

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 destination benefits. It includes:

- 2.1 Introduction
- 2.2 Design Methodologies
 - 2.2.1 Simplified Approach
Form SIM
 - 2.2.2 Presumptive Approach
Surface Infiltration Facility Design Approach for Destination
 - 2.2.3 Performance Approach
 - 2.2.4 Green Street Approach
- 2.3 Hydrologic Analysis
- 2.4 Infiltration Testing
- 2.5 Control Structures for Detention Systems
- 2.6 Access for Operations and Maintenance
- 2.7 Landscaping
- 2.8 Outfall Design
- 2.9 Facility Selection and Design

To Use This Chapter:

- 1) Use the ordinance in **Appendix A** and **Chapter 1.0** to determine the pollution reduction, flow control, and destination requirements for the project.
- 2) Select stormwater management facilities from **Section 2.9: Facility Selection and Design** to meet pollution reduction, flow control, and/or destination 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 or Performance 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 Selection and Design**.
- 5) Consult **Chapter 3.0** for the operations and maintenance guidelines for each stormwater management facility.

2.1 INTRODUCTION

Facilities presented in this chapter receive credit toward compliance with pollution reduction, flow control, destination, 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 approaches. Each design approach has limitations on applicability, particularly as related to the soil formations on-site. Soil formations are classified by NRCS soil types A, B, C, or D. 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
Eco-roof & roof garden	Simplified	Simplified	NA
Pervious pavement	Simplified	Simplified	Simplified/ Presumptive ⁴
Contained planter	Simplified	Simplified	NA
Tree credit	Simplified	Simplified	NA
Stormwater planter	Simplified ¹	Simplified	Presumptive
Swales < 15,000 sq-ft impervious area	Simplified ¹	NA	Presumptive
Swales > 15,000 sq-ft impervious area	Presumptive	NA	Presumptive
Level Spreader	Presumptive ⁷	Presumptive ⁷	Presumptive ⁷
Vegetated filter strip	Simplified	NA	Simplified ⁵
Rain Garden	Simplified ¹	Simplified	Simplified
Sand filter	Simplified ¹	Simplified	Presumptive
Wet pond	Presumptive	NA	NA
Extended wet det. pond	Presumptive	Presumptive	NA
Dry detention pond	Presumptive ³	Presumptive	NA
Treatment wetland	Presumptive	Presumptive	NA
Manufactured treatment technology	Performance	NA	NA
Structural detention facility	NA	Presumptive	NA
Spill control manhole	Presumptive ²	NA	NA
Soakage trench	NA ⁶	Presumptive	Presumptive
Infiltration sump	NA	Presumptive	Presumptive
Drywell	NA	Presumptive	Presumptive

Exhibit 2-1 Notes:

¹The Presumptive Approach may be used to downsize these Simplified Approach facilities.

²Spill control manholes receive credit for oil removal only; additional pollution reduction facilities will be required to meet basic water quality management.

³Vegetated or grassy swales must be integrated into the bottom of dry detention ponds to receive pollution reduction credit.

⁴Pervious pavements in NRCS soil types A or B meet destination requirements when designed using the SIM Form.

⁵Vegetated filter strips designed using the SIM Form may be used for destination for some small projects as outlined in **Chapter 2**.

⁶Soakage trenches, having a minimum 18-inch layer of sand for filtration installed below the soakage trench and designed per "Soakage Trench" facility design requirements, may meet pollution reduction requirements.

⁷Level spreaders must include dedicated filtration buffer in the design for management credit.

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. Simplified approaches facilitate the surface retention of stormwater, 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 drainage ways 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. Overall, these facilities help mimic the natural hydrologic cycle by slowing and infiltrating stormwater.

Simplified Approach Sizing

Facilities may be designed using the Simplified Approach (Form SIM:2008) to comply either with sizing requirements for pollution reduction only or pollution reduction with flow control. Facilities so designed using the Simplified Approach are presumed to comply with the City’s pollution reduction and/or flow control requirements.

One and two family residential development applications having either NRCS soil types A or B may use the pollution reduction with flow control sizing factors to size on-site infiltration facilities to meet destination requirements. Commercial applications must use a Presumptive Approach when sizing facilities to meet destination standards.

Sizing factors for the simplified approaches (shown on **Form SIM: 2008**) were developed as a quick effective 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 a Presumptive Approach and submit an alternative facility size, along with supporting engineering calculations for City review for compliance with the performance criteria.

The first four simplified approaches on Form SIM (pervious pavements, eco-roofs and roof gardens, contained planter boxes, and tree credits) are impervious area reduction techniques that reduce the overall square-footage of impervious area requiring stormwater management for pollution reduction and flow control. These facilities intercept rainfall and are not designed to receive stormwater runoff from other surfaces. The second group of simplified approaches on Form SIM (stormwater planters, vegetated and grassy swales, vegetated filter strips, rain gardens, and sand filters) is designed to receive stormwater runoff from impervious surfaces.

