Flow control is achieved using the relatively large surface area and for slopes greater than 5%, a generous proportion of check dams or berms. Pollutants are removed through filtration and sedimentation. Filters can be planted with a variety of trees, shrubs, and ground covers, including grasses. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. There can be many ways to fit this concept into site designs and designers are encouraged to use the site landscape areas for this purpose. Unless designed for stormwater disposal, an approved conveyance and disposal method per **Section 1.4** will be required at the end of the filter.

**Design Considerations:** When designing vegetated filters, slopes should be kept as flat as possible to prevent erosion. Spreading the flow evenly across the filter is also important in ensuring that the facility functions correctly and avoids flow channeling.

**Construction Considerations:** Vegetated filter areas should be clearly marked before site work begins to avoid soil disturbance during construction. No vehicular traffic, except that specifically used to construct the facility, should be allowed within 10 feet of filter areas. Flow spreaders must be constructed perfectly level to distribute flows evenly across the filter, and for public facilities must be surveyed after construction.

**Design Requirements:**

**Soil Suitability:** Vegetated filters are appropriate for all soil types. Unless existing vegetated areas are used for the filter, topsoil shall be used within the

top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

**Dimensions and Slopes:** Maximum allowable vegetated filter slopes are 10%. Terraces may be used to decrease ground slopes. Minimum slopes are 0.5%.

**Setbacks:** Required setback from property lines is 5 feet, and 10 feet from building foundations unless lined with impermeable fabric.

**Sizing:** Unless used for very long, narrow projects such as pathways and trails, vegetated filters cannot be used to manage flow from more than 2,000 square-feet of impervious area. Filters shall be a minimum of 10 feet wide x 10 feet long. A simplified approach sizing factor of 0.2 may be used to receive credit for pollution reduction and flow control. A high-flow by-pass mechanism will not be required in these cases, but a high-flow overflow must be provided at the downstream end of the filter to an approved disposal point, per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor.

**Check Dams:** Check dams shall be constructed of durable, non-toxic materials such as rock, brick, or concrete, or graded into the native soils. Check dams shall be 12 inches in length, by the width of the filter, by 3 to 5 inches in height.

**Landscaping:** Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. Sod may be used for single-family residential sites, where a simple downspout disconnection into lawn or landscaping is used. For other projects, minimum plant material quantities per **100** square feet of facility area are as follows. The "facility area" is equivalent to the area of the filter, as calculated from Form SIM.

| | | |
|---|---|---|
| **1** - Evergreen or deciduous tree (planted around the perimeter of the swale): | | |
| | Evergreen trees: | Minimum height: 6 feet |
| | Deciduous trees: | Minimum caliper: 1 ½ inches at 6 inches above base. |
| **4** - Large shrubs/small trees: | | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants: | | 1-gallon containers or equivalent |

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

# Vegetated Filter

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

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification (if applicable)
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
5) Landscaping plan
6) Flow spreader details and specifications
7) Check dam or terrace details and specifications

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Filter grading (if applicable) | Call for inspection |
| Flow spreaders/Terraces (if applicable) | Call for inspection |
| Piping (if applicable) | Call for inspection |
| Growing medium (if applicable) | |
| Plantings | Call for inspection |

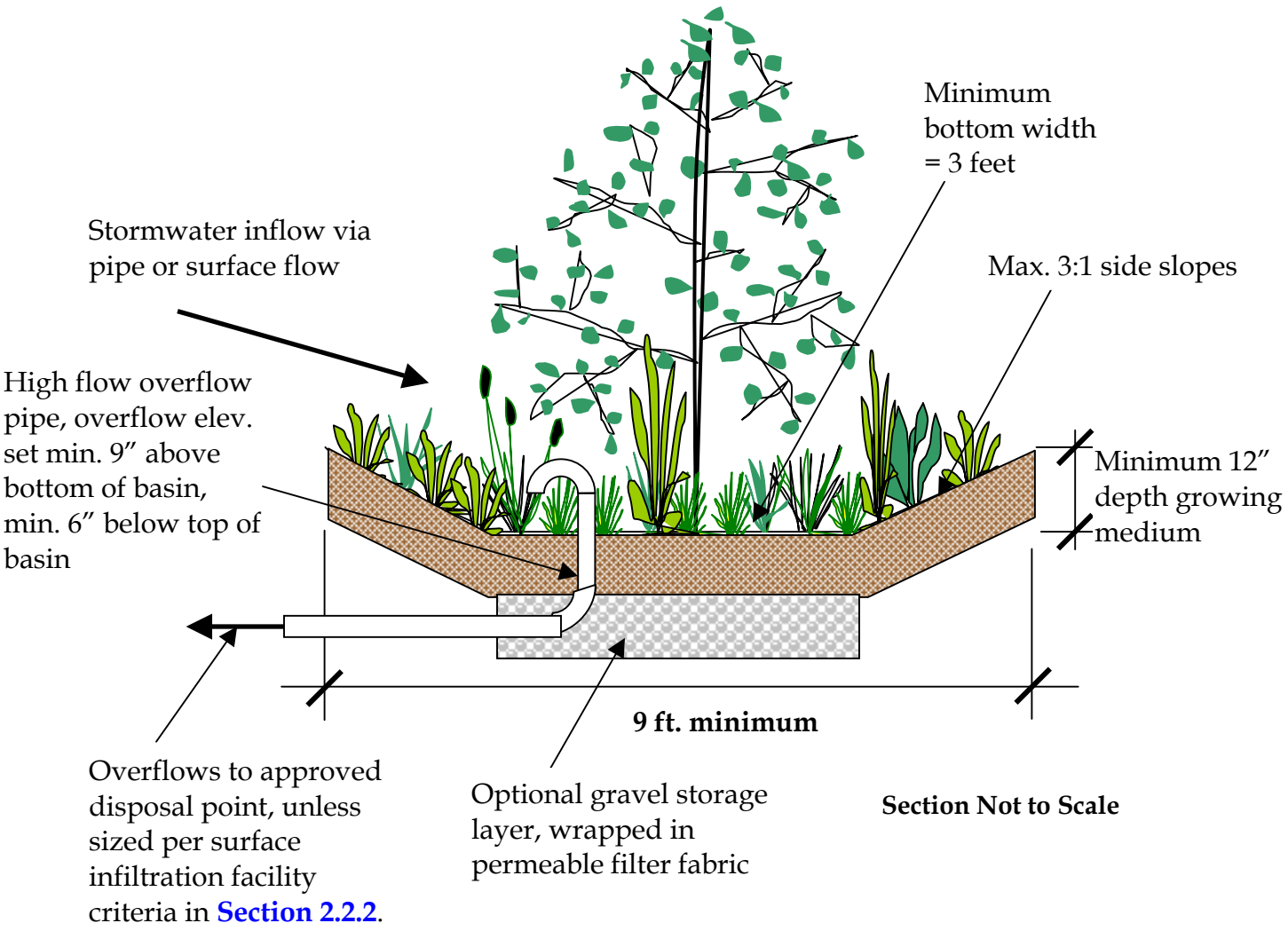
**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to vegetated filter O&M form**

**Additional photos and drawings:**

*** Link to vegetated filter photos**
*** Link to vegetated filter drawings**

# Vegetated Infiltration Basin




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| √ Destination/ Disposal | PRES[2] |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution control. **2)** The surface infiltration facility sizing methodology from Section 2.2.2 may be used to achieve stormwater disposal. Vegetated infiltration basins can be used to manage stormwater from all impervious surface types, and must be located on private property.

# Vegetated Infiltration Basin


**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. In addition to providing pollution reduction, flow rates and volumes can also be managed with vegetated infiltration basins. They should be integrated into the overall site design and can be used to help fulfill a site's required landscaping area requirement. As shown in the example photos, the design can be formal or informal in character and planting scheme. An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required, unless the basin is designed per surface infiltration facility guidelines presented in **Section 2.2.2**.

**Design Considerations:** When designing vegetated infiltration basins, the infiltration rate of the native soil is a key element in determining size and viability. Slopes and depth should be minimized to avoid safety risks.

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

**Design Requirements:**

**Soil Suitability:** Vegetated infiltration basins are appropriate for soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B). There shall be no less than three feet of undisturbed infiltration medium between the bottom of the facility and any impervious layer (i.e. hardpan, solid rock, high groundwater levels, etc.). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

# Vegetated Infiltration Basin

**Dimensions:** 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.

**Setbacks:** Required setback from property lines is 5 feet, and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; infiltration trenches shall not be used where slopes exceed 30%.

**Sizing:** Vegetated infiltration basins sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.09 may be used to receive credit for pollution reduction and flow control. A high-flow overflow must be provided, or to receive credit for complete stormwater infiltration, the surface infiltration facility design criteria from **Section 2.2.2** must be used. In this case, pre and post-construction infiltration tests are required to demonstrate infiltration performance. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used in conjunction with a measured infiltration rate to downsize the simplified approach sizing factor. Drawdown time (time for the basin to empty when full) shall not exceed 30 hours.

**Landscaping:** Vegetation helps improve infiltration functions, protects from rain and wind erosion, and enhances aesthetic conditions. The "facility area" is equivalent to the area of the basin, including bottom and side slopes, plus a 10-foot buffer around the basin. Minimum plant material quantities per 300 square feet of facility area are as follows:

**1** - Evergreen or deciduous tree (planted around the perimeter of the basin):

| | |
|---|---|
| Evergreen trees: | Minimum height: 6 feet |
| Deciduous trees: | Minimum caliper: 1 ½ inches at 6 inches above base. |
| **4** - Large shrubs/small trees: | 3-gallon containers or equivalent. |
| **6** - Shrubs/large grass-like plants: | 1-gallon containers or equivalent |
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to require mowing. Where mowing cannot be

avoided, facilities shall be designed to require mowing no more than once annually. Turf and lawn areas are not allowed for BES-maintained facilities; any exceptions will require BES approval.

**For public vegetated infiltration basins, the following additional design criteria shall apply:**

1) Two staff gauges shall be installed at opposite ends of the bottom of the basin, to enable maintenance staff to measure the depth of accumulated silts.
2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for infiltration.

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Basin grading | Call for inspection |
| Piping | Call for inspection |
| Filter fabric | |
| Growing medium | |
| Plantings | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

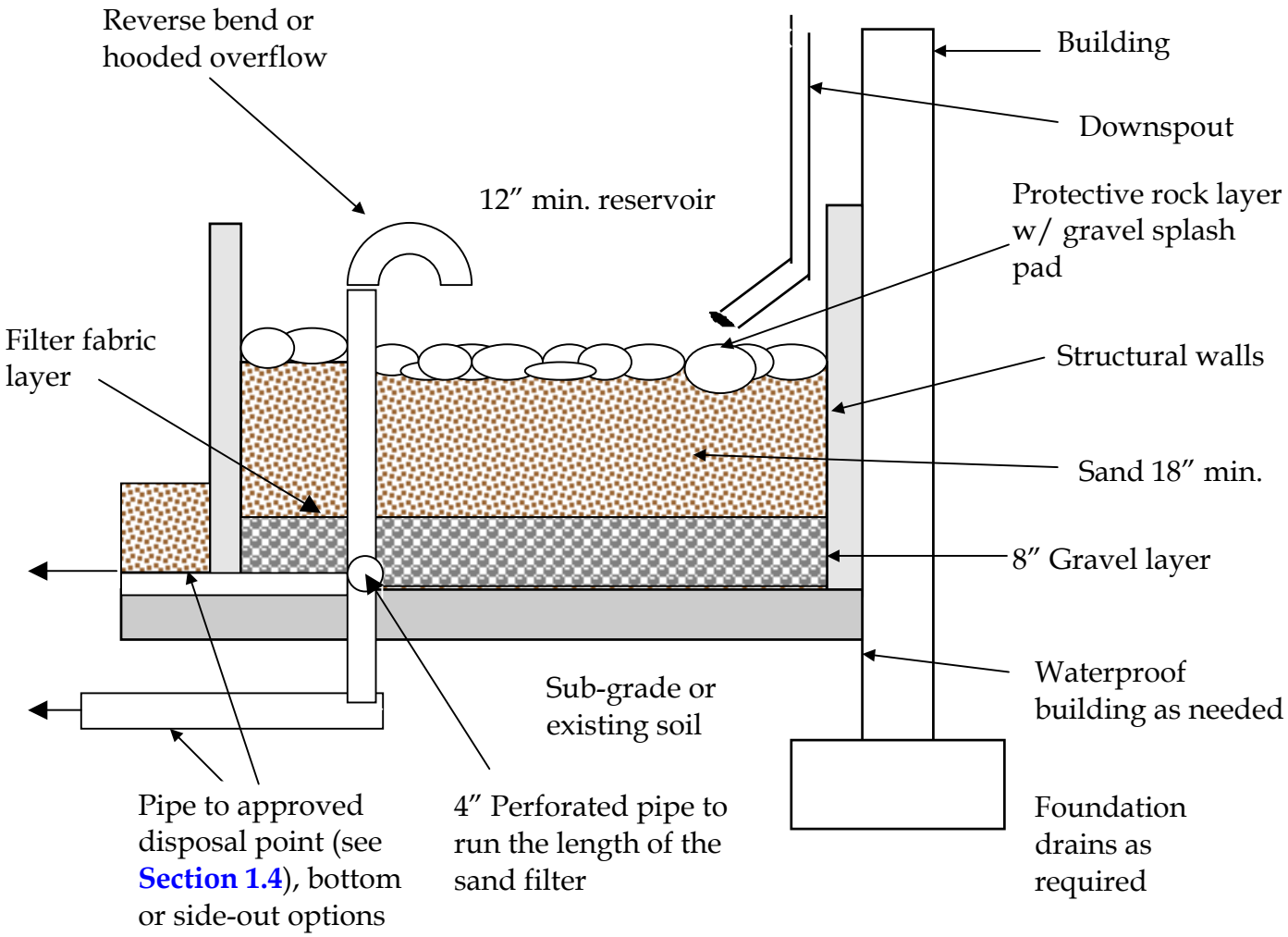
*** Link to vegetated infiltration basin O&M form**

**Additional photos and drawings:**

*** Link to vegetated infiltration basin photos**

*** Link to vegetated infiltration basin drawings**

# Sand Filter




**Section not to scale**

| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | SIM, PERF[1] |
| √ Flow Control | SIM |
| √ Destination/ Disposal | PRES[2] |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The performance approach may be used to downsize the simplified approach sizing factor when the only goal is pollution reduction. Sand filters can be used to manage stormwater from any impervious surface, and must be located on private property. **2)** The surface infiltration facility design procedure from Section 2.2.2 may be used to receive credit for stormwater disposal.

# Sand Filter

**Description:** There are two sand filter options. One is designed with an impervious bottom or is placed on an impervious surface. It can be used for all soil types. The other option, for native soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B), allows filtered water to infiltrate into the ground. For both options, pollutant reduction is achieved as the water filters through the sand; flow control is obtained by slowing the discharge rate as the water filters through the sand. Filters may be constructed in-ground or above grade. Because they can include a waterproof lining, sand filters are extremely versatile and can be used next to foundation walls, adjacent to property lines (if less than 30" in height), or on slopes. An overflow to an approved conveyance and disposal method per **Section 1.4** will be required.

**Design Considerations:** When designing sand filters, the structural walls can often times be incorporated with building foundation plans.

**Construction Considerations:** Special attention needs to be paid to the filter waterproofing if constructed adjacent to building structures.

**Design Requirements:**

**Soil Suitability:** Lined sand filters are appropriate for all soil types. Filters designed to infiltrate into native soils are appropriate in soils with a minimum infiltration rate of 2 inches per hour (NRCS soil types A and B).

**Dimensions and Slopes:** Facility storage depth must be at least 12 inches, unless a larger-than-required planter square-footage is used. Minimum sand filter width is 18 inches. Filter slopes shall be less than 0.5%.

**Setbacks:** Required setback from property lines is 5 feet, unless the sand filter height is less than 30 inches. Required setback from building structures is 10 feet, unless the sand filter is properly lined.

# Sand Filter

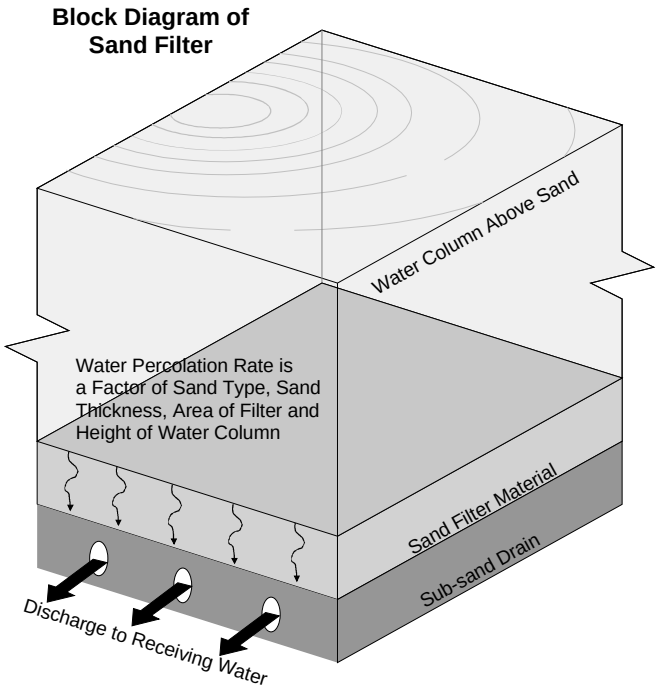
**Structural Walls:** Sand filter walls shall be made of stone, concrete, brick, or wood. Chemically treated wood that can leach out toxic chemicals and contaminate stormwater shall not be used.

**Sizing:** Sand filters sized with the simplified approach shall be designed to receive less than 15,000 square-feet of impervious area runoff. For these projects, a simplified approach sizing factor of 0.06 may be used to receive credit for pollution reduction and flow control. For projects with more than 15,000 square-feet of impervious surface, additional facilities may be required to meet flow control requirements. A high-flow overflow must be provided to an approved disposal point per **Section 1.4**. In cases when pollution reduction is the only stormwater management goal, the performance approach may be used to downsize the simplified approach sizing factor. Sand filters shall be designed to pond water for less than 4 hours after each storm event.

**Vegetation:** Plantings are optional in sand filters. For aesthetic purposes, potted plants may be submerged in the sand filter.

**For public sand filters, the following additional criteria shall apply:**

The sand filter consists of an inlet structure, sand bed, underdrain piping, and basin liner. Criteria for these components are provided below.




**Inlet Structure**

1) 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/ Filter Medium**

1) The length-to-width ratio shall be 2:1 or greater.

# Sand Filter

2) The sand bed configuration may be either of the two configurations shown in **Exhibit 2-17**. All depths shown are final depths. 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.

3) Sand used as filter medium shall be certified by a testing laboratory as meeting or exceeding the specifications presented below:

The filter bed medium shall consist of clean medium to fine sand with no organic material, or other deleterious materials and meeting 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 |

**Sand Bed with Gravel Filter** (**Exhibit 2-17:A**)

1) The top layer shall be a minimum of 18 inches of approved sand.

2) The sand shall be placed over an acceptable geofabric material covering a layer of ½- to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) No gravel is required below the underdrain piping system.

**Sand Bed Using Trench Design** (**Exhibit 2-17:B**)

1) The top layer shall be a minimum of 12 inches of approved sand.

2) The sand shall be placed over an acceptable geotextile fabric material covering a layer of ½ to 2-inch washed drain rock. The finished depth of this drain rock shall be sufficient to provide a minimum of 2 inches of cover over the underdrain piping system.

3) The piping and gravel shall be underlain with geotextile fabric.

# Sand Filter

**Underdrain Piping**

1) The underdrain piping system shall consist of appropriately sized (minimum 4-inch diameter) collector manifold with perforated lateral branch lines. The pipe used in this conveyance system shall be schedule 40 polyvinyl chloride (PVC) material or an approved equal. Lateral spacing shall not exceed 10 feet.

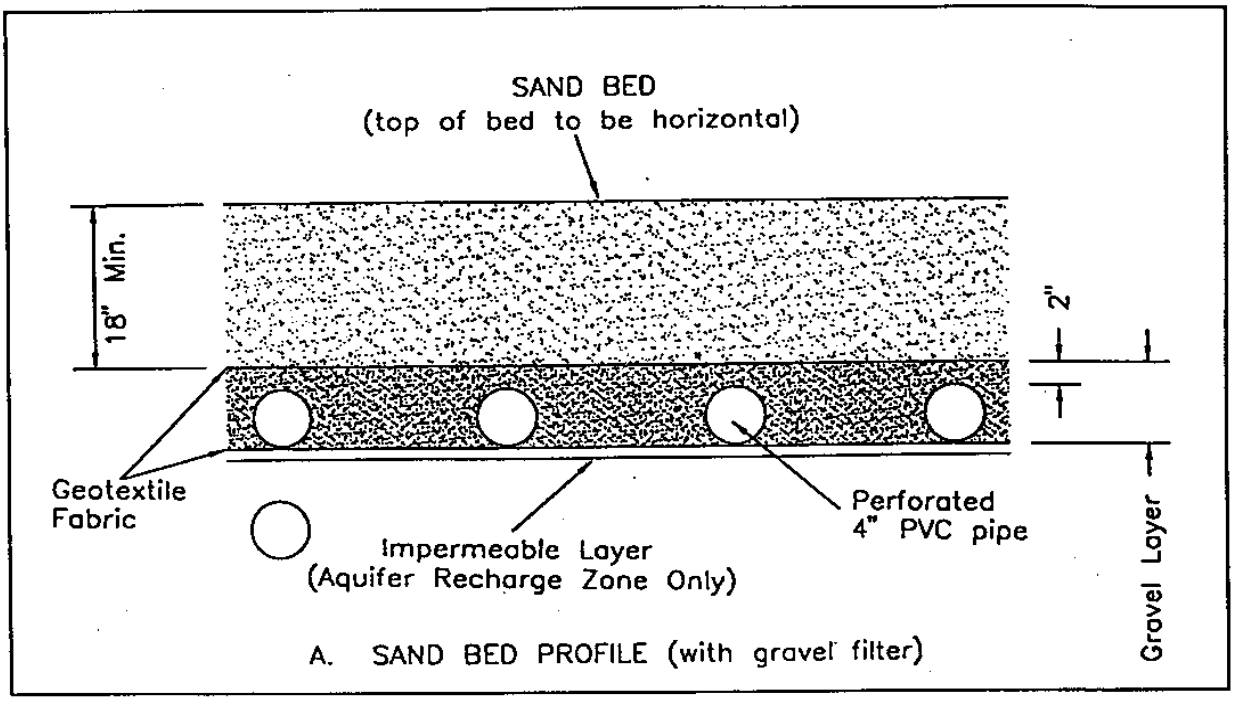
2) The underdrain laterals shall be placed with positive gravity drainage to the collector manifold.

3) The collector manifold shall have a minimum 1 percent grade toward the discharge point.

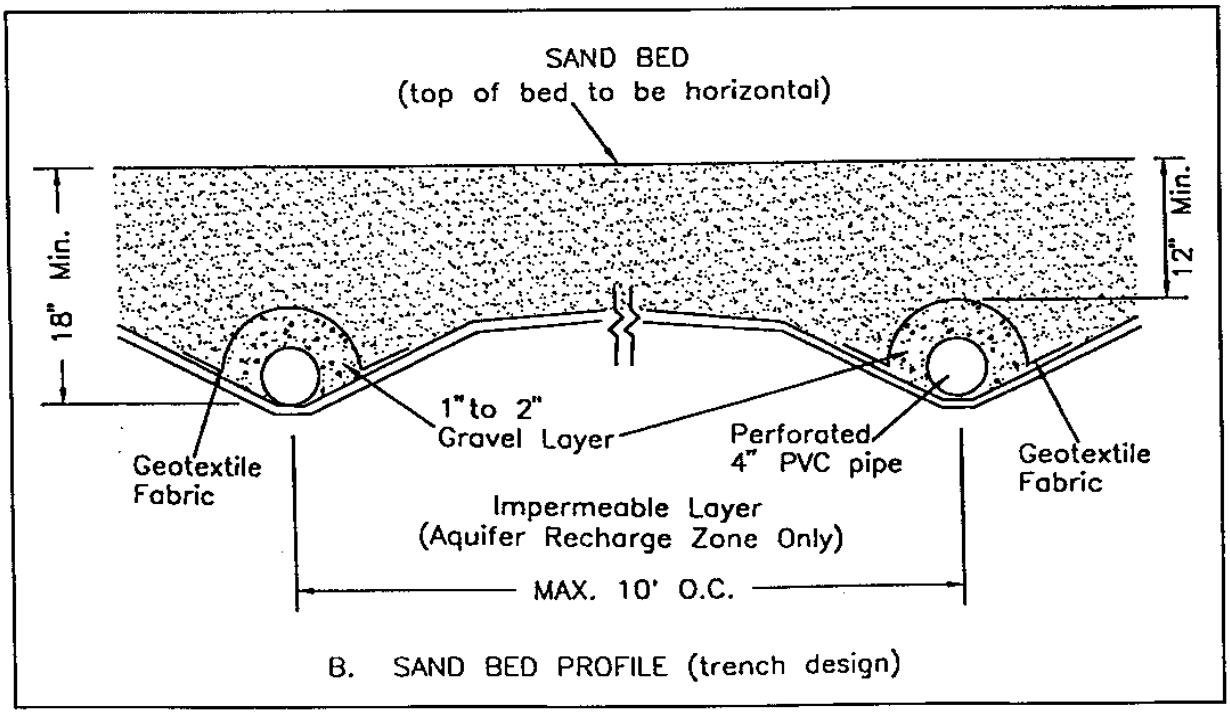
4) All laterals and collector manifolds shall have cleanouts installed, accessible from the surface without removing or disturbing filter media.

# Sand Filter

**Exhibit 2-17**




A. SAND BED PROFILE (with gravel filter)




B. SAND BED PROFILE (trench design)

# Sand Filter

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Structural wall material specification
4) Sand specification
5) Filter fabric specification
6) Rock surface layer specification
7) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Sand filter grading | Call for inspection |
| Structural walls | Call for inspection |
| Piping | Call for inspection |
| Sand | |
| Filter fabric | |
| Rock layer | Call for inspection |
| Plantings (if applicable) | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

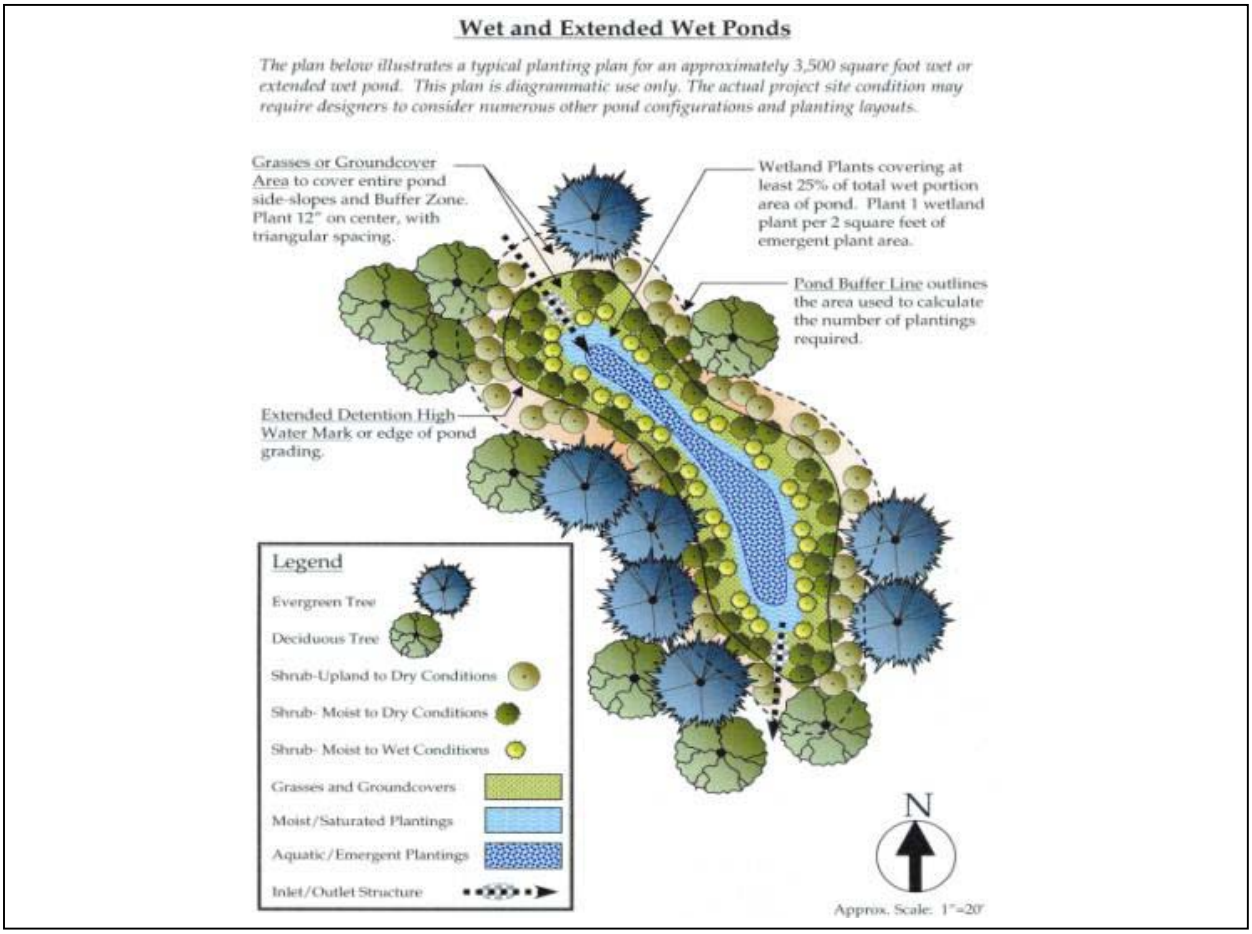
*** Link to sand filter O&M form**

**Additional photos and drawings:**

*** Link to sand filter photos**

# Sand Filter

# Wet, Extended Wet, & Dry Detention Pond




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction…….. | PRES[1] |
| √ Flow Control……..…… | PRES[2] |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Wet and extended wet detention ponds receive credit for pollution reduction. For dry detention ponds to receive credit for pollution reduction, the bottom flow path of the pond must be designed as a vegetated or grassy swale, with sizing and design in accordance with criteria presented in this chapter. **2)** Only extended wet detention and dry detention ponds receive credit for flow control. All ponds must overflow to an acceptable stormwater disposal point per **Section 1.4**. Wet and extended wet detention ponds can be used to provide pollution reduction for any impervious surfaces, and must be located outside of public rights-of-way.

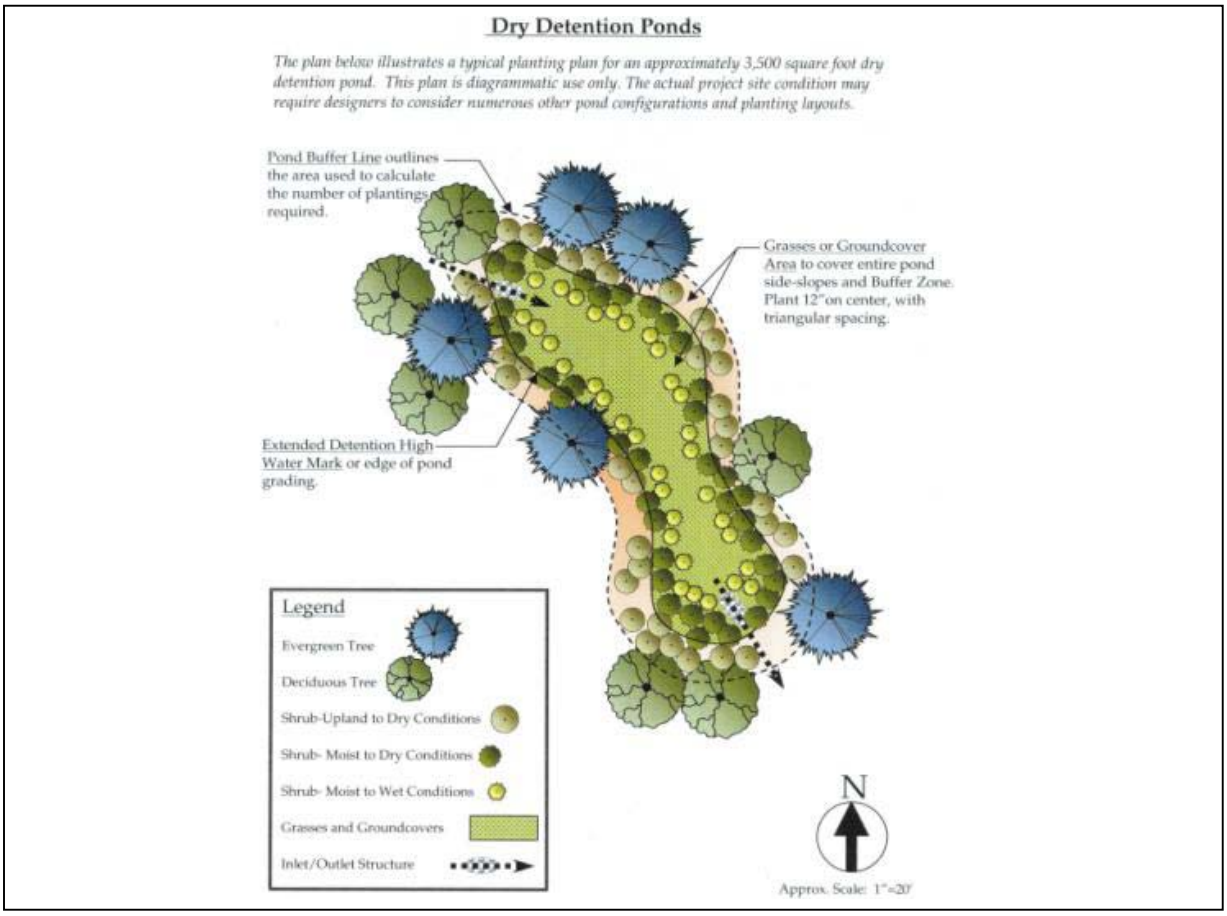
# Wet, Extended Wet, & Dry Detention Pond

**Wet Pond Description:** Wet ponds are constructed with a permanent pool of water (called pool storage or dead storage). Stormwater runoff enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. Additional facilities will be required to meet flow control requirements, as applicable. An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.

**Extended Wet Detention Pond Description:** Extended wet detention ponds are constructed with a permanent pool of water (called pool storage or dead storage) and additional storage above, which 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 biologic processes. When the sizing criteria presented in this section is used, pollution reduction requirements are presumed to be met. The extended detention portion of this facility must be designed using acceptable hydrologic modeling techniques (see **Section 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**). An overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.

**Dry Detention Pond Description:** Dry detention ponds are vegetated basins 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 2.3**) to meet applicable flow control requirements (see **Section 1.6.2**). Additional facilities are required to meet pollution reduction requirements, unless the bottom flow path of the pond is designed as a vegetated or grassy swale, per swale sizing and design criteria. An

overflow mechanism to an approved conveyance and disposal method per **Section 1.4** will be required.




# Wet, Extended Wet, & Dry Detention Pond

**Design Considerations:** Slopes and depth should be kept as mild as possible to avoid safety risks. 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. The City encourages applicants to design ponds to function as multi-purpose facilities (e.g., parks, open space, recreation facilities, or parking lots), provided that any alternative uses are compatible with the primary stormwater functions and maintenance standards. Instream ponds are not encouraged. If used, they require special approvals from the National Marine Fisheries Service, Oregon Department of Fish and Wildlife, Oregon Division of State Lands, and City of Portland, in addition to water rights from the Oregon Division of Water Rights.

**Construction Considerations:** As 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.

**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.

**Setbacks:** Ponds shall be constructed to maintain the following setback distances from structures and other facilities. (All distances are measured from the edge of the maximum water surface elevation. The setback limit applies to ponds near the top of slope, not the bottom.)

- 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: 50 feet.
- Surrounding slopes shall not exceed 10%. 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 (**Exhibit 2-18**).
- Minimum distance from the edge of the pond water surface to a well: 100 feet (**Exhibit 2-18**).

# Wet, Extended Wet, & Dry Detention Pond

**Geometry/ Design Requirements:**

- Slopes within the pond shall not exceed 3 horizontal to 1 vertical.
- 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.
- 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.
- Minimum freeboard shall be 1 foot above the highest potential water surface elevation (one foot above the emergency overflow structure or spillway elevation).
- Wet and extended wet detention ponds are applicable in NRCS Type C and D soils (A and B soils with impermeable liner). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.
- Dry detention ponds are applicable in NRCS type B, C, and D soils (the pond should most likely be designed as an infiltration basin in type A soils). Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.
- Unless designed with a pollution reduction swale in the bottom flow path, 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 feet 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, and shall provide at least 0.5 feet of dead storage for sediment accumulation.
- Public ponds shall be designed with an upstream sedimentation manhole with downturned elbow or tee riser outflow pipe (See **Exhibit 2-32**) to trap oils and reduce the likelihood of a visible sheen on the pond surface.
- Access routes to the pond for maintenance purposes must be shown on the plans. Public ponds will need to provide a minimum 8-foot wide access route, not to exceed 10 percent in slope.
- Where possible, a dewatering outlet with shut-off valve shall be provided to aid in the maintenance of the permanent pool.
- For wet and extended wet detention ponds, a water budget shall be submitted for review. The water budget must demonstrate that the baseflow to the pond is sufficient such that water stagnation/alga matting will not become a problem.

**Outlet/ Overflow:**

- If a riser pipe outlet is used, it shall be protected by a trash rack and anti-vortex plate. If an orifice plate is used, it shall be protected with a trash rack with at least 10 square feet of open surface area. In both cases, the rack must be hinged or easily removable to allow for cleaning. The rack shall be adequately secured to prevent it from being removed or opened when maintenance is not occurring.
- All ponds shall have an emergency overflow spillway or structure designed to convey the 100- year, 24-hour design storm for post-development site conditions, assuming the pond is full to the overflow spillway or structure crest. The overflow shall be designed to convey these extreme event peak flows around the berm structure for discharge into the downstream conveyance system. The overflow shall be designed and sited to protect the structural integrity of the berm. This will assure that catastrophic failure of the berm is avoided, property damage is avoided, and water quality of downstream receiving water bodies is protected (see **Exhibit 2-20**).
- 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 towards 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 2.8** and shall extend to the toe of each face of the berm embankment. The emergency overflow spillway weir section shall be designed for the maximum design storm event for post-development conditions, using the following formula:

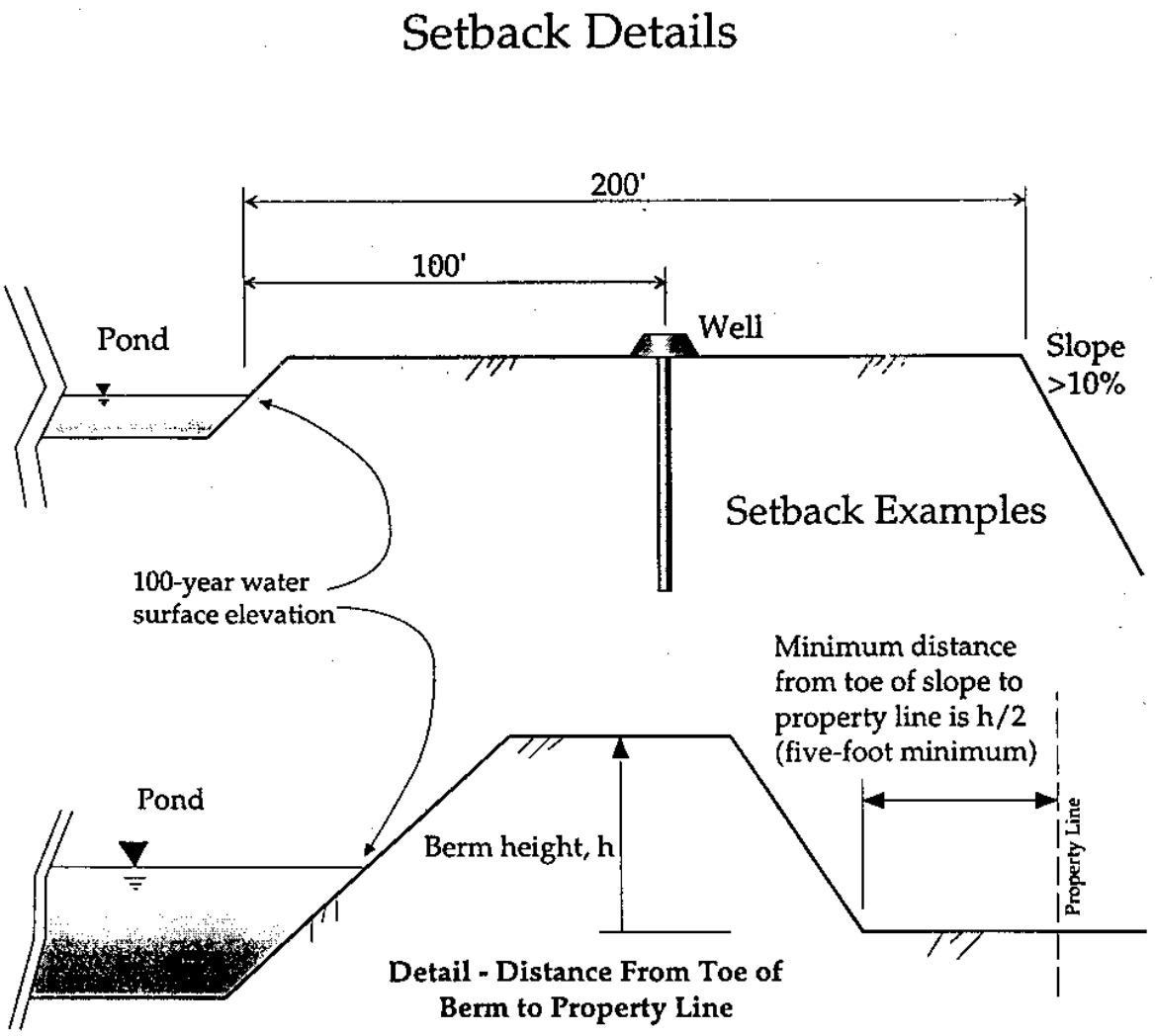
$$L = \frac{Q_{100}}{3.21H^{1.5}} - 2.4\,H$$

where:

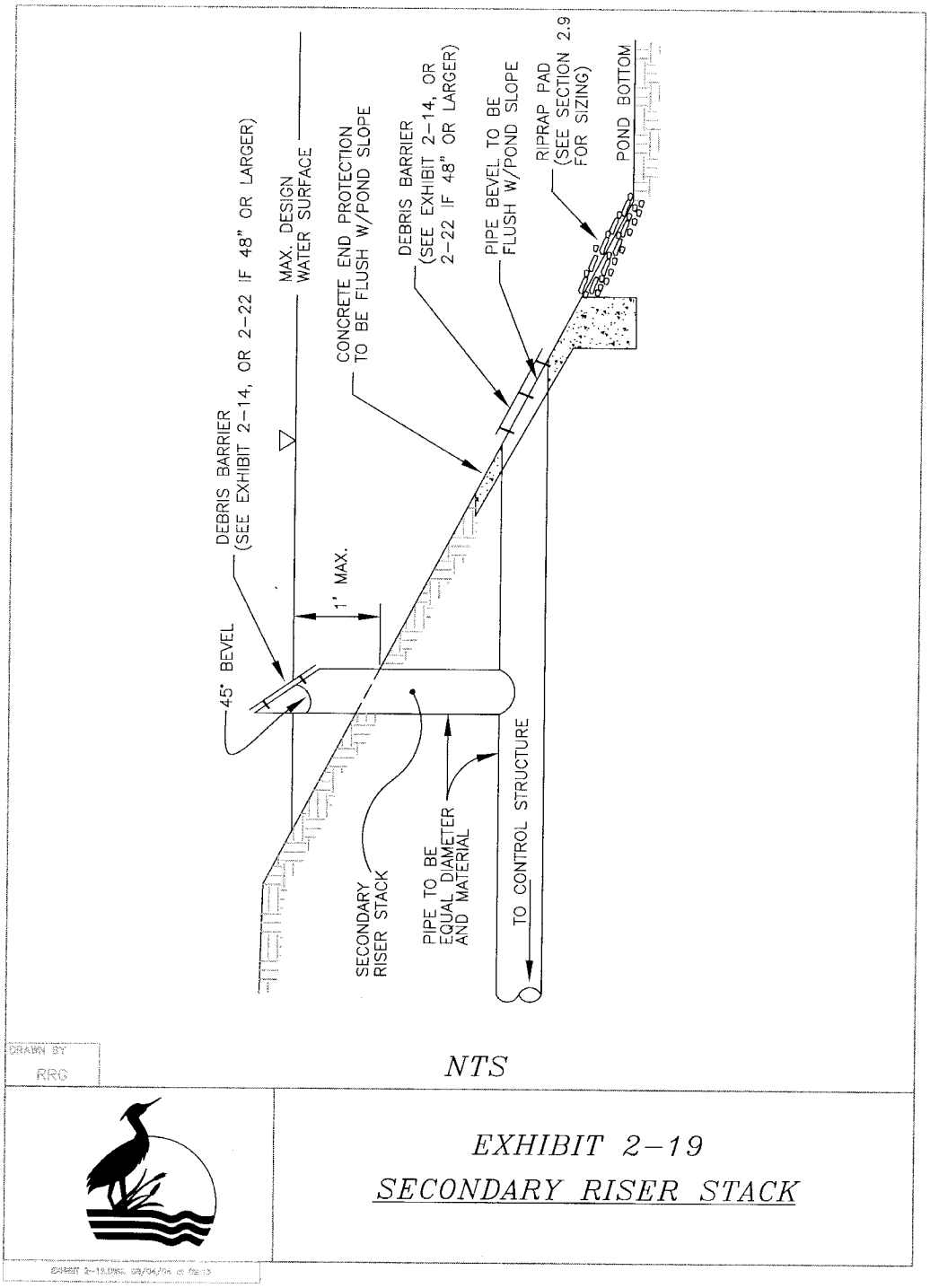
| | | |
|---|---|---|
| L | = | Length of bottom of weir, feet |
| $Q_{100}$ | = | 100-year post-development flow rate, cfs |
| H | = | Height of emergency overflow water surface, feet |

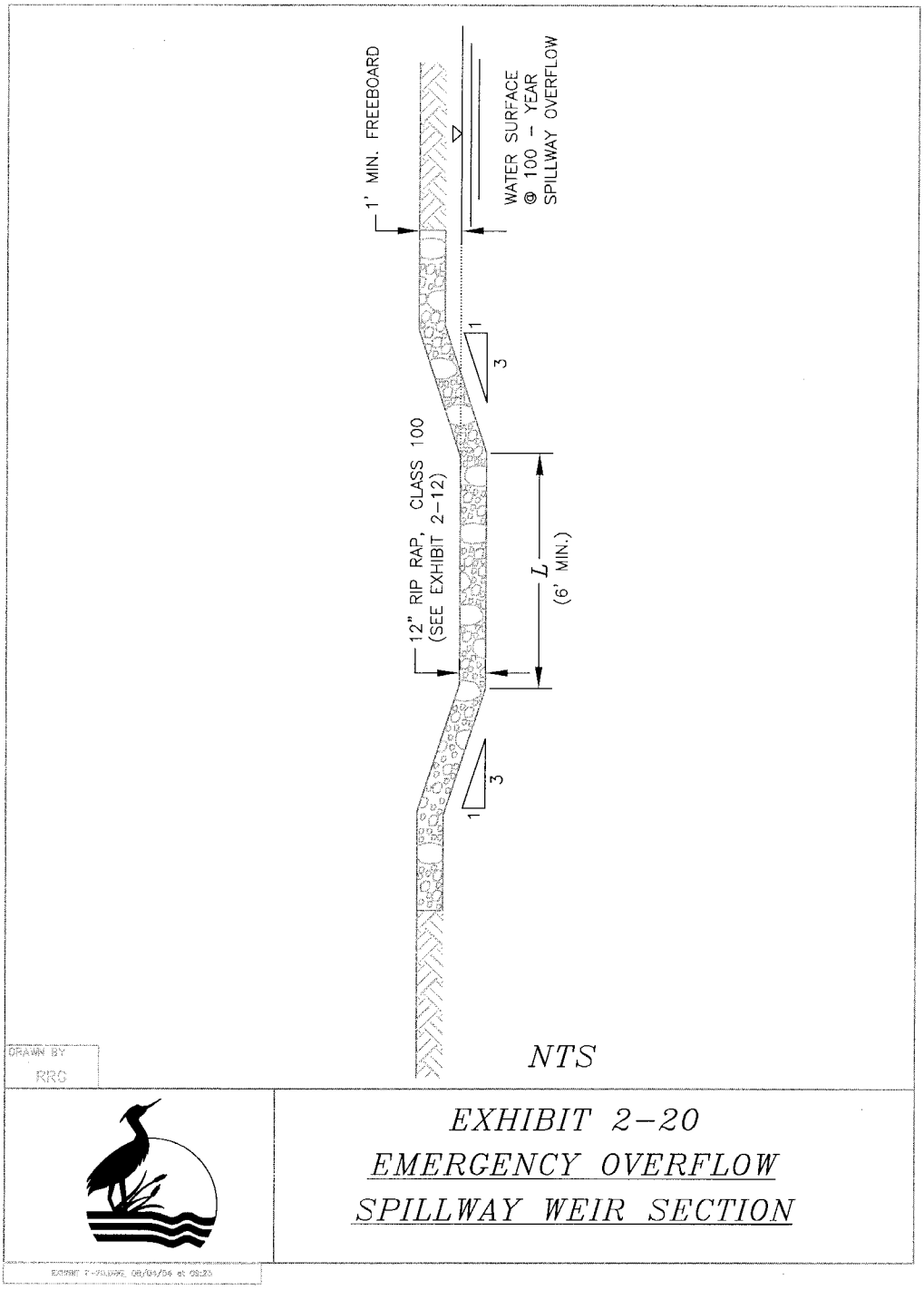
# Wet, Extended Wet, & Dry Detention Pond

## EXHIBIT 2-18



# Wet, Extended Wet, & Dry Detention Pond




1' MIN. FREEBOARD
WATER SURFACE
@ 100 - YEAR
SPILLWAY OVERFLOW
1
3
12" RIP RAP, CLASS 100
(SEE EXHIBIT 2-12)
L
(6' MIN.)
1
3
NTS
DRAWN BY
RRC
EXHIBIT 2-20
EMERGENCY OVERFLOW
SPILLWAY WEIR SECTION

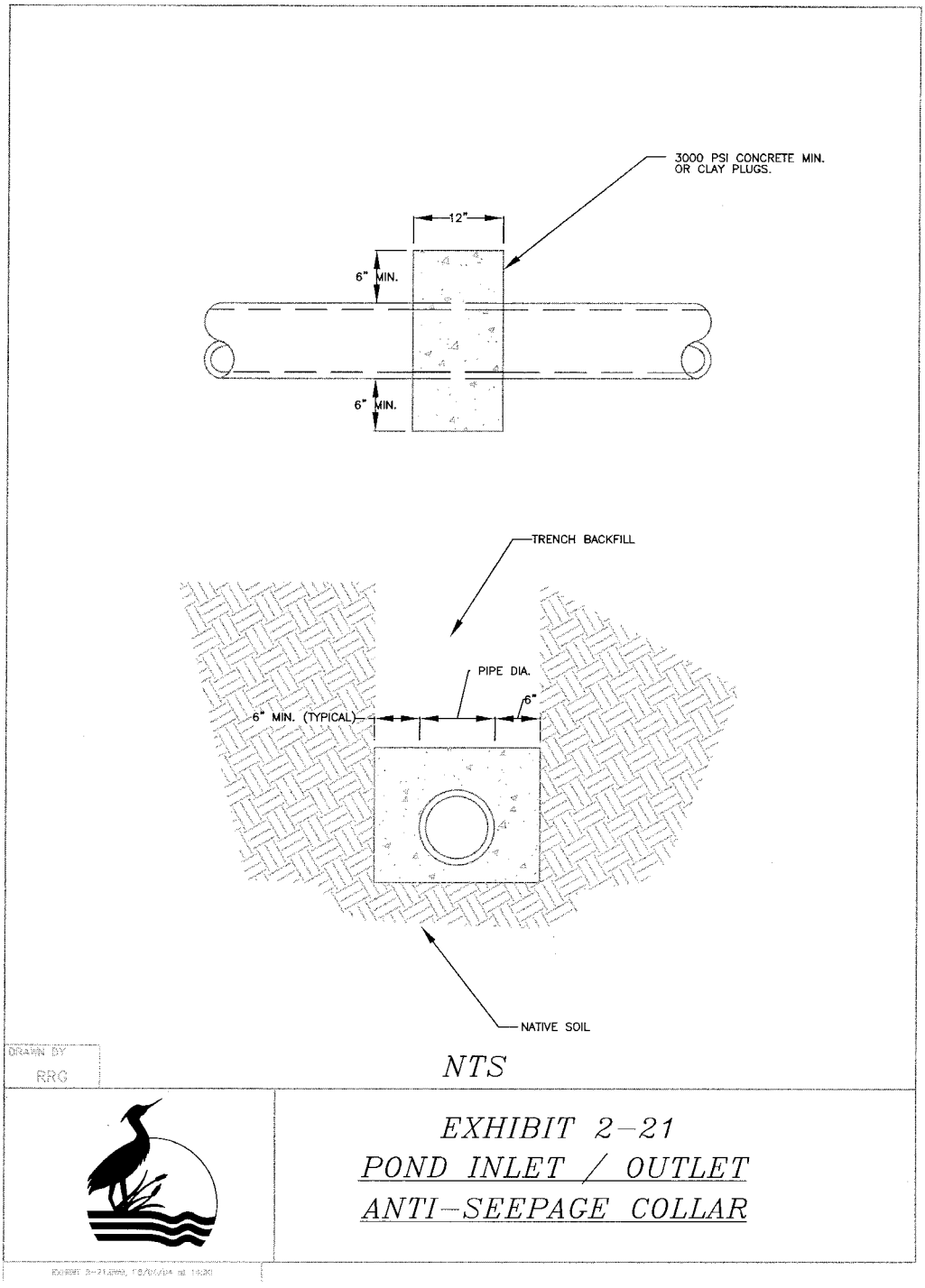
# Wet, Extended Wet, & Dry Detention Pond

**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 will be 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. (Note: A key in a berm is an excavated trench below the berm filled with soil material used to make the berm. It acts to "key" the berm into the native soil to prevent 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 impounding water greater than 8 feet in depth **(**see **Exhibit 2-21).**
- During construction, exposed earth on the pond side slopes shall be sodden 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 (i.e. steepest) slope of 3H: 1V on the upstream and downstream face. Side slopes **within** the pond shall be sloped no steeper than 3H: 1V. The use of retaining walls in ponds requires pre-approval from BES. Retaining walls shall not exceed one-third of the circumference of the pond. Detailed structural design calculations must be submitted with every retaining wall proposal.
- Pond berm embankments 6 feet or less in height including freeboard, measured through the center of the berm, shall have a minimum top width of 6 feet, or as recommended by a geotechnical engineer.
- Where maintenance access is provided along the top of berm, the minimum width of the top of berm shall be at least 15 feet.

**For public ponds, the following additional design criteria shall apply:**

- Two staff gauges shall be installed at opposite ends of the bottom of the pond, to enable maintenance staff to measure the depth of accumulated silts.


3000 PSI CONCRETE MIN.
OR CLAY PLUGS.
12"
6" MIN.
6" MIN.
TRENCH BACKFILL
PIPE DIA.
6"
6" MIN. (TYPICAL)
NATIVE SOIL
DRAWN BY
RRG
NTS
EXHIBIT 2-21
POND INLET / OUTLET
ANTI-SEEPAGE COLLAR

# Wet, Extended Wet, & Dry Detention Pond

**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. Generally, a pond with gently sloping sides (less than 3:1) and including a 10-foot-wide safety bench around the facility at the point of slope transition does not require a fence. Applicants can request BES approval to use fencing if there are safety concerns.

For City-maintained facilities where fencing is not required, the applicant must have BES approval to use fencing. Approval will be granted only if there is no practical alternative. If fencing is required or approved, the design shall address screening requirements.

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 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 designed to City of Portland *Standard Construction Specifications*.

# Wet, Extended Wet, & Dry Detention Pond

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

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

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

**EXAMPLE**

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

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

Permanent Pool Volume = 2 * (2,276 * 12) = 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 1.6.2**, a control structure designed in accordance with **Section 2.5** 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 (see **Section 2.5: Control Structures**).

# Wet, Extended Wet, & Dry Detention Pond

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

Facility area is equivalent to the area of the pond, including bottom and side slopes, plus a 10-foot buffer around the pond. Minimum plant material quantities per **250** square feet of the facility area are as follows:

**1** - Evergreen or deciduous tree:

| | |
|---|---|
| Evergreen trees: | Minimum height: 6 feet |
| Deciduous trees: | Minimum caliper: 1 ½ inches at 6 inches above base. |

**4** - Large shrubs/small trees 3-gallon containers or equivalent.

**6** - Shrubs/large grass-like plants 1-gallon containers or equivalent

| | |
|---|---|
| Ground cover plants: | 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants. |
| Wetland plants: | 1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area. |

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to 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 will require BES approval.

# Wet, Extended Wet, & Dry Detention Pond

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

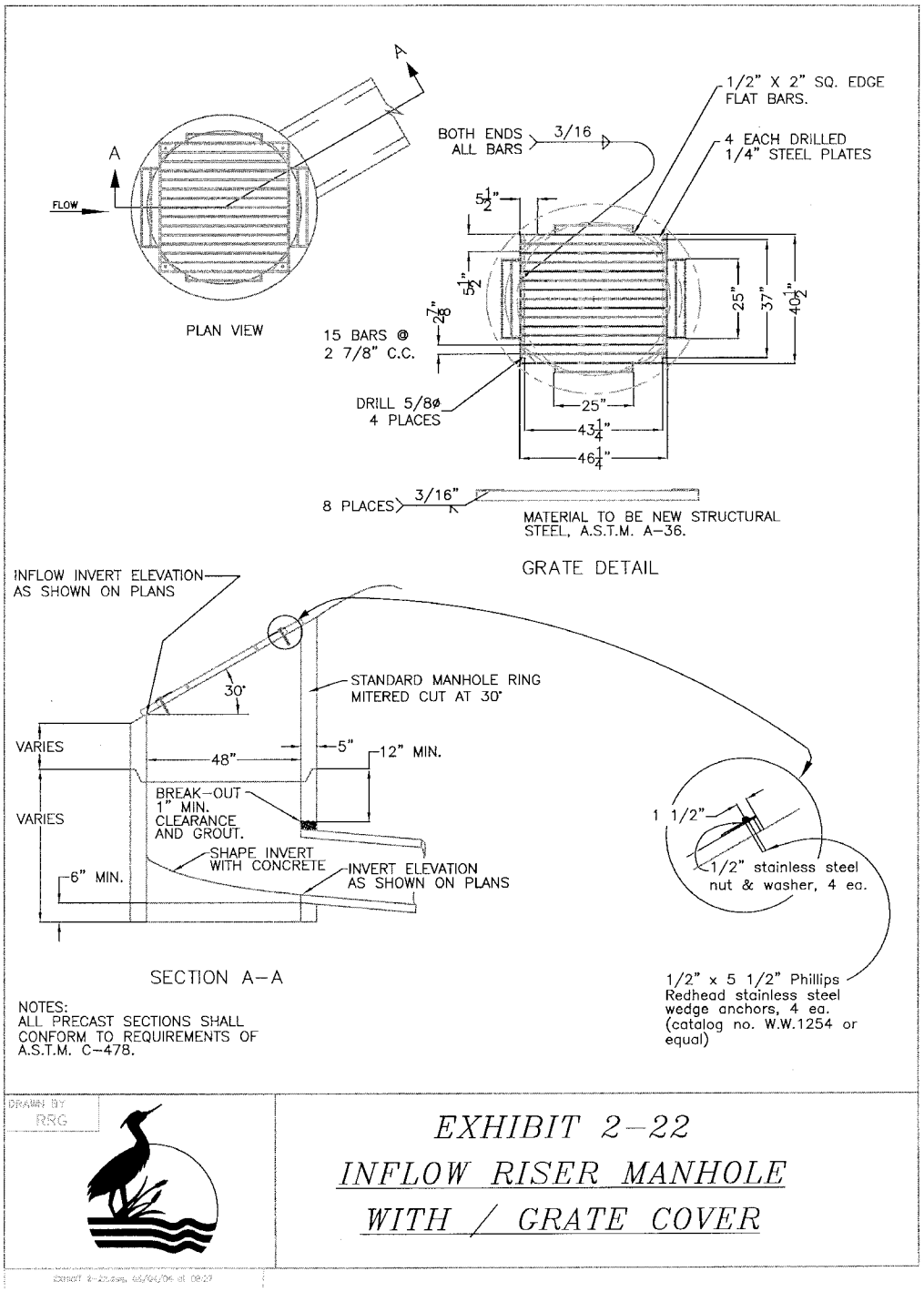
| Facility Component | Inspection Requirement |
|---|---|
| Pond grading | Call for inspection |
| Piping | Call for inspection |
| Control (orifice) structure for extended wet detention and dry detention ponds | Call for inspection |
| Filter fabric or lining (if applicable) | |
| Growing medium | |
| Plantings | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to wet, extended wet detention, & dry detention pond O&M form**

**Additional photos and drawings:**

*** Link to wet and extended wet detention pond photos**
*** Link to wet and extended wet detention pond drawings**
*** Link to dry detention pond photos**
*** Link to dry detention pond drawings**


A
A
FLOW
PLAN VIEW
1/2" X 2" SQ. EDGE FLAT BARS.
BOTH ENDS ALL BARS
3/16
4 EACH DRILLED 1/4" STEEL PLATES
5 1/2"
5 1/2"
7/8"
25"
37"
40 1/2"
15 BARS @ 2 7/8" C.C.
DRILL 5/8ø 4 PLACES
25"
43 1/4"
46 1/4"
8 PLACES
3/16"
MATERIAL TO BE NEW STRUCTURAL STEEL, A.S.T.M. A-36.
GRATE DETAIL
INFLOW INVERT ELEVATION AS SHOWN ON PLANS
30°
STANDARD MANHOLE RING MITERED CUT AT 30°
VARIES
48"
5"
12" MIN.
VARIES
BREAK-OUT 1" MIN. CLEARANCE AND GROUT.
SHAPE INVERT WITH CONCRETE
INVERT ELEVATION AS SHOWN ON PLANS
6" MIN.
SECTION A-A
NOTES:
ALL PRECAST SECTIONS SHALL CONFORM TO REQUIREMENTS OF A.S.T.M. C-478.
1 1/2"
1/2" stainless steel nut & washer, 4 ea.
1/2" x 5 1/2" Phillips Redhead stainless steel wedge anchors, 4 ea. (catalog no. W.W.1254 or equal)
DRAWN BY
RRG
EXHIBIT 2-22
INFLOW RISER MANHOLE
WITH / GRATE COVER

# Constructed Treatment Wetland

| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction…….. | PRES |
| √ Flow Control……..…… | PRES |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Wetlands can be used to manage stormwater from any type of impervious surface.