Simplified Approach Applications

Applicants using the simplified approach shall submit **Form SIM: 2008** as part of their permit application, along with construction drawings and details. **Page 2 of Form SIM: 2008** 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 packet (see **Chapter 3.0**) shall also be included. Projects that utilize simplified approach facilities must also fulfill Stormwater Destination requirements.

Application		PEP/BPS #	
Address		Residential / Commercial	
Tax Lot #			

Form SIM: 2008 (Simplified Approach for Stormwater Management)

List the following areas, including roof areas:

List the roof areas which are included in the totals to the left:

Total New or Replaced Impervious Surface Area
New or Replaced Imp. Surface Area to be Treated
Total Existing Imp. Surface Area to be Treated
Total Impervious Surface Area to be Treated **Box 1**

New Roof Area
New Roof Area to be Treated
Existing Roof Area to be Treated
Total Roof Area to be Treated

INSTRUCTIONS

1. Enter square footage of all impervious areas to be treated in Box 1.

2. Select impervious area reduction techniques from rows 1-4 to reduce the site's resulting stormwater pollution reduction/flow control requirements. Tree credit can be calculated using the Tree Credit Worksheet. Add square footage of rows 1-4 and enter in Box 2.

3. Subtract Box 2 from Box 1 and enter number in Box 3. This is development area that is required to provide pollution reduction/flow control facilities for its stormwater runoff.

4. Select desired stormwater management facilities from rows 5-12. Enter the square footage of impervious area that each facility will manage.

5. Multiply the square feet of each impervious area managed by the corresponding sizing factor for Pollution Reduction or Pollution Reduction w/ Flow Control, and enter the result. This is the facility surface area needed to manage runoff from the impervious area to provide pollution reduction treatment or pollution reduction treatment with flow control.

6. Box 4 must be equal to or greater than Box 3.

7. Identify Stormwater Destination. If infiltration is chosen, submit percolation rate and presumptive design calculations for sizing destination facility.⁵

Impervious Area Reduction Technique	Facility Surface Area						
1) Pervious Pavement(s)	_____ sf						
2) Eco-Roof / Roof Garden	_____ sf						
3) Contained Planter	_____ sf						
4) Tree Credit (See Next Page)	_____ sf						
5) Rainwater Harvesting (See Next Page)	_____ sf						
		<input type="text"/> Box 2	Total Impervious Area Reduction for Pollution Reduction and Flow Control Credit				
		<input type="text"/> Box 3	New Impervious Management Area¹ (Box 1 - Box 2)				
Stormwater Management Facility	Impervious Area Managed	Pollution Reduction ² Sizing Factor	Facility Surface Area	w/Flow Control ³ Sizing Factor	Facility Surface Area	Unit	
5) Infiltration Rain Garden (Vegetated Infiltration Basin)	_____ sf	x 0.09 =	<input type="text"/> sf	x 0.18 =	<input type="text"/> sf		
6) Filtration Rain Garden	_____ sf	x 0.05 =	<input type="text"/> sf	x 0.11 =	<input type="text"/> sf		
7) Infiltration Stormwater Planter (Infiltration Planter)	_____ sf	x 0.07 =	<input type="text"/> sf	x 0.18 =	<input type="text"/> sf		
8) Filtration Stormwater Planter (Flow-through Planter)	_____ sf	x 0.03 =	<input type="text"/> sf	x 0.07 =	<input type="text"/> sf		
9) Vegetated Swale	_____ sf	x 0.05 =	<input type="text"/> sf	n/a			
10) Grassy Swale	_____ sf	x 0.06 =	<input type="text"/> sf	n/a			
11) Vegetated Filter Strip	_____ sf	x 0.2 =	<input type="text"/> sf	n/a			
12) Infiltration Sand Filter	_____ sf	x 0.07 =	<input type="text"/> sf	x 0.18 =	<input type="text"/> sf		
13) Filtration Sand Filter	_____ sf	x 0.03 =	<input type="text"/> sf	x 0.07 =	<input type="text"/> sf		
Total Impervious Area Managed			<input type="text"/> Box 4				

NRCS Soil Type

A/B **C** **D**

Stormwater Destination⁴	Overflow to Gutter (weephole)	<input type="checkbox"/>
	Overflow to public drain pipe	<input type="checkbox"/>
	Overflow to Open Drainage	<input type="checkbox"/>
	Infiltration	<input type="checkbox"/>
Percolation Rate		<input type="text"/>

¹New Impervious Management Area to apply Flow Control and/or Pollution Reduction Treatment

²Pollution Reduction Treatment only; Address Stormwater Destination below

³Flow Control and Pollution Reduction Treatment only; Address Stormwater Destination below

⁴Stormwater Destination required for all New or Replaced Impervious Surface Areas (Box 1)

⁵Residential applications with NRCS soil types A or B may size infiltrating facilities using the Pollution Reduction w/Flow Control Sizing Factor to meet stormwater destination requirements.