# Constructed Treatment Wetland


**Description:** A wetland is an area inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Jurisdictional wetlands include swamps, marshes, bogs, and similar areas except those constructed as pollution reduction or flow control facilities. The Corps of Engineers and Division of State Lands make specific wetland designations. Constructed treatment wetlands are wetlands designed and constructed for the specific purpose of providing stormwater management. Unlike natural wetlands, constructed treatment wetlands are not regulated by the Corps of Engineers and the Division of State Lands.

Wetlands remove pollutants through several treatment processes, including sedimentation, filtration, and biological uptake. When enough volume is provided, constructed treatment wetlands can also provide a significant level of flow control.

**Design Criteria:** To receive pollution reduction credit, the wet portion or permanent pool of the wetland shall be equal to that required for wet ponds, or the residence time of the stormwater volume (calculated as the pollution reduction design storm volume divided by the average facility outflow rate) shall be no less than 36 hours. A design team with experience in hydrology, wetland plants, and engineering will be needed to develop a successful wetland pollution reduction facility. A water budget analysis shall be performed with the design of the facility.

**Sizing:** Drainage area to be served shall be no less than 10 acres. To meet pollution reduction requirements, dead storage within the wetland must equal or exceed wet pond dead storage criteria. To meet flow control requirements, a detailed hydraulic analysis must be performed by a Professional Engineer,

showing compliance with flow control standards presented in **Section 1.6.2**. For stormwater report requirements, see **Exhibit 2-2**.

**Geometry:** The configuration of a constructed wetland shall be tailored to each site, rather than limited to one design. Major elements of a wetland can include channels or trenches, shallow marshes, and deeper ponded areas. These elements shall be combined to take advantage of the site topography. Maximum slopes within the wetland area shall be 20%, and maximum slopes of surrounding land shall not exceed 10%. All wetland design shall address habitat, planting, and aesthetic issues.

1) The volume of water to be treated shall be allocated over the treatment area of the facility as follows:

| Component | Percent of Design Volume (approx.) | Percent of Facility Surface Area (approx.) |
|---|---|---|
| Forebay | 10 | 5 |
| Micropool | 10 | 5 |
| Deep water (> 18″) | 50 | 40 |
| Deep wetland (6″-18″) | 20 | 25 |
| Shallow wetland (<6″) | 10 | 25 |

**Definitions:**

Forebay: A relatively deep zone placed where influent water discharges to a stormwater wetland. It traps coarse sediments, reduces incoming velocity, and helps distribute runoff evenly over the wetland.

Micropool: A deep (4 to 6 feet) pool placed at the outlet of a stormwater wetland forebay.

Deep-water: The area within a stormwater wetland that has a water depth greater than 18 inches.

Deep wetland: The area within a stormwater wetland that has a water depth between 6 and 18 inches.

Shallow wetland: The area within a stormwater wetland that has a water depth less than 6 inches.

2) The minimum length-to-width ratio shall be 3:1, unless otherwise approved by the City. 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.

3) Where wetland vegetation is to be planted, side slopes shall be no steeper than 5:1. Wetland plant selection shall be consistent with anticipated hydrology.

4) Access routes to the wetland for maintenance purposes must be shown on the plans. Public wetlands will need to provide a minimum 8-foot wide access route, not to exceed 10 percent in slope.

**Flow:**

1) Flow velocity through the wetland shall average less than 0.01 feet per second for the water quality design storm event (see **Section 1.5.2**). If natural slope does not allow for this velocity, berms shall be used to create ponded benches.

2) Flow through the wetland shall be distributed as uniformly as possible across the marsh and ponded section.

**Forebay:**

1) The forebay area shall be established along the wetland inflow points to capture sediment. The forebay shall have a water depth of about 3 feet and have at least 10 percent and up to 25 percent of the total treatment wetland volume.

An overflow mechanism to an approved conveyance/ destination method per **Section 1.4** will be required.

**Soil Suitability:** Constructed treatment wetlands are appropriate for NRCS type C and D soils. Topsoil shall be used within the top 12 inches of the facility, or the soil shall be amended per **Appendix F** to support plant growth.

**Setbacks:** Required setback from property lines is 5 feet, and 10 feet from building foundations. Infiltration basins shall meet the following setback requirements from downstream slopes: minimum of 100 feet from slopes of 10%; add 5 feet of setback for each additional percent of slope up to 30%; 200-foot

setback for slopes of 30%; infiltration trenches shall not be used where slopes exceed 30%.

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

Facility area is equivalent to the area of the wetland, including bottom and side slopes, plus a 10-foot buffer around the wetland. Minimum plant material quantities per **200** square feet of the facility area are as follows:

**1** - Evergreen or deciduous tree:
- Evergreen trees: Minimum height: 6 feet
- Deciduous trees: Minimum caliper: 1 ½ inches at 6 inches above base.

**4** - Large shrubs/small trees: 3-gallon containers or equivalent.

**6** - Shrubs/large grass-like plants: 1-gallon containers or equivalent

Ground cover plants: 1 per 12 inches on center, triangular spacing, for the ground cover planting area only, unless seed or sod is specified. Minimum container: 4-inch pot. At least 50 percent of the facility shall be planted with grasses or grass-like plants.

Wetland plants: 1 per 2 square feet of a pond emergent plant zone. The emergent plant zone shall be at least 25 percent of the total pond water surface area.

Wildflowers, native grasses, and ground covers used for BES-maintained facilities shall be designed not to 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 will require BES approval.

***Link to Recommended Plants**

# Constructed Treatment Wetland

**For public constructed treatment wetlands, the following additional design criteria shall apply:**

1) Two staff gauges shall be installed at opposite ends of the bottom of the wetland, to enable maintenance staff to measure the depth of accumulated silts.

2) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional geotechnical engineer, shall inspect the soil after the system is excavated to confirm that soils remain in suitable condition for planting.

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Growing medium specification
4) Filter fabric specification (if applicable)
5) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection
6) Landscaping plan

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Wetland grading | Call for inspection |
| Piping | Call for inspection |
| Filter fabric (if applicable) | |
| Growing medium | |
| Plantings | Call for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to constructed treatment wetland O&M form**

**Additional photos:**

*** Link to constructed treatment wetland photos**

# Manufactured Treatment Technology

| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction | PERF |
| Flow Control | NA |
| Destination/ Disposal | NA |

These facilities may or may not be classified as Underground Injection Control structures (UICs), depending on specific manufacturer design.

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** For a list of currently accepted manufactured stormwater treatment technologies, call BES at 503-823-7761. Manufactured stormwater treatment technologies can be used to provide pollution reduction for any impervious surface. They can be located on private property, and some are approved for use in public right-of-ways.

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

To be approved for use as a public facility (see **Section 1.10**: Public vs. Private Stormwater Management), the manufacturer must also submit detailed information about the facility's design criteria, construction techniques, operation and maintenance procedures, reliability, and cost. This information will be reviewed by BES's Standards and Practices Committee, which will decide whether or not the facility can be used for public projects.

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

In addition to design calculations shown in **Exhibit 2-2**, the following must be submitted with each manufactured stormwater treatment technology project:

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

# Manufactured Treatment Technology

An operations and maintenance manual must also be submitted for BES review. See **Chapter 3.0** for O&M plan guidance.

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. Rather, a pollution reduction facility that is presumed by BES to meet the TMDL requirement must be used.

For a list of currently approved manufactured stormwater treatment technologies, contact BES at (503) 823-7761.

**Checklist of minimal information to be shown on the permit drawings:**

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

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

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Vault excavation | |
| Piping | Call for inspection |
| Vault installation | Cal for inspection |

**Operations and Maintenance requirements**: An operations and maintenance plan will be required, including information from the manufacturer, as per **Chapter 3.0**.

# Structural Detention Facility

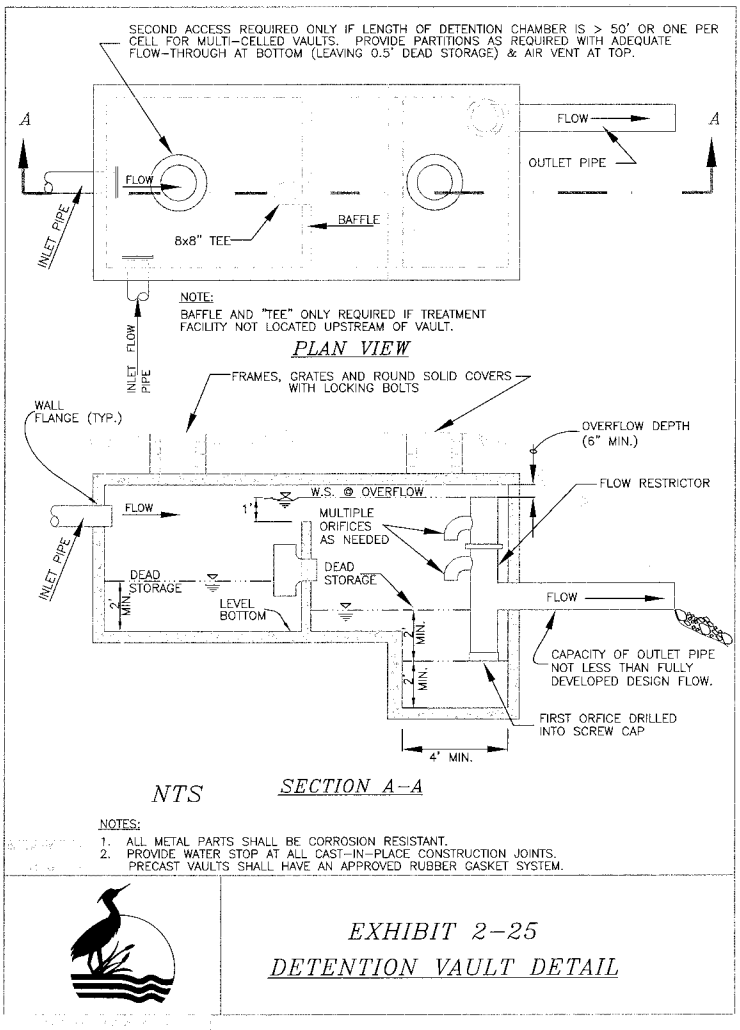



*EXHIBIT 2-25*
*DETENTION VAULT DETAIL*

| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| Pollution Reduction…….. | NA |
| √ Flow Control…….. | PRES |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** See **Exhibit 2-2** for hydrologic and hydraulic calculations that must be submitted with structural detention design. Structural detention facilities may be used to provide flow control for any impervious surface type, and may be located on private property or within the public right-of-way.

# Structural Detention 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 2.3**) to meet applicable flow control requirements. Additional facilities will be required to meet applicable pollution reduction requirements.

Tanks and vaults typically do not have a built-in design feature for containing sediment, as do multi-cell ponds. When tanks or vaults are used for detention storage, therefore, either a 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. 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.

Tanks and vaults can be used in conjunction with other detention storage facilities, such as ponds or parking lot ponds, to provide initial or supplemental storage.

Because of minimum orifice size specifications, structural flow control facilities (such as detention tanks, vaults, and oversized pipes) for projects with less than 15,000 square feet of impervious surface are not effective and will not be required. Projects with less than 15,000 square feet of impervious surface are required to use surface retention facilities to control flows. Where this is not possible, the applicant must pay the off-site management fee (See **Section 1.11**).

**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 3.0**: Operation and Maintenance)

# Structural Detention Facility

- All tanks and vaults shall be designed as flow-through systems, unless separate sediment containment is provided.
- 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 BES's Sewer 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 **Exhibits 2-23 and 2-25).**
- Detention tanks and vaults shall have a minimum of ½ foot of dead storage, unless upstream sedimentation is provided (see **Exhibits 2-23 and 2-25**).

**Flow Control:**

- To restrict flow rates exiting the pond to those required by **Section 1.6.2**, a control structure per **Section 2.5** must be used.

**Materials and Structural Stability:**

- For public facilities, pipe materials and joints shall conform to the City of Portland *Sewer 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.

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures

2) Profile view of facility, including typical cross-sections with dimensions
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

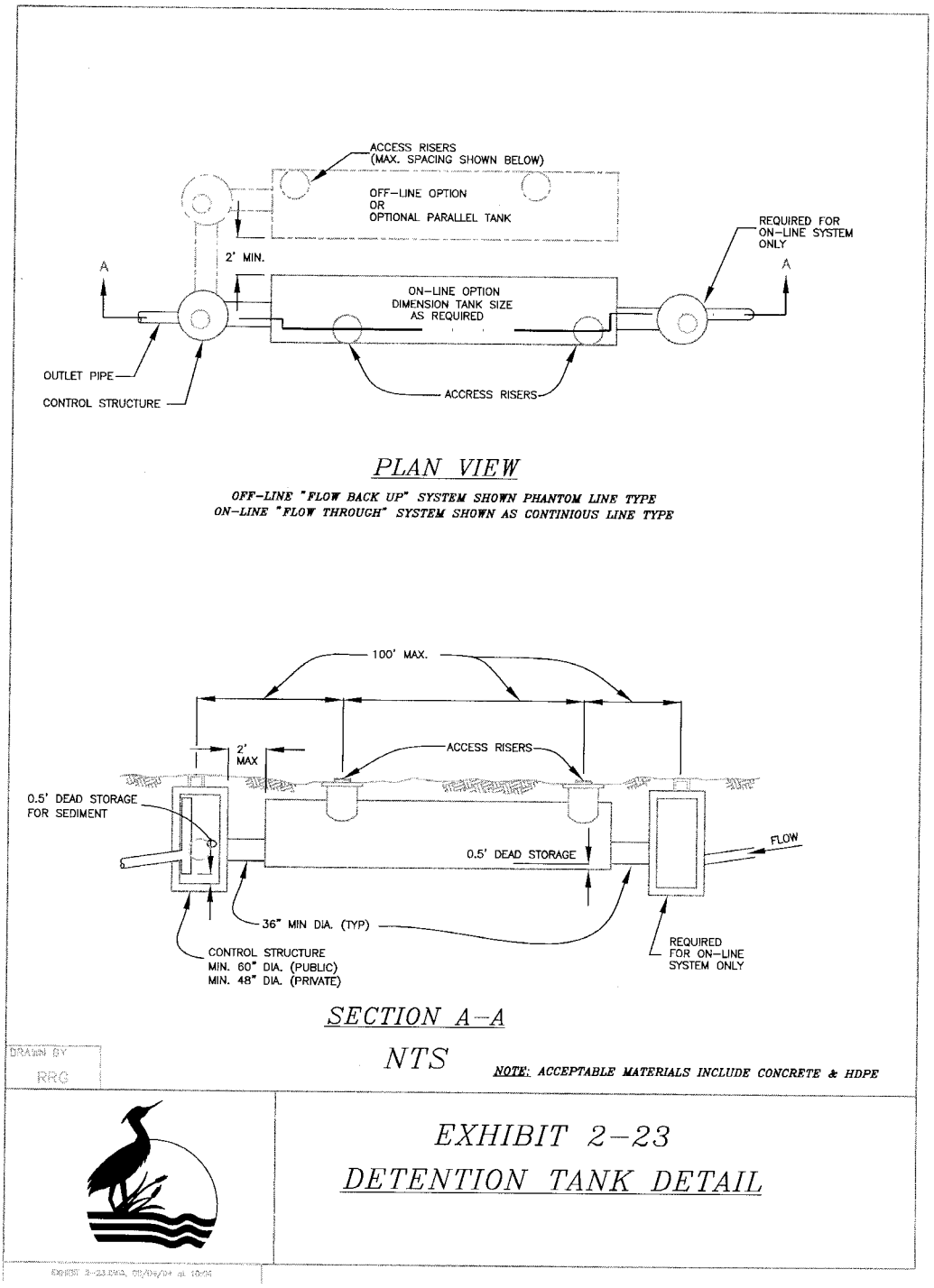
| Facility Component | Inspection Requirement |
|---|---|
| Vault excavation | |
| Piping | Call for inspection |
| Vault installation | Call for inspection |
| Control structure (orifice structure) | Call for inspection |

**OPERATIONS AND MAINTENANCE REQUIREMENTS: See Chapter 3.0.**

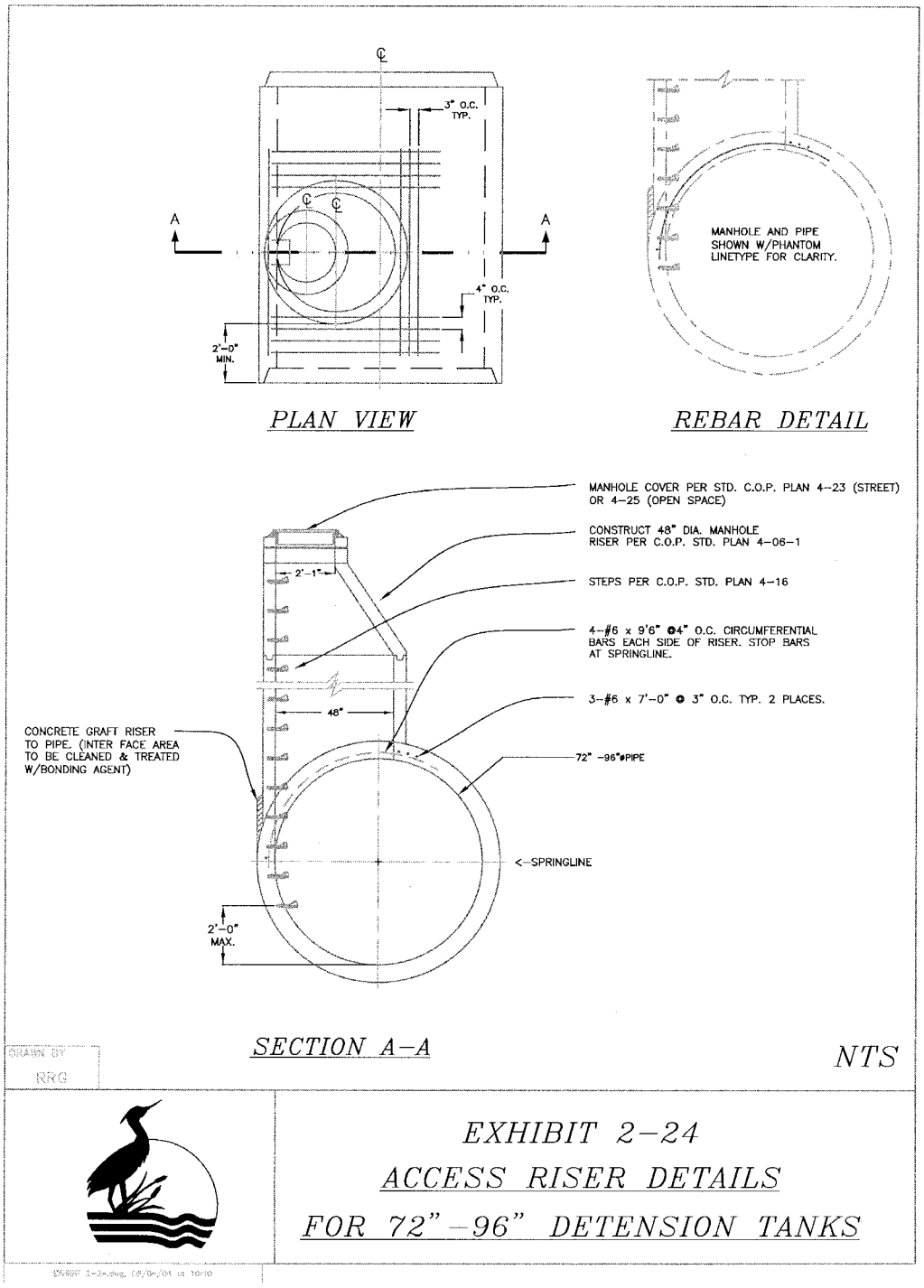
*** Link to tank, vault, and oversized pipe O&M form**

**STORMWATER REPORT REQUIREMENTS**: See **Exhibit 2-2**.

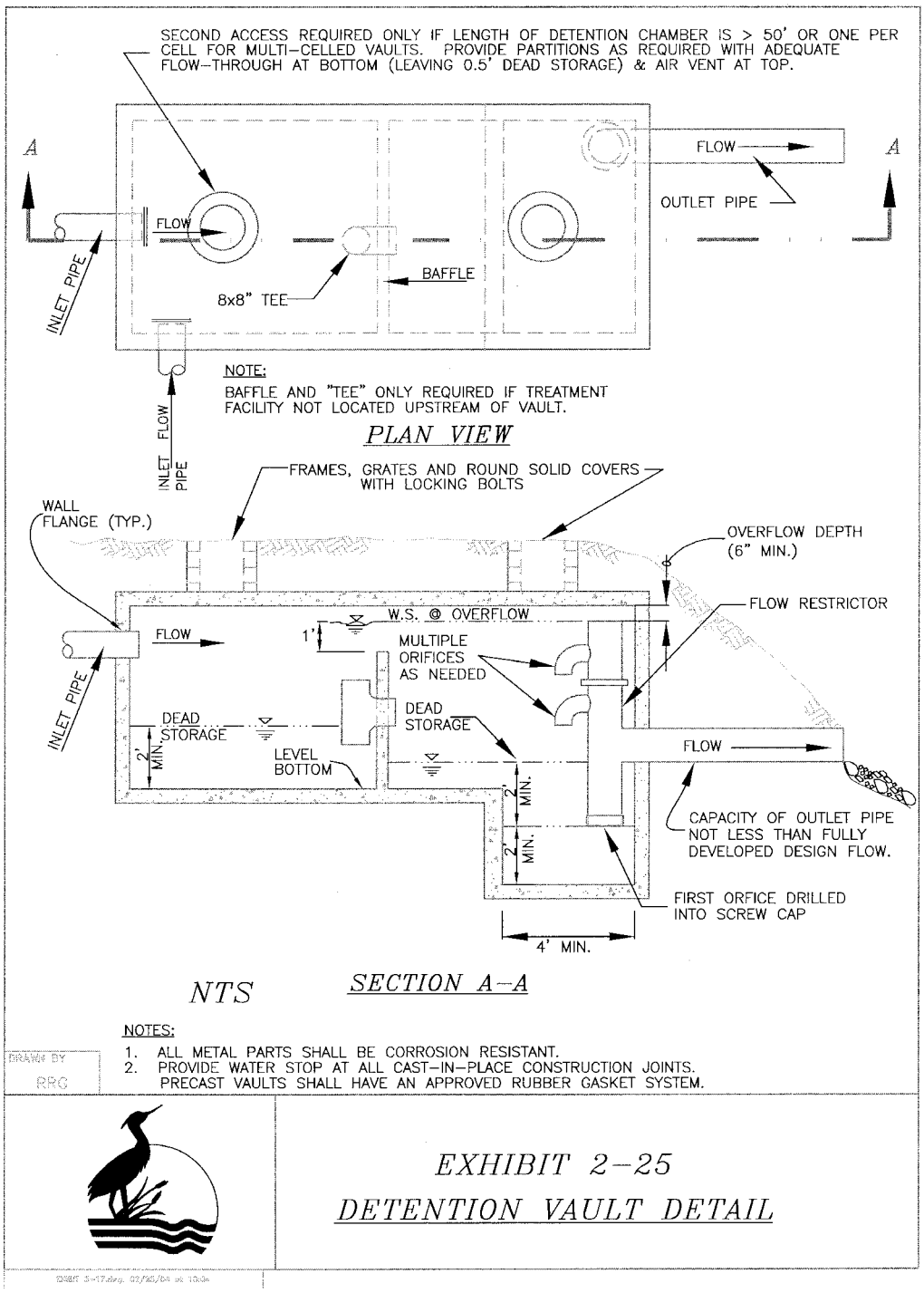
# Structural Detention Facility



# Structural Detention Facility

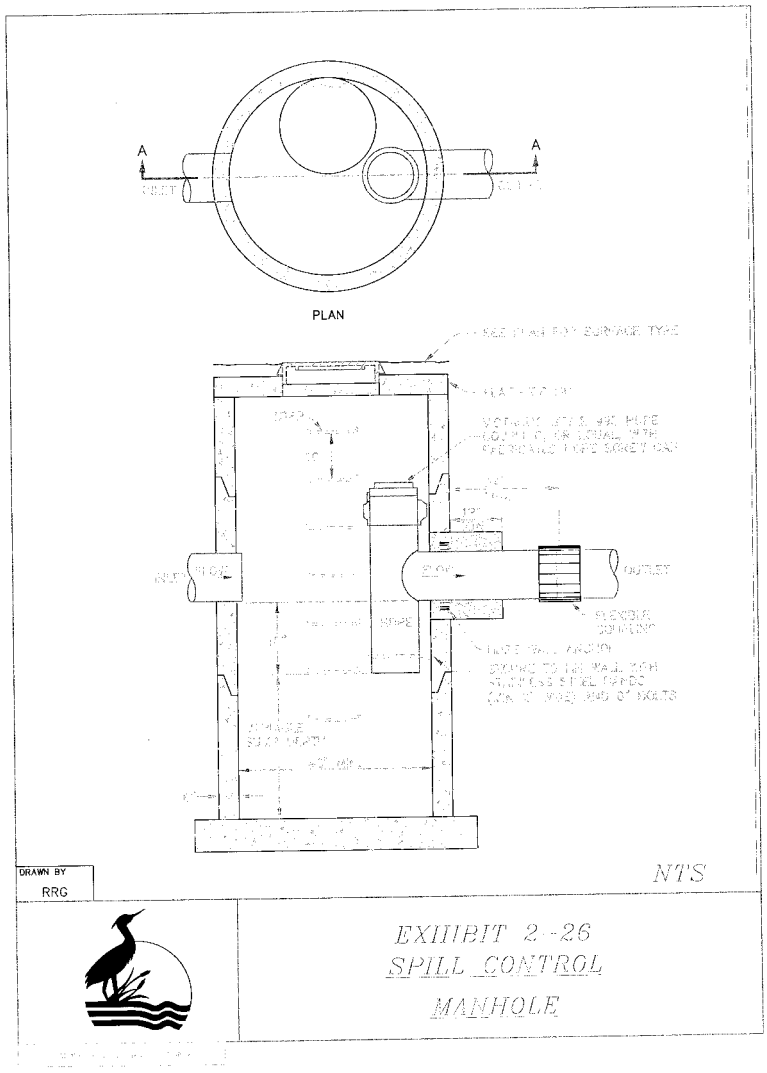


# Structural Detention Facility



# Structural Detention Facility

# Spill Control Manhole




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction[1] (Oil Only)…….. | PRES[1] |
| Flow Control…….…… | NA |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Spill control manholes receive credit for oil removal only. They may be used to remove oil from parking lots and other vehicular access areas.

# Spill Control Manhole

**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 "T" outlet designed to trap small spills. Spill control manholes will not be given credit for basic pollution reduction requirements. They must be used in conjunction with other pollution reduction systems from this chapter to meet oil control and pollution reduction requirements.

**Other Options:** There may be other acceptable oil controls not listed above. Applicants may propose an alternative oil control option under the performance approach. However, proposal of a new oil control will require an additional review process for approval, which may delay issuance of related building permits.

**Design and Sizing Criteria:**

- Spill control manholes shall be used in conjunction with an appropriately sized vegetated pollution reduction facility from this chapter to achieve 10 ppm oil effluent from the peak flow generated by the pollution reduction design storm intensity of 0.19 inches per hour. The spill control sump volume shall be 60 cubic feet *or* 20 cubic feet of sump capacity for each cubic feet per second (cfs) of peak pollution reduction design flow, whichever is greater. This treatment train configuration, when sized per the above requirements, will be presumed to meet the 10 ppm effluent design standard.

- To maintain efficiencies and reduce size, all roof drainage shall enter the stormwater system downstream of the spill control manhole, unless sized accordingly.

- Any pumping devices shall be installed downstream of the spill control manhole to prevent oil emulsification in stormwater.

- Engineered calculations are required, using the Rational Method (Q=C*I*A).

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility dimensions and setbacks from property lines and structures.

# Spill Control Manhole

2) Profile view of facility, including typical cross-section details with dimensions. These details shall match manufacturer specifications and details.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

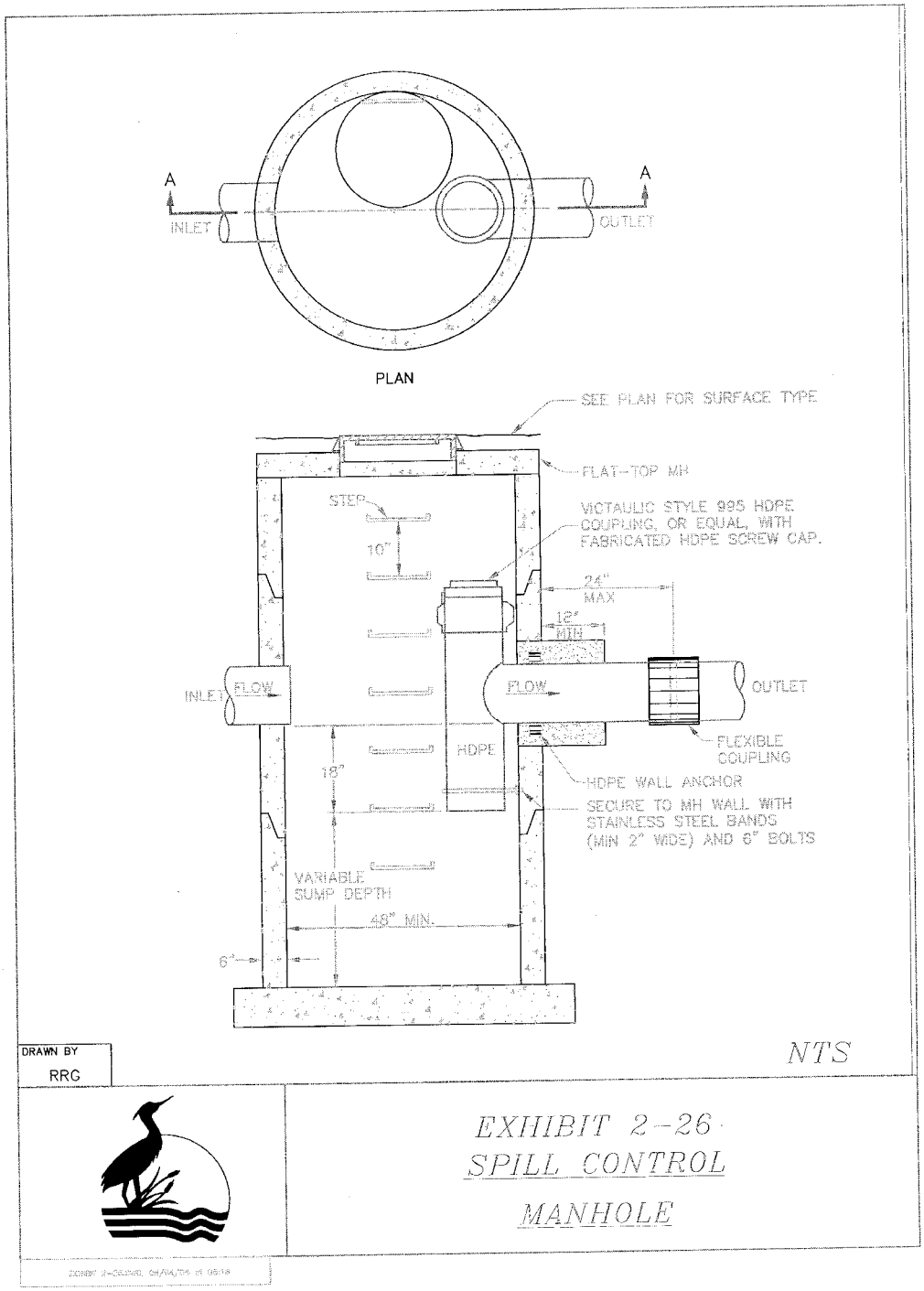
| Facility Component | Inspection Requirement |
|---|---|
| Manhole excavation | |
| Piping | Call for inspection |
| Manhole installation | Cal for inspection |

**OPERATIONS AND MAINTENANCE REQUIREMENTS: See Chapter 3.0.**

*** Link to Spill Control Manhole O&M form**

**STORMWATER REPORT REQUIREMENTS**: See **Exhibit 2-2**.

# Spill Control Manhole



# Rainwater Harvesting


| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction…….. | PERF[1] |
| √ Flow Control……..…… | PERF[1] |
| Destination/ Disposal…… | NA |

This facility is **not** classified as an Underground Injection Control structure (UIC).

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** The required water storage volume is a function of drainage area, rate of water usage, and stormwater management goal. Rainwater harvesting systems may be used to manage stormwater from rooftops and depending on the water use, other impervious surfaces, and must be located on private property.

# Rainwater Harvesting

**Description:** Stormwater may 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 and at hose bibs. Reducing the water used from the City water system can reduce a site's water bill. BDS plumbing approval must be obtained with any such system. Reference the BDS website for more information on re-use guidelines:

**http://www.bds.ci.portland.or.us/pubs/CodeGuides/Upc/RES34 1.pdf**

Rainwater harvesting can provide several stormwater management benefits:

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

- Pollution reduction: As a result of the significant reduction in off-site flow volume that can be achieved, a significant reduction in the discharge of pollutants associated with stormwater can also be accomplished. Where it isn't feasible to meet a development site's full pollution reduction obligation, rainwater harvesting can be used to manage a portion of the flow and lessen the overall pollution reduction requirement.

**Checklist of minimal information to be shown on the permit drawings, or included with the permit submittal package:**

1) Water storage facility details and specifications
2) Pump and associated electrical details and specifications
3) Piping size, material, and placement details and specifications
4) Average daily water use documentation
5) Hydraulic calculations demonstrating compliance with stormwater management requirements (pollution and flow control)
6) Approximate setbacks from property lines and structures shall be shown
7) Overflow connection to approved stormwater destination per **Section 1.4**

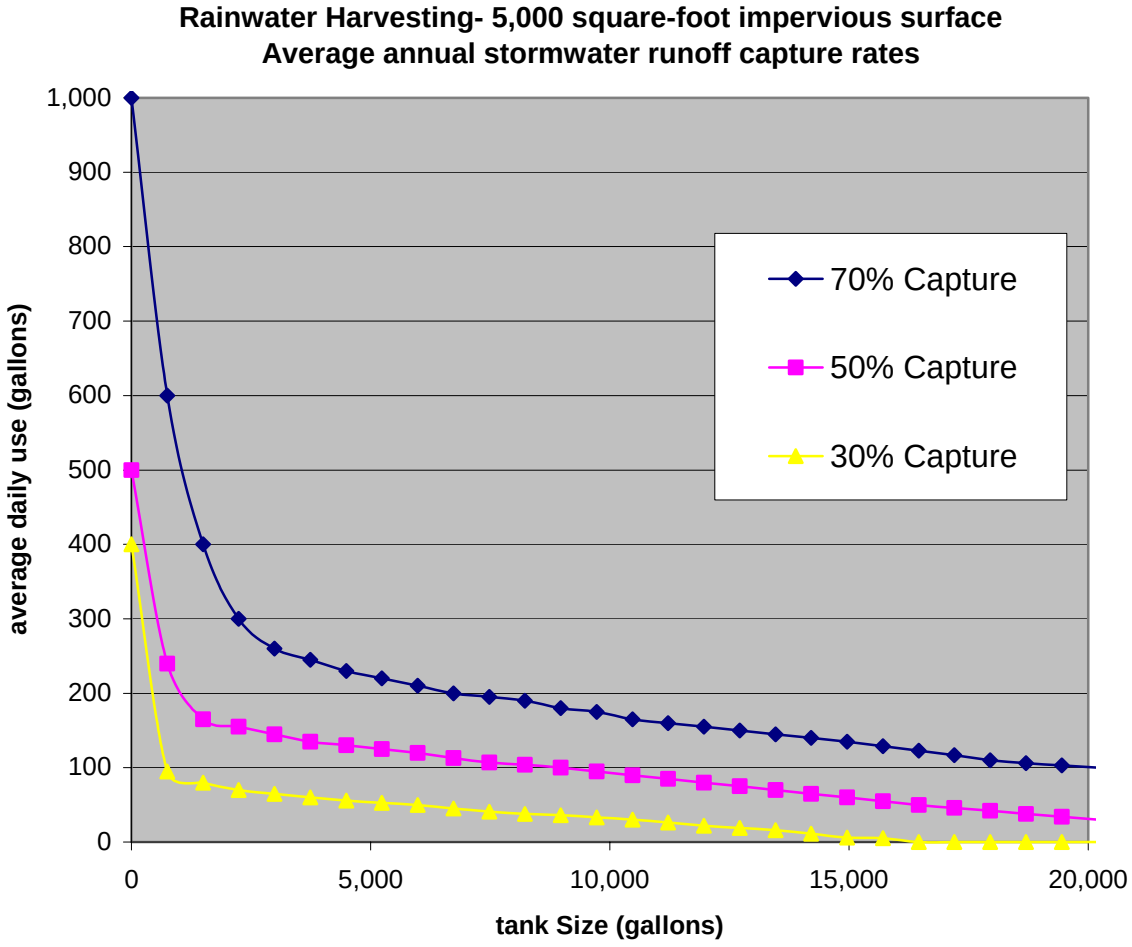
**Operations and Maintenance requirements**: See **Chapter 3.0**.

# Rainwater Harvesting

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

For example, if the stormwater management goal is 50% reduction of the annual release volume, the pink line is used to show that if a 2,000-gallon tank were used, the average daily use would need to be approximately 160 gallons per day. A larger tank would necessitate a smaller average daily use rate to achieve the same stormwater management goal of 50% annual volume reduction.

**Exhibit 2-27:**



# Rainwater Harvesting

# Private Soakage Trench

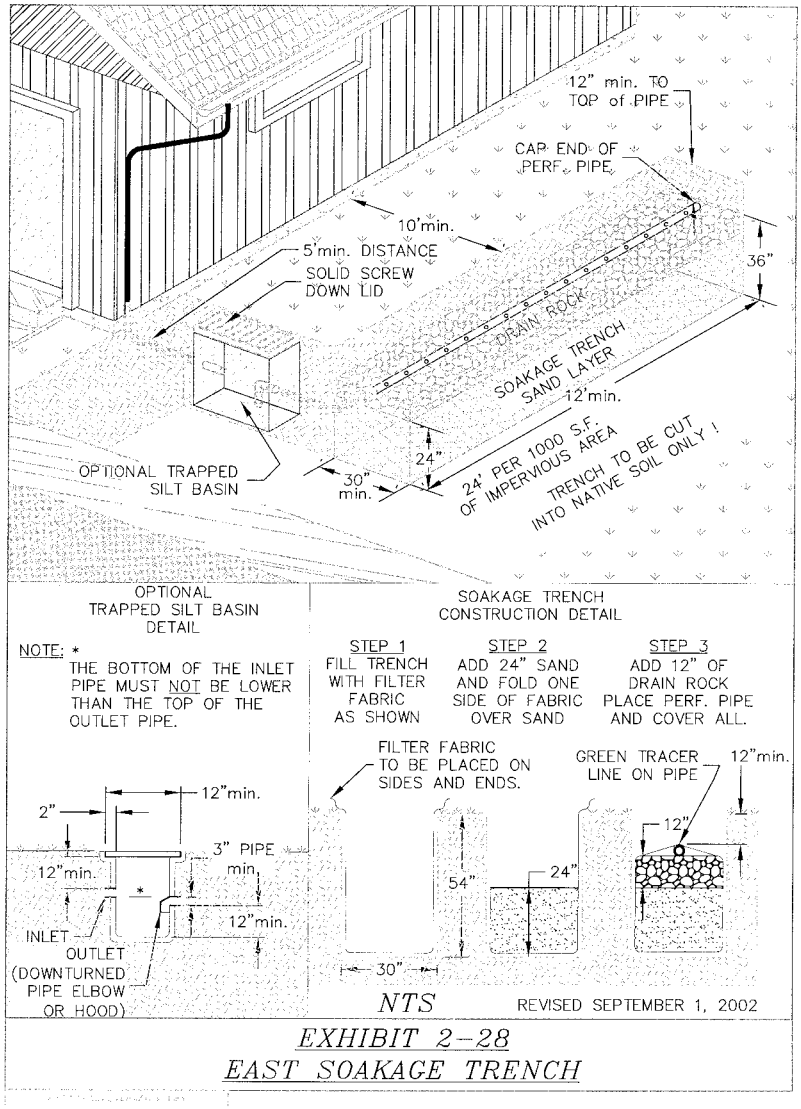



*EXHIBIT 2-28*
*EAST SOAKAGE TRENCH*

| **Stormwater Management Goals Achieved** | **Acceptable Sizing Methodologies** |
|---|---|
| √ Pollution Reduction…….…….. | PRES |
| √ Flow Control…… | PRES |
| √ Destination/ Disposal…… | PRES |

**This facility is classified as an Underground Injection Control structure (UIC).**

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Soakage trenches can be used to manage stormwater runoff from private property.

# Private Soakage Trench

A soakage or "infiltration" trench is a shallow trench in permeable soil that is backfilled with sand and coarse stone and lined with filter fabric. The trench surface may be covered with grating, stone, sand, grass, or plantings.

Private soakage trenches can be used to provide stormwater disposal by collecting and recharging stormwater runoff into the ground. The use of soakage trenches is highly dependent on soil type and height of the groundwater table.

**Note:** DEQ has identified soakage trenches as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of soakage trenches that serve rooftops only. All soakage trenches, with the exception of those that drain residential rooftops only, must be registered with DEQ.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call DEQ- UIC Program at 503-229-5886. For copies of applications or forms, call 503-229-5189.

Soakage trenches are recognized as a stormwater disposal point, and with a sufficient layer of sand or soil for filtration, may be used to meet pollution reduction requirements. **Exhibits 2-28 and 2-29** provide detailed drawings of standard soakage trenches.

Soakage trenches are excluded from use within the Columbia South Shore and Cascade Station/ Portland International Center Plan Districts (see **Exhibit 2-33**).

## Private Soakage Trench Design and Sizing Method

Soil conditions are critical to the success of soakage trenches. Because of this, the use of soakage trenches must be pre-approved by the Environmental Soils section of BDS. Supporting geotechnical evidence and a documented infiltration test may be required to demonstrate that soakage trenches will work in the project area. Soakage trenches shall be sized in accordance with **Exhibits 2-28 and 2-29**, once BDS approval has been given for on-site infiltration.

# Private Soakage Trench

**General Requirements:**

| | |
|---|---|
| Maximum area to be served: | 15,000 square-feet per trench |
| Soils requirements: (NRCS classification) | A or B; C soils may be used if drawdown times are met |
| Maximum ground slopes | 20 percent |
| Soil test requirement | ASTM D 3385-88 or BDS approval |

1) If designed as the only stormwater destination, the soakage trench shall infiltrate the entire design storm without overflow.

2) Soakage trenches shall not be accepted in soils with a tested infiltration rate of less than 2 inches per hour.

3) There shall be no less than 4 feet of undisturbed depth of infiltration medium between the bottom of the facility and any impervious layer (hardpan, solid rock, etc.) or seasonal high groundwater levels.

4) Drawdown time when full shall not exceed 10 hours.

5) Soakage trenches shall meet the following setback requirements for downstream slopes: minimum of 100 feet from slopes of 20%; add 5 feet of setback for each additional percent of slope up to 30%; infiltration trenches shall not be used within 200 feet of where slopes exceed 30%.

6) The bottom of the soakage trench shall be flat, or clay check-dams may be used to prevent water from collecting near the downstream end.

7) Drain medium shall have filter fabric between the medium and native soils or backfill.

8) 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.

9) A soil scientist, or suitably trained person working under the supervision of an Oregon licensed professional engineer, shall inspect the soil after the system is excavated, before trenches are filled with drain medium, to

confirm that soils remain in suitable condition to perform at anticipated infiltration rates.

10) Soakage trenches should be located down slope of structures, and are required to be setback at least 10 feet from buildings, 5 feet from property lines, and 5 feet from public utility lines.

**Checklist of Minimal Information To Be Shown on the Permit Drawings:**

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

1) Facility dimensions and setbacks from property lines and structures
2) Profile view of facility, including typical cross-sections with dimensions
3) Drain rock specification
4) Sand specification
5) Filter fabric specification
6) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection

**Inspection Requirements and Schedule:**

The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Trench grading | Call BDS for inspection |
| Piping | Call BDS for inspection |
| Filter fabric | |
| Sand layer | Call BDS for inspection |
| Drain rock | Call BDS for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to private soakage trench O&M form**

# Private Soakage Trench

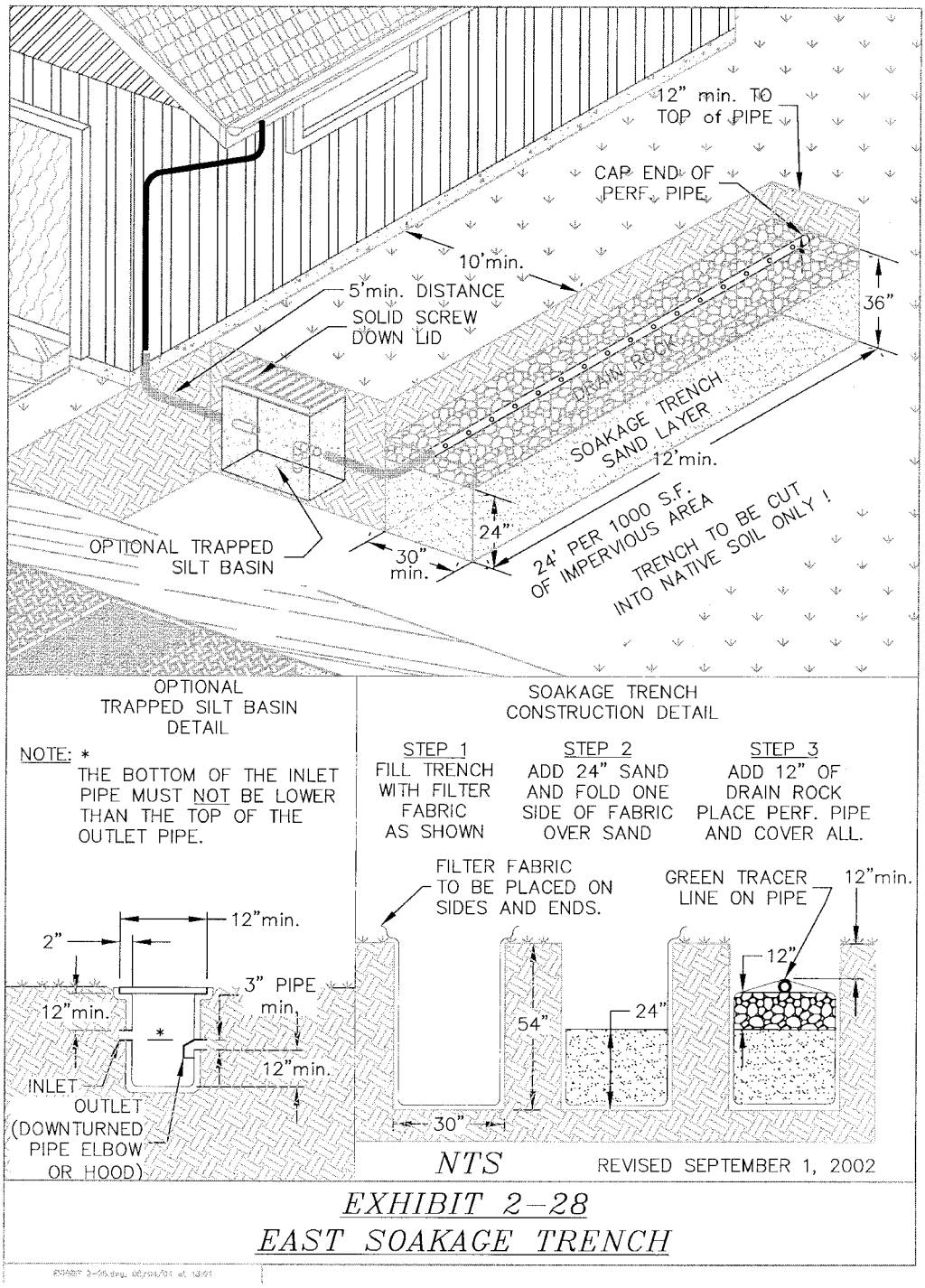



*EXHIBIT 2-28*

*EAST SOAKAGE TRENCH*

# Private Soakage Trench

**East Side Soakage Trench**

Applicable to Areas **East** of the Willamette River

**Soakage Trench Sizing**

For every 1,000 sf of impervious surface, 24 linear feet of 30" wide soakage trench is required, with a minimum 12-foot long trench. Soakage trenches 12 feet long serve a maximum of 500 sf of horizontally projected roof area or other impervious surface.

**Trench**

- Soakage trench and perforated pipe must be installed level and parallel to contour of finish grade.
- Soakage trench shall be located no closer than 10 feet to any building structure and not closer than 5 feet from property line.
- Unless a separate pollution reduction facility is used upstream of the trench, the sand filter portion of soakage trench must be filled with a minimum of 24" medium sand meeting OAR 340-71-295 (3)(e).
- Minimum 12" of ¾" – 2 ½" round or crushed rock to cover sand separated by one layer of filter fabric.
- The pipe shall be laid on top of this gravel and covered with filter fabric.
- At least 12" minimum of backfill shall be placed over the trench.
- All trenches shall be constructed on native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.
- Slope shall not exceed 20% without a stamped and signed geotechnical report addressing slope stability.
- Trench shall not be constructed under current or future impervious surface.

**Sand**

Medium sand meeting OAR 340-71-295 (3)(e) will be required. Sieve analysis of the medium sand is required to be made by a qualified party and a report provided to City of Portland plumbing inspector at the time of inspection. Analysis to comply with ASTM C136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregate and in conjunction and accordance with ASTM C-117, Standard Test Method for Materials Finer than No.200 Sieve in Mineral Aggregates by Washing.

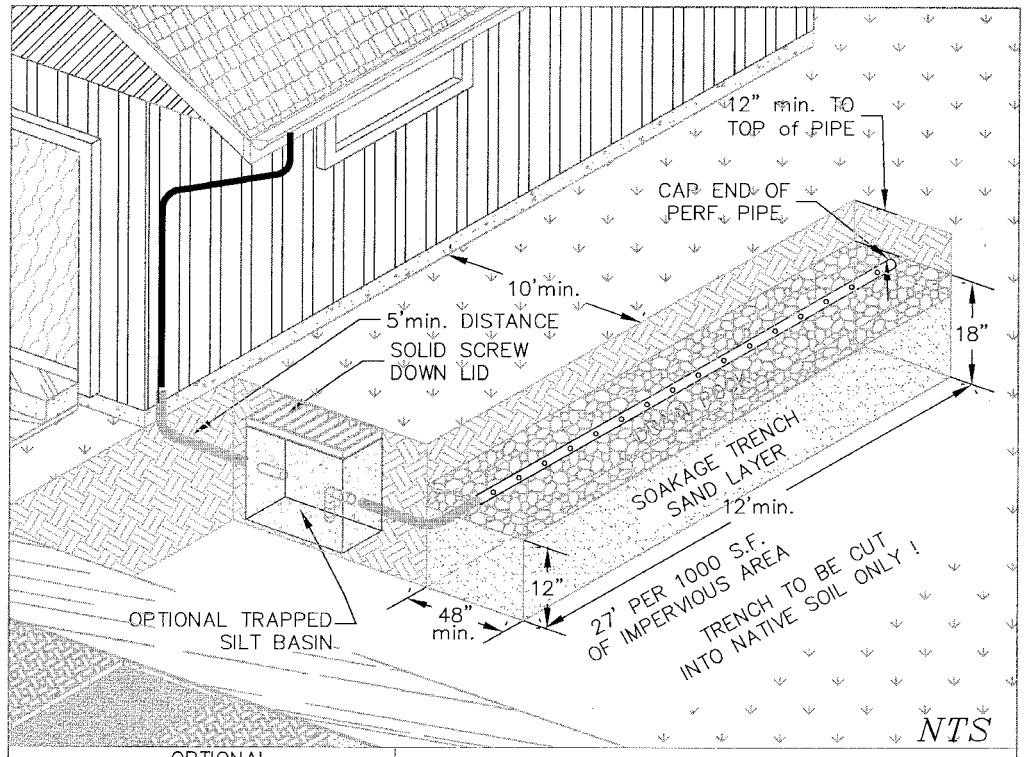
| Sieve # | % Passing |
|---|---|
| 3/8 | 100% |
| #4 | 95-100% |
| #8 | 80-100% |
| #16 | 45-85% |
| #30 | 15-60% |
| #50 | 3-15% |
| #100 | 4% or less |

**Pipe**

- The solid pipe from building or other source to connection with perforated pipe must be installed at a ¼" per foot slope.
- All piping within 10 feet of building must be sch. 40 ABS, sch. 40 PVC, cast iron, sch. 40 ABS, 3" sch. 40 PVC or 3" cast iron pipe may be used for rain drain piping serving not more than 1500 sf of roof or surface area. Use 4" pipe if area is greater than 1500 sf.
- Pipe must have a minimum cover of 12" measured from top of pipe to finished grade.
- The pipe within the trench shall either be PVC D2729 or HDPE Leach field pipe.
- The silt trap shall be installed between the dwelling and the sand filter, a minimum of 5' from the dwelling.

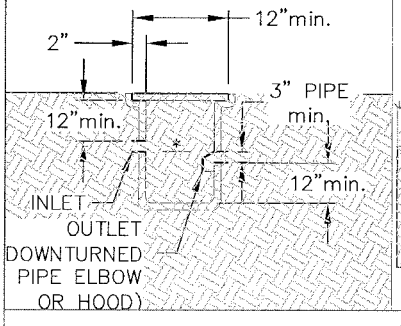
**Filter Fabric** must be one of the following types/brands: LINQ 125EX; LINQ TYPAR3201; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL.

# Private Soakage Trench



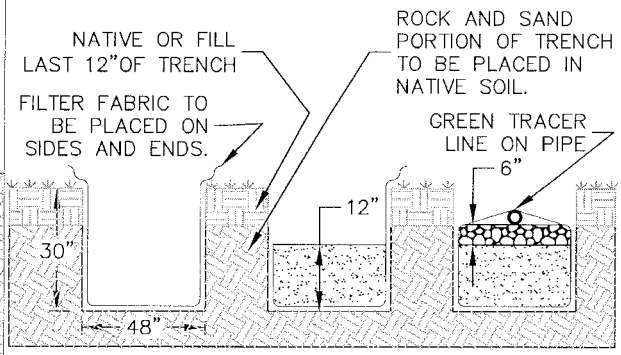

OPTIONAL TRAPPED SILT BASIN DETAIL

NOTE: *
THE BOTTOM OF THE INLET PIPE MUST NOT BE LOWER THAN THE TOP OF THE OUTLET PIPE.




SOAKAGE TRENCH CONSTRUCTION DETAIL

| STEP 1 | STEP 2 | STEP 3 |
|---|---|---|
| FILL TRENCH WITH FILTER FABRIC AS SHOWN | ADD 12" SAND AND FOLD ONE SIDE OF FABRIC OVER SAND | ADD 6" OF DRAIN ROCK PLACE PERF. PIPE AND COVER ALL. |




NTS REVISED SEPTEMBER 1, 2002

*EXHIBIT 2-29*
*WEST SOAKAGE TRENCH*

# Private Soakage Trench

**West Side Soakage Trench**

Applicable to Areas **West** of the Willamette River

**Soakage Trench Sizing**

For every 1,000 sf of impervious surface, 27 linear feet of 48" wide soakage trench is required, with a minimum 13.5-foot long trench. Soakage trenches 13.5 feet long serve a maximum of 500 sf of horizontally projected roof area or other impervious surface.

**Trench**

- Soakage trench and perforated pipe must be installed level and parallel to contour of finish grade.
- Soakage trench shall be located no closer than 10 feet to any building structure and not closer than 5 feet from property line.
- Unless a separate pollution reduction facility is used upstream of the trench, the sand filter portion of soakage trench must be filled with a minimum of 12" medium sand meeting OAR 340-71-295 (3)(e).
- Minimum 6" of ¾" – 2 ½" round or crushed rock to cover sand separated by one layer of filter fabric.
- The pipe shall be laid on top of this gravel and covered with filter fabric.
- At least 12" minimum of backfill shall be placed over the trench.
- All trenches shall be constructed on native soil and shall not be subject to vehicular traffic or construction work that will compact the soil, thus reducing permeability.
- Slope shall not exceed 20% without a stamped and signed geotechnical report addressing slope stability.
- Trench shall not be constructed under current or future impervious surface.

**Sand**

Medium sand meeting OAR 340-71-295 (3)(e) will be required. Sieve analysis of the medium sand is required to be made by a qualified party and a report provided to City of Portland plumbing inspector at the time of inspection. Analysis to comply with ASTM C136, Standard Methods for Sieve Analysis of Fine and Coarse Aggregate and in conjunction and accordance with ASTM C-117, Standard Test Method for Materials Finer than No.200 Sieve in Mineral Aggregates by Washing.

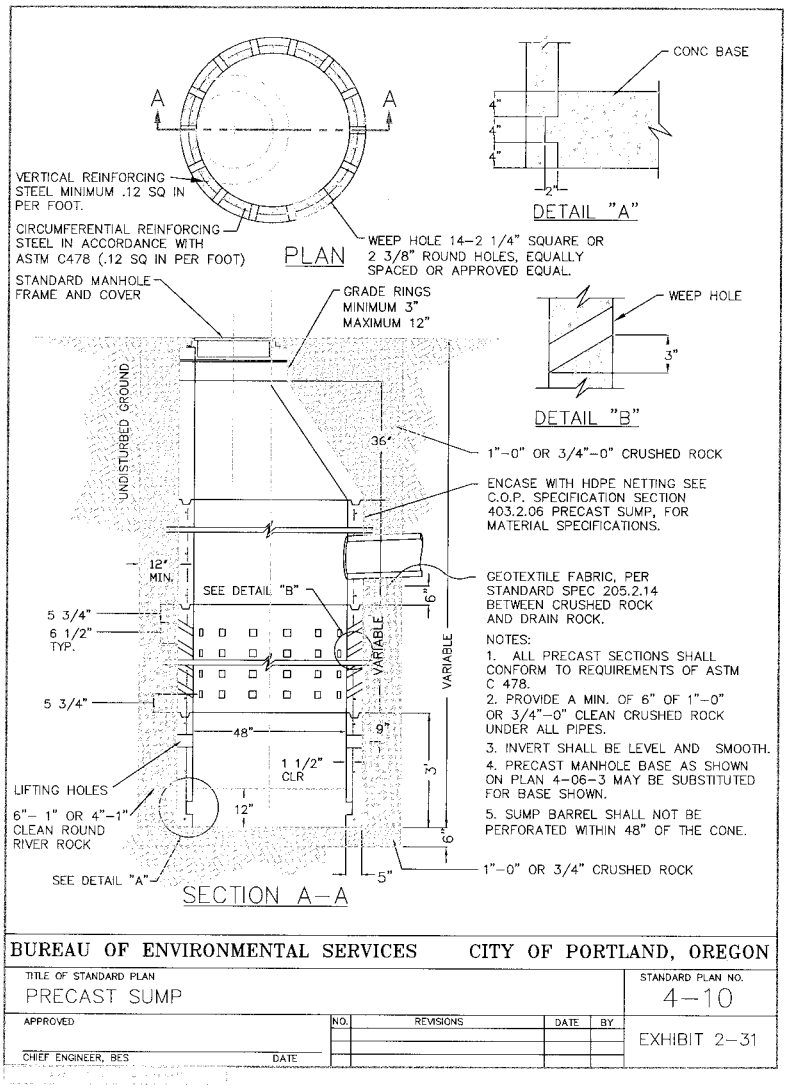
| Sieve # | % Passing |
|---|---|
| 3/8 | 100% |
| #4 | 95-100% |
| #8 | 80-100% |
| #16 | 45-85% |
| #30 | 15-60% |
| #50 | 3-15% |
| #100 | 4% or less |

**Pipe**

- The solid pipe from building or other source to connection with perforated pipe must be installed at a ¼" per foot slope.
- All piping within 10 feet of building must be sch. 40 ABS, sch. 40 PVC, cast iron, sch. 40 ABS, 3" sch. 40 PVC or 3" cast iron pipe may be used for rain drain piping serving not more than 1500 sf of roof or surface area. Use 4" pipe if area is greater than 1500 sf.
- Pipe must have a minimum cover of 12" measured from top of pipe to finished grade.
- The pipe within the trench shall either be PVC D2729 or HDPE Leach field pipe.
- The silt trap shall be installed between the dwelling and the sand filter, a minimum of 5' from the dwelling.

**Filter Fabric** must be one of the following types/brands: LINQ 125EX; LINQ TYPAR3201; TNS E040; TNS R035; TNS R040; TNS R042; AMOCO 4535; Marafi 140NL.

# Public Infiltration Sump System




| Stormwater Management Goals Achieved | Acceptable Sizing Methodologies |
|---|---|
| √ Pollution Reduction[2]…….…….. | PRES[2] |
| √ Flow Control…….…… | PRES |
| √ Destination/ Disposal…… | PRES |

**This facility is classified as an Underground Injection Control structure (UIC).**

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Public infiltration sump systems are used to manage stormwater from public street surfaces. **2)** Pollution reduction credit is only given in low-use (< 1,000 average daily trips) residential scenarios.

# Public Infiltration Sump System

**PUBLIC INFILTRATION SUMP SYSTEMS**

Public infiltration sump systems can be used to provide public street drainage by collecting and recharging stormwater runoff into the ground. The use of sumps is highly dependent on soil type and elevation of the groundwater table.

**Note:** The Oregon Department of Environmental Quality (DEQ) has identified sumps as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be either authorized by rule or authorized by permit by DEQ. In the case of public infiltration sumps, BES administers the rule authorization process with DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, site controls and pollution reduction facilities are required prior to disposing stormwater into them.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call DEQ- UIC Program at 503-229-5886, and for copies of applications or forms call 503-229-5189.

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 **Exhibit 2-33**)
- Major City traffic streets (including district collectors) in combined sewer areas, or neighborhood collectors in commercially zoned areas (Refer to *Transportation Element, Comprehensive Plan,* Office of Transportation, 2000)
- Within 500 feet of municipal or domestic drinking water wells, or a two-year time of travel zone, whichever is greater
- In areas with permanent or seasonally-shallow groundwater (< 40 feet below the ground surface)

A "sump system" (see **Exhibit 2-30**) is the total of all sump components at a single location (e.g., an intersection) and consists of inlets, piping, a sedimentation manhole, and one or more sumps. If one sump lacks adequate capacity to handle the design flow, a second sump may be placed in series with the first to provide additional capacity.

# Public Infiltration Sump System

Sedimentation manholes with oil traps receive runoff from inlets before stormwater enters the sumps. The sedimentation manholes settle out most of the large particulate material that can clog sumps' drainage holes, decreasing maintenance needs and increasing long-term effectiveness.

Detailed drawings of a standard sump and standard sedimentation manhole can be found as **Exhibits 2-31** and **2-32** of this manual.

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

## Public Sump System Method of Analysis

- 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 Design Manual.*

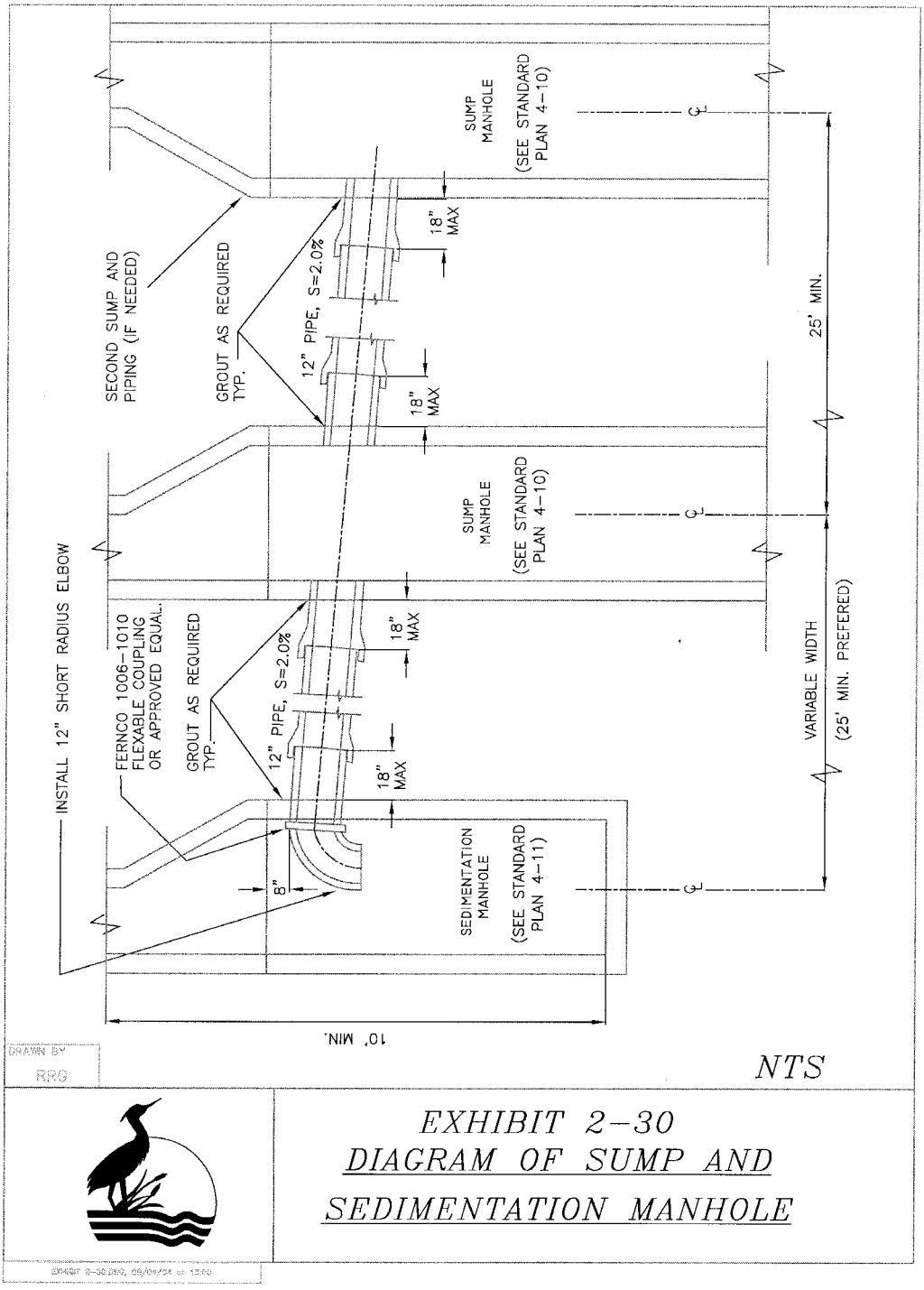
- Sumps shall be designed for a 10-year design storm, with a safety factor of 2.

- The time of concentration for sump design shall be 5 minutes.

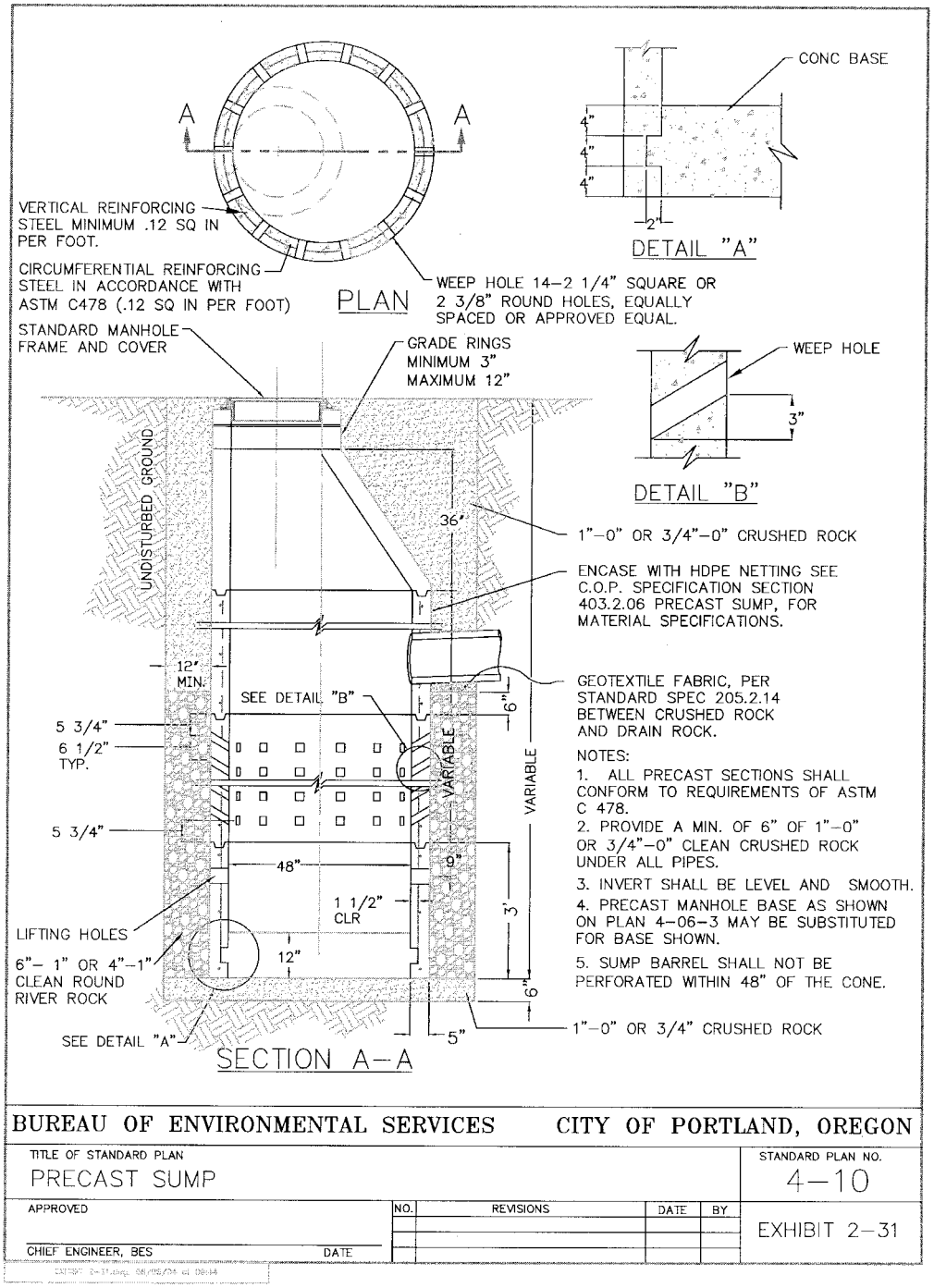
**Example:** What is the design percolation rate that a sump system must achieve to adequately dispose of runoff from 10,000 square-feet of paved street area?

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

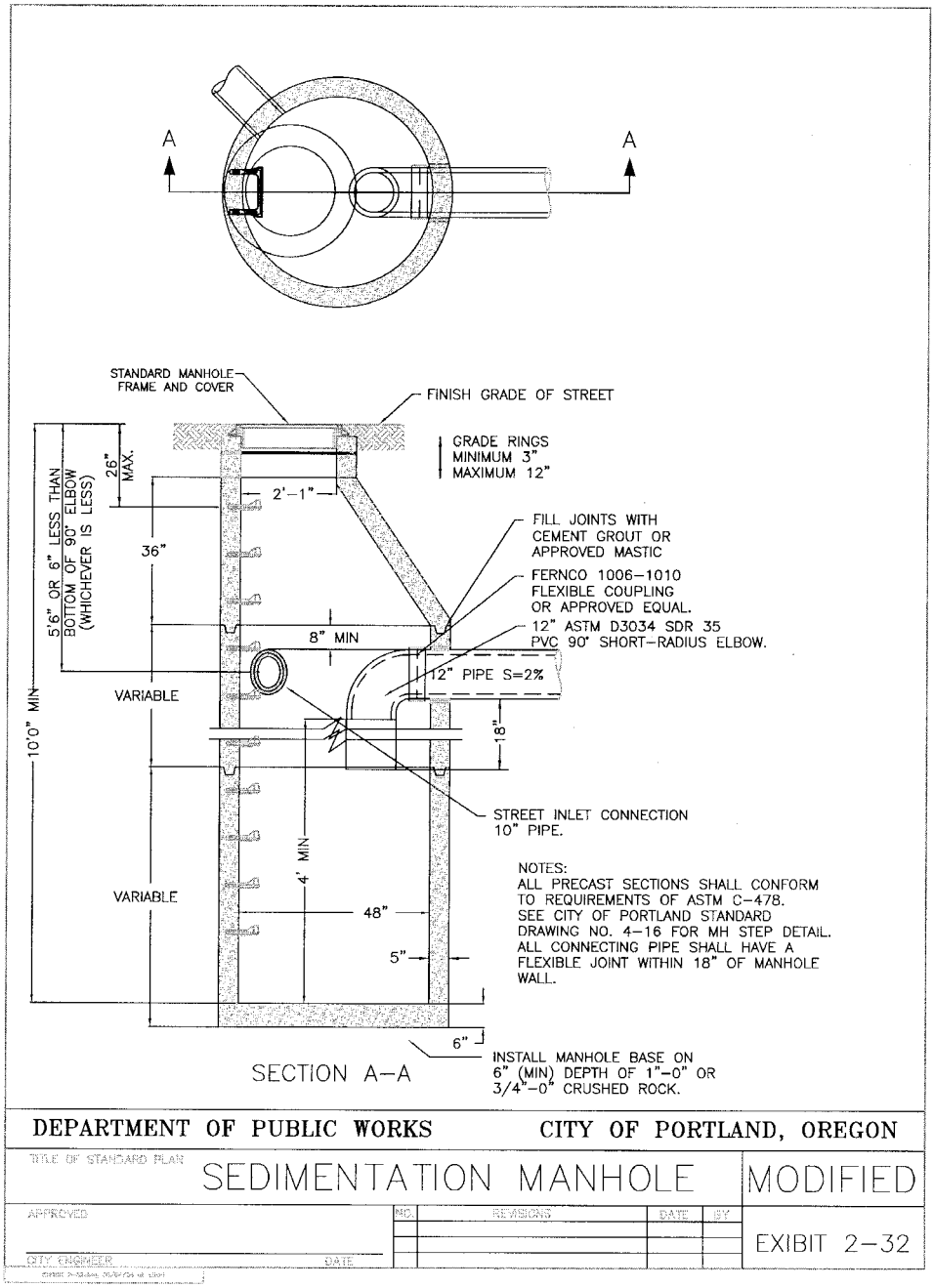
# Public Infiltration Sump System



# Public Infiltration Sump System

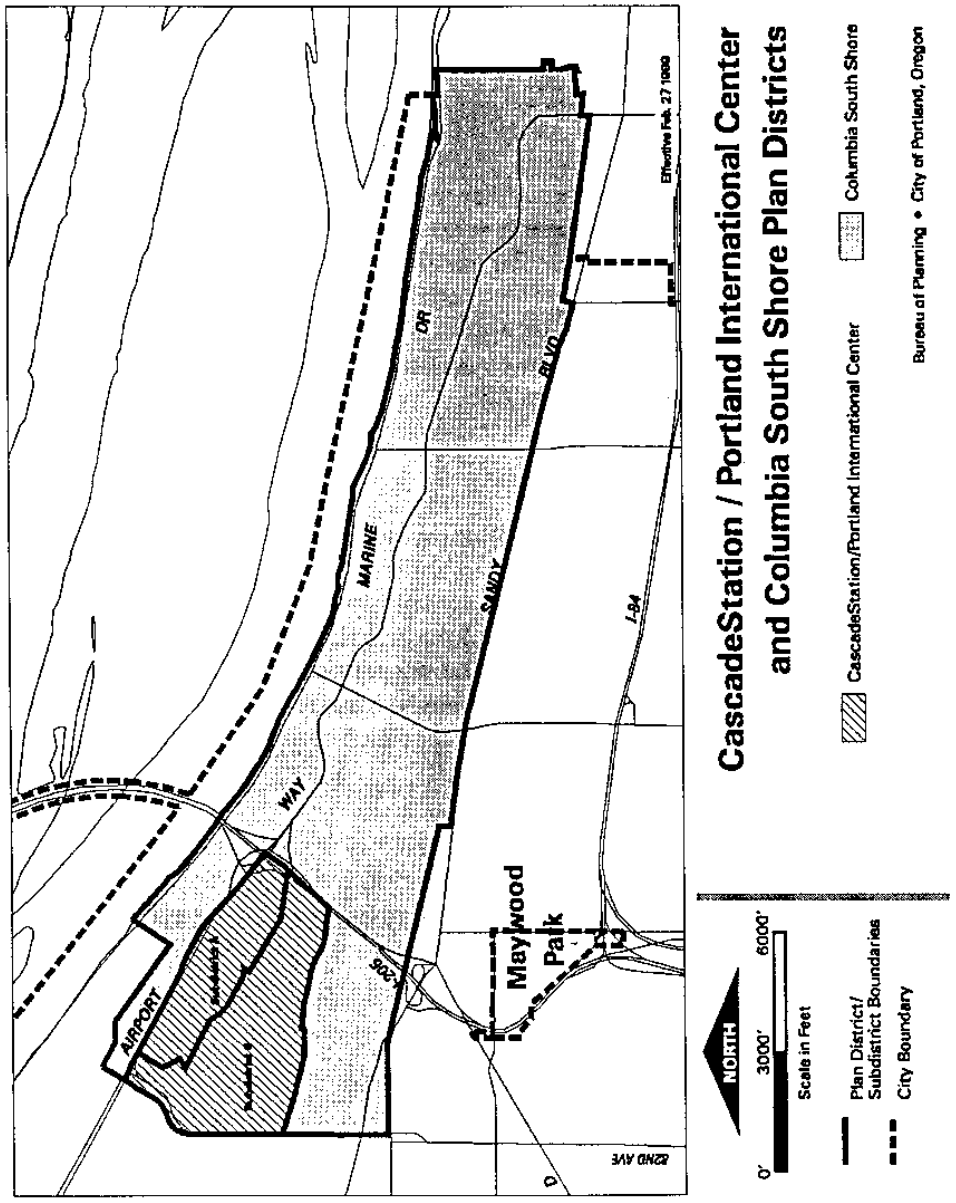


# Public Infiltration Sump System



# Public Infiltration Sump System

**EXHIBIT 2-33**
**CASCADE STATION/ PORTLAND INTERNATIONAL CENTER AND COLUMBIA SOUTH SHORE PLAN DISTRICTS**



# Public Infiltration Sump System

## Public Sump System Design Requirements

- Public sump systems shall be designed to handle **twice** the flow from the calculated design storm.
- 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 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.
- 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 **Exhibit 2-32.**)
- See the City of Portland's *Sewer Design Manual* for acceptable pipe material types between the sump and sedimentation manhole.
- Sumps shall not be located in areas with a constant or seasonally high groundwater table, or shallow bedrock. The bottom of the sump shall be at least 10 feet above the seasonal high water table, and at least 3 feet above bedrock.

### SUMP TESTING

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. Before being accepted by the City, all public sumps shall be tested after construction to ensure they meet or exceed the design capacity. The following sump testing procedure shall be used and must be shown on the construction plans of all public works sump projects:

# Public Infiltration Sump System

| SUMP NOTES |
| --- |
| Design flows reflect a factor of safety of 2. |
| All sumps shall be tested by the contractor as directed and approved by the city inspector. |
| Sump testing shall take place after sump construction is complete and before the construction of the sedimentation manhole. Should a sump test fail to verify adequate capacity, an additional sump, constructed in series with the first sump (a maximum of two sumps per system) shall be required, as approved by BES. Should a test of two sumps in series fail to verify adequate capacity, an alternative public stormwater destination shall be required, as approved by BES. |
| Notify BES inspector, or BES construction office at (503) 823-5728, at least 48 hours before beginning sump testing. A BES representative must be present during all sump capacity tests. |
| Contractor shall contact the City Water Bureau, or applicable water district, to arrange for sump test water supply. Contractor shall be responsible for obtaining necessary permits, authorization, and any fees. |
| Contractor may lease sump testing equipment from BES Materials Testing Laboratory, subject to leasing conditions and fees. Contact the laboratory, located at 1405 N River, at (503) 823-2340. Similar testing equipment from any vendor may be used, as approved by BES. |
| Provide water flow from fire hydrants to sump being tested using 8-inch nominal diameter pipe. Deliver clean potable water to sump. Introduction of sediment is not acceptable and may result in failure of sump capacity test and reconstruction of sump. |
| Fill sump with water at an initial rate of 300 gallons per minute (gpm) and record water elevation below sump manhole lid, every five minutes. When water surface reaches a constant elevation, increase flow rate to sump to 600 gpm. Record water surface elevations every five minutes. Continue to increase flow rate 300 gpm each time water surface elevation stabilizes, until maximum capacity is reached. |
| Immediately upon completion of the sump test, provide BES inspector with recorded test data. Contractor shall sign the results and submit to the BES inspector. |
| The closest fire hydrant for sump testing is located at the intersection of _____ & _____. Contact the Water Bureau to apply for a hydrant use permit. |

# Public Infiltration Sump System

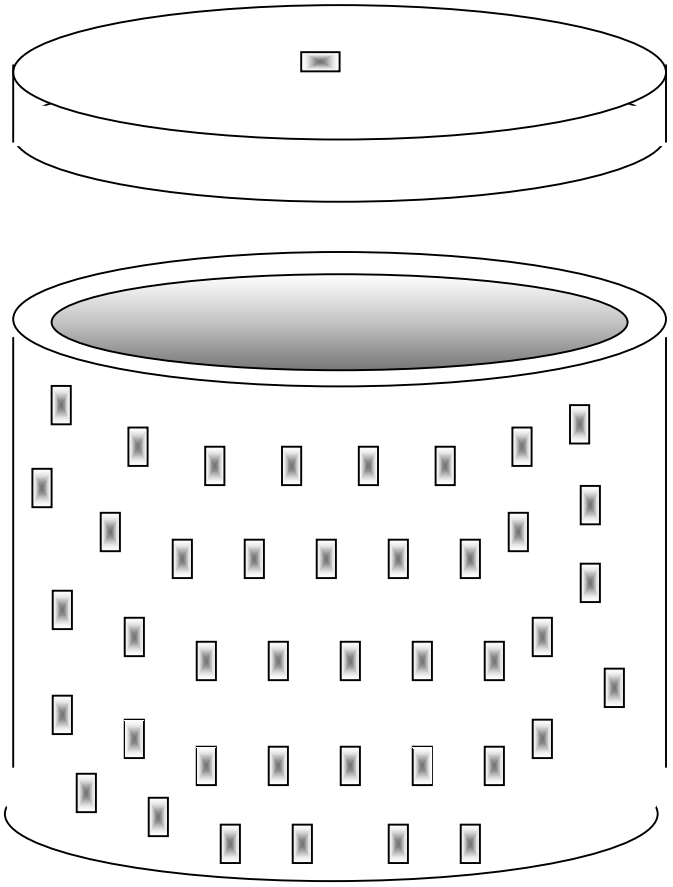
**Checklist of minimal information to be shown on the permit drawings:**

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

1) Sump and sedimentation manhole location with setbacks to curb, right-of-way lines, and other existing and proposed utilities.
2) Rim and bottom elevation.
3) The sump and sedimentation manhole shall reference the City of Portland standard plan numbers.
4) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

**Operations and Maintenance requirements**: The applicant or contractor is required to maintain the public infiltration sump system for two 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.

# Private Drywell



| Stormwater Management Goals Achieved | | Acceptable Sizing Methodologies |
|---|---|---|
| | Pollution Reduction…….…….. | NA |
| √ | Flow Control…… | PRES |
| √ | Destination/ Disposal…… | PRES |

**This facility is classified as an Underground Injection Control structure (UIC).**

SIM=Simplified Approach, PRES= Presumptive Approach, PERF= Performance Approach

**Notes: 1)** Private drywells can be used to manage stormwater from private property.

# Private Drywell

**Description:** Private drywells can be used as stormwater disposal points by collecting and recharging stormwater runoff into the ground. The use of drywells is highly dependent on soil type and elevation of the groundwater table.

**Note:** DEQ identifies drywells as "Class V Injection Wells" under the federal Underground Injection Control (UIC) Program. These facilities must be classified as exempt, authorized by rule, or authorized by permit by DEQ. Since the UIC Program states that these types of wells can have a direct impact on groundwater, pollution reduction is required before disposing stormwater into them, with the exception of drywells that serve rooftops only. All drywells, with the exception of those that drain residential rooftops only, must be registered with DEQ prior to City permit issuance.

More information about the UIC Program can be found in **Section 1.4.4** or at DEQ's website at: **Http://www.deq.state.or.us/wq/groundwa/uichome.htm**

For technical questions call the DEQ UIC Program at 503-229-5886. For copies of applications or forms call 503-229-5189.

Drywells are recognized as a stormwater disposal point, but they are not intended to be used to meet pollution reduction requirements. Unless a drywell used exclusively for roof runoff, pollution reduction facilities must be used to receive runoff before it enters the drywell. If used for residential streets with less than 1,000 average daily trips, or non-vehicular access areas such as pedestrian plazas, a spill control manhole per **Exhibit 2-26** may be used to meet pollution reduction requirements.

Drywell systems are prohibited from use within the Columbia South Shore and Cascade Station/ Portland International Center Plan Districts (see **Exhibit 2-33**). Drywells are also prohibited where permanent or seasonally shallow groundwater will exist within 10 feet of the bottom of the drywell.

## Private Drywell Design and Sizing Method

Soil conditions are critical to the success of drywells. Because of this, the use of drywells must be pre-approved by the Environmental Soils section of BDS. Supporting geotechnical evidence and a documented drywell test may be required to demonstrate that drywells will work in the project area. Drywells shall not be located in areas with a constant or seasonally high groundwater table.

# Private Drywell

**Exhibit 2-34** shall be used to design private drywells, after BDS approval has been given. To use this chart, the impervious surface area flowing to the proposed drywell must be known. The gray boxes corresponding to combinations of drywell diameter and depth may be used. Any other combinations of drywell diameter and depth will need to be pre-approved by BDS, and drywell testing may be required in accordance with the drywell testing procedure below.

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

## Drywell Testing Procedure

Equipment Needed:

- Water supply capable of filling drywell
- 25-foot tape measure
- Stopwatch
- Flashlight

Procedure: In the presence of a City Building Inspector:

1) Place the measuring tape against drywell wall, measuring to the bottom of drywell. Secure in place for the duration of the test.

2) Fill the drywell with clean potable water. Document water level before starting stopwatch.

3) Shut off water supply and start stopwatch.

4) Stop stopwatch when water level has dropped by 5 feet. Document this elapsed time.

5) Compare this time to the "Maximum Time in Minutes for Water to Drop by 5 feet in Drywell" from **Table B of Exhibit 2-35**. The diameter of the drywell and square footage of impervious site area that will flow into the drywell must be known to determine drawdown time.

   If the elapsed time is less than the time shown on the chart, one (1) drywell is sufficient. If the elapsed time is greater than the time shown on the chart, divide the elapsed time by the chart time and round to the nearest whole number. This is the number of drywells that will be required.

# Private Drywell

## Exhibit 2-34: Drywell Sizing

Once approval has been given by BDS for on-site infiltration of stormwater, the following chart shall be used to select the number and size of drywells.

| Impervious Area (sq-ft) | 28" Diameter Drywell Depth | | | | 48" Diameter Drywell Depth | | | | 60" Diameter Drywell Depth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5' | 10' | 15' | 20' | 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 | | | | | | | | | | | | |

# Private Drywell

## Exhibit 2-35: Drywell Testing

**Table A: Minimum Infiltration Rate Required in Gallons per Minute**

| Impervious Area (sq-ft) | 28" Diameter Drywell Depth | | | | 48" Diameter Drywell Depth | | | | 60" Diameter Drywell Depth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5' | 10' | 15' | 20' | 5' | 10' | 15' | 20' | 5' | 10' | 15' | 20' |
| **1000** | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 | 53 |
| **2000** | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 | 106 |
| **3000** | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 | 159 |
| **4000** | 212 | 212 | 212 | 212 | 212 | 212 | 212 | 212 | 212 | 212 | 212 | 212 |
| **5000** | 265 | 265 | 265 | 265 | 265 | 265 | 265 | 265 | 265 | 265 | 265 | 265 |
| **6000** | 318 | 318 | 318 | 318 | 318 | 318 | 318 | 318 | 318 | 318 | 318 | 318 |
| **7000** | 371 | 371 | 371 | 371 | 371 | 371 | 371 | 371 | 371 | 371 | 371 | 371 |
| **8000** | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 | 424 |
| **9000** | 477 | 477 | 477 | 477 | 477 | 477 | 477 | 477 | 477 | 477 | 477 | 477 |
| **10000** | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 | 530 |
| **11000** | 583 | 583 | 583 | 583 | 583 | 583 | 583 | 583 | 583 | 583 | 583 | 583 |
| **12000** | 636 | 636 | 636 | 636 | 636 | 636 | 636 | 636 | 636 | 636 | 636 | 636 |
| **13000** | 689 | 689 | 689 | 689 | 689 | 689 | 689 | 689 | 689 | 689 | 689 | 689 |
| **14000** | 742 | 742 | 742 | 742 | 742 | 742 | 742 | 742 | 742 | 742 | 742 | 742 |
| **15000** | 795 | 795 | 795 | 795 | 795 | 795 | 795 | 795 | 795 | 795 | 795 | 795 |
| **16000** | 848 | 848 | 848 | 848 | 848 | 848 | 848 | 848 | 848 | 848 | 848 | 848 |
| **17000** | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 |
| **18000** | 954 | 954 | 954 | 954 | 954 | 954 | 954 | 954 | 954 | 954 | 954 | 954 |
| **19000** | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 | 1007 |
| **20000** | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 | 1060 |

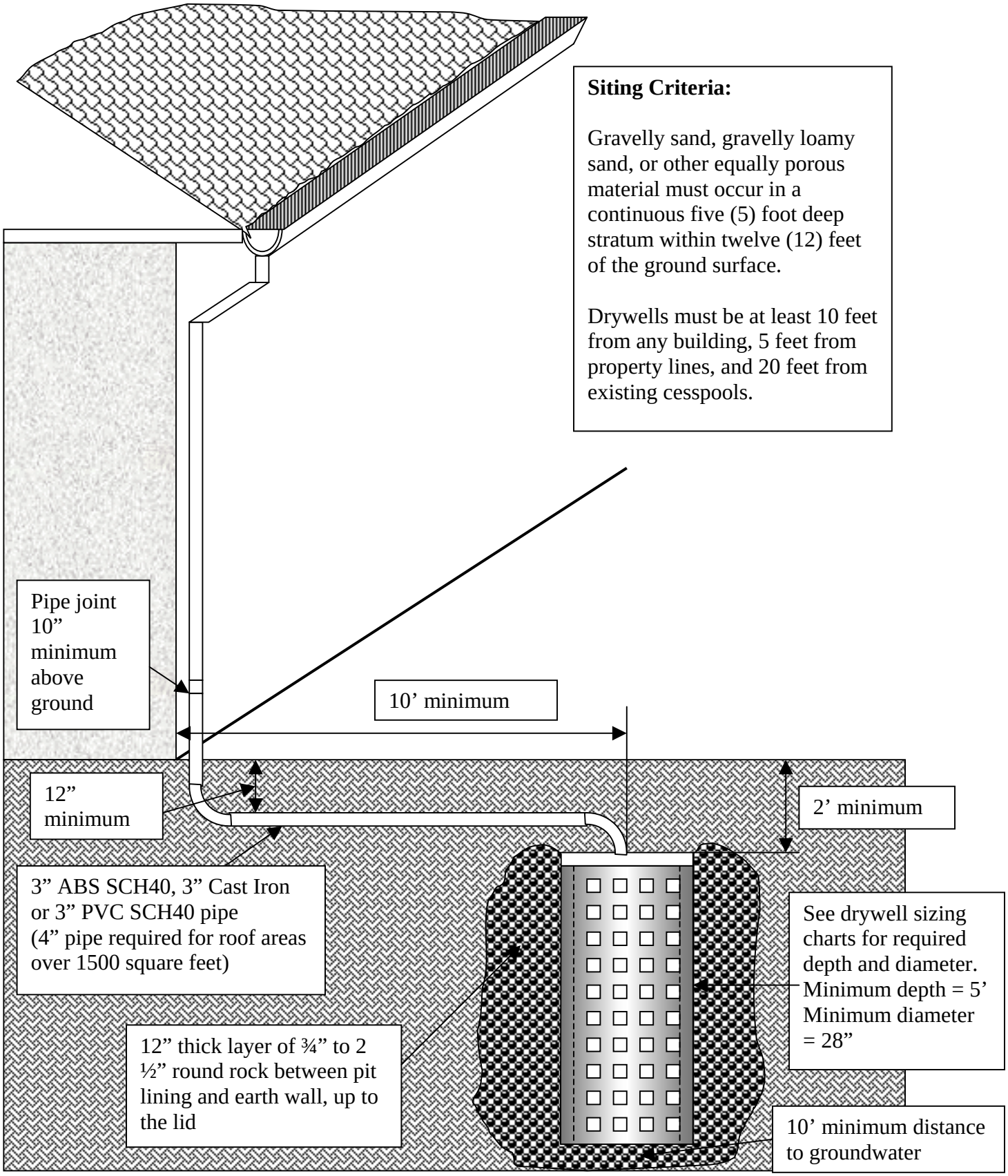
**Table B: Maximum Time in Seconds for Water to Drop by 5 feet in Drywell**

| Impervious Area (sq-ft) | 28" Diameter Drywell Depth | | | | 48" Diameter Drywell Depth | | | | 60" Diameter Drywell Depth | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5' | 10' | 15' | 20' | 5' | 10' | 15' | 20' | 5' | 10' | 15' | 20' |
| **1000** | 180 | 180 | 180 | 180 | 534 | 534 | 534 | 534 | 828 | 828 | 828 | 828 |
| **2000** | 90 | 90 | 90 | 90 | 270 | 270 | 270 | 270 | 414 | 414 | 414 | 414 |
| **3000** | 60 | 60 | 60 | 60 | 180 | 180 | 180 | 180 | 276 | 276 | 276 | 276 |
| **4000** | 48 | 48 | 48 | 48 | 132 | 132 | 132 | 132 | 210 | 210 | 210 | 210 |
| **5000** | 36 | 36 | 36 | 36 | 108 | 108 | 108 | 108 | 168 | 168 | 168 | 168 |
| **6000** | 30 | 30 | 30 | 30 | 90 | 90 | 90 | 90 | 138 | 138 | 138 | 138 |
| **7000** | 24 | 24 | 24 | 24 | 78 | 78 | 78 | 78 | 120 | 120 | 120 | 120 |
| **8000** | 24 | 24 | 24 | 24 | 66 | 66 | 66 | 66 | 102 | 102 | 102 | 102 |
| **9000** | 18 | 18 | 18 | 18 | 60 | 60 | 60 | 60 | 90 | 90 | 90 | 90 |
| **10000** | 18 | 18 | 18 | 18 | 54 | 54 | 54 | 54 | 84 | 84 | 84 | 84 |
| **11000** | 18 | 18 | 18 | 18 | 48 | 48 | 48 | 48 | 78 | 78 | 78 | 78 |
| **12000** | 18 | 18 | 18 | 18 | 42 | 42 | 42 | 42 | 72 | 72 | 72 | 72 |
| **13000** | 12 | 12 | 12 | 12 | 42 | 42 | 42 | 42 | 66 | 66 | 66 | 66 |
| **14000** | 12 | 12 | 12 | 12 | 36 | 36 | 36 | 36 | 60 | 60 | 60 | 60 |
| **15000** | 12 | 12 | 12 | 12 | 36 | 36 | 36 | 36 | 54 | 54 | 54 | 54 |
| **16000** | 12 | 12 | 12 | 12 | 36 | 36 | 36 | 36 | 54 | 54 | 54 | 54 |
| **17000** | 12 | 12 | 12 | 12 | 30 | 30 | 30 | 30 | 48 | 48 | 48 | 48 |
| **18000** | 12 | 12 | 12 | 12 | 30 | 30 | 30 | 30 | 48 | 48 | 48 | 48 |
| **19000** | 12 | 12 | 12 | 12 | 30 | 30 | 30 | 30 | 42 | 42 | 42 | 42 |
| **20000** | 12 | 12 | 12 | 12 | 24 | 24 | 24 | 24 | 42 | 42 | 42 | 42 |

(Rational Method, Safety Factor of 2)

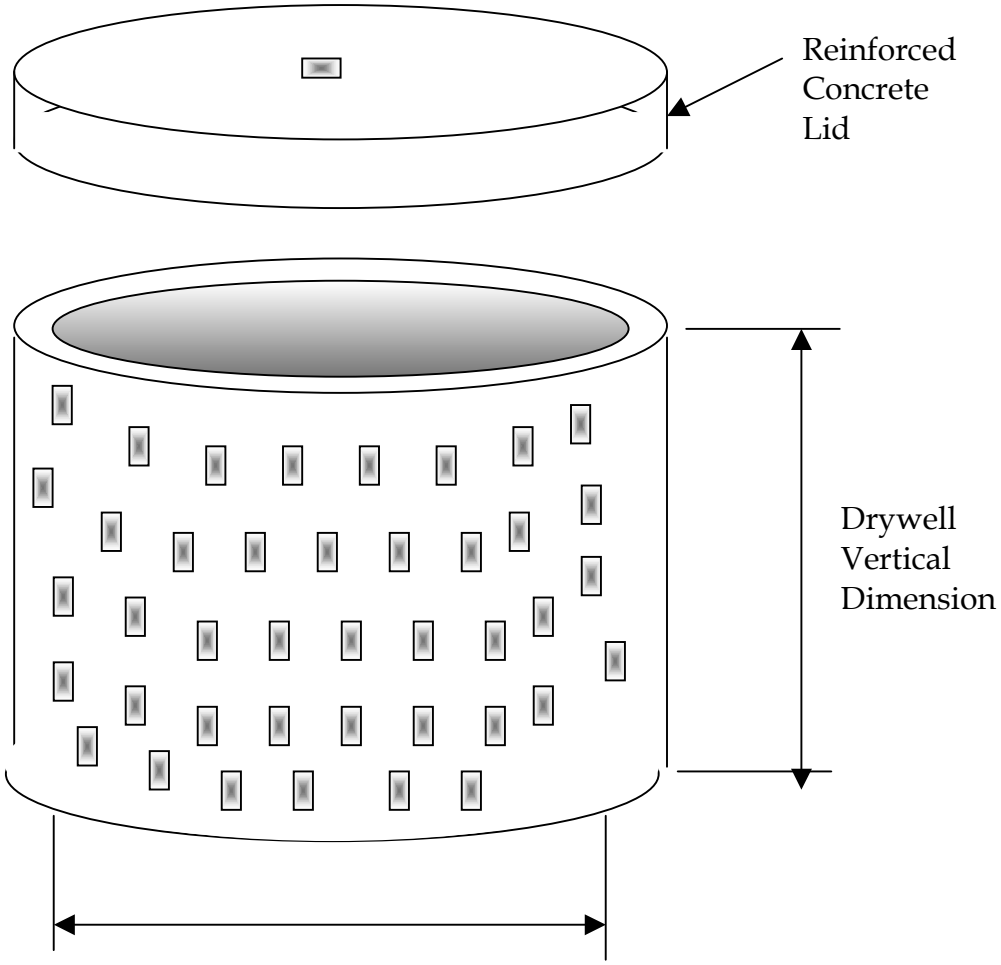
# Private Drywell

**Exhibit 2-36: Private Reinforced Concrete Drywell Typical Configuration**



# Private Drywell

**Exhibit 2-37: Typical Private Drywell:**



# Private Drywell

**Checklist of minimal information to be shown on the permit drawings:**

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

1) Facility location with setbacks from property lines and structures.
2) Depth and diameter of drywell.
3) All stormwater piping associated with the facility, including pipe materials, sizes, slopes, and invert elevations at every bend or connection.

**Inspection requirements and schedule:** The following table shall be used to determine which stormwater facility components require City inspection, and when the inspection shall be requested:

| Facility Component | Inspection Requirement |
|---|---|
| Drywell excavation | |
| Piping | Call for inspection |
| Drywell installation & backfill | Cal for inspection |

**Operations and Maintenance requirements**: See **Chapter 3.0**.

*** Link to drywell O&M form**