Form SIM: Tree Credit Worksheet

See "Tree Credits" section for more information regarding the use of trees to meet Stormwater Impervious Area Reduction.

New Evergreen Trees

To receive Impervious Area Reduction Credit, new evergreen trees must be planted within 25 feet of the new or replaced impervious surfaces. New trees cannot be credited against rooftop areas. 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 Impervious Area Reduction Credit, new large deciduous trees must be planted within 25 feet of the new or replaced impervious surfaces and new small deciduous trees must be planted within 10 feet of new or replaced impervious surfaces. New trees cannot be credited against rooftop areas. 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 A by 100 and enter result in Box D. Box D

Existing Tree Canopy

To receive Impervious Area Reduction Credit, existing tree canopy must be within 25 feet of ground-level impervious surfaces (cannot be credited against roof top surfaces). Existing tree canopy credited towards Impervious Area Reduction must be preserved during and after construction throughout the life of the development. Minimum tree caliper to receive credit is 4 inches. No credit will be given to existing tree canopy located within environmental conservation areas.

Enter square footage of existing tree canopy that meet qualification requirements in Box E. Box E

Multiply Box E by 0.5 and enter result in Box F. Box F

Total Tree Credit

Add Boxes B, D, and F and enter the result in Box G. Box G

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. (This is the amount to be entered as "Tree Credit" on Form SIM. ****Stop Here****) Box I

2.2.2 Presumptive Approach

Facilities that utilize this design approach are classified as “presumptive,” *i.e.*, facilities that are *presumed* to be in compliance with the City’s pollution reduction, flow control, and/or destination 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 destination), 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 Application

In addition to detailed construction drawings and details 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 packet (see **Chapter 3.0**) shall also be provided. In addition, a geotechnical report is required by the City to evaluate the suitability of the proposed facility location. Projects using facilities designed under the Presumptive Approach must also fulfill Stormwater Destination requirements.

Exhibit 2-2: Checklist of Calculations to be Included with Presumptive Design Reports

Stormwater Facility Type					
A= Swale Facilities					
B= Infiltration Treatment Facilities (pervious pavements, planters, basins, sand filters, soakage trenches)					
C= Filtration Treatment Facilities (pervious pavements, planters, basins, sand filters)					
D= Constructed Treatment Ponds & Wetlands					
E= Structural Treatment Facilities					
Parameter or Calculated Value to be Included in the Stormwater Report	A	B	C	D	E
Site Variables:					
Site soil type (A, B, C, or D)	x	x		x	
Contributing area (acres impervious/pervious)	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	
Post-developed time of concentration T of C (minutes)	x	x	x	x	
Distance from ground surface to max. height of seasonal groundwater (feet)	x	x		x	
Facility Geometry:					
Side slopes (h: v or %)	x	x	x	x	
Longitudinal slope (h: v or %)	x	x	x	x	
Bottom width and length (feet)	x	x	x	x	
Overall width and length (feet)	x	x	x	x	
Hydraulic Controls:					
Orifice or weir descriptions, sizes, and elevations, including by-pass facilities			x	x	x
Elevation, size, and type of overflow spillway or pipe			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	
Hydraulic residence time for the pollution control storm	x				
Detailed storm routing data (i.e. SBUH) for the water quality and flood control storm events, showing inflow rate, outflow rate, and water surface elevation in the facility every 10 minutes throughout the storm.		x	x	x	

PRESUMPTIVE SURFACE INFILTRATION DESTINATION DESIGN

Where soil conditions allow for infiltration near the ground surface, surface infiltration facilities can be used to dispose of stormwater from large storm events to meet destination standards. 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 and recharging groundwater and increasing evapotranspiration.

Surface infiltration facilities may be sized using an approved Hydrologic Analysis found in **Section 2.3** or the following *Surface Infiltration Facility Design* approach. Regardless of the methodology used, the design infiltration rate shall be the lesser of 2.5 inches per hour (the maximum allowable infiltration rate for a growing medium) or the measured infiltration rate divided by 2.

Surface Infiltration Facility Design:

- 1) Infiltration testing in accordance with Section 2.4 is required to determine the feasibility of surface infiltration. The minimum acceptable infiltration rate for surface infiltration facilities to meet destination standards is 0.5 inches per hour. A clogging factor of 2 is then applied to the resulting infiltration rate to be used in the design of the facility.
- 2) The design infiltration rate (measured infiltration rate divided by 2) is then used to check the facility drawdown time. When full, the facility drawdown time shall not exceed 30 hours.
- 3) The wet seasonal high water table must be determined, and a minimum 4-foot clearance to bottom of facility must be maintained.
- 4) Minimum setbacks from surface infiltration facilities to structures are shown in **Exhibit 2-4**.
- 5) 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 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%
Clay 10 - 25%

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

- 7) Surface infiltration facility areas shall be clearly marked before site work begins to avoid soil disturbance during construction. Vehicular traffic and construction activities shall not be allowed to compact the soil, thus reducing permeability, prior to constructing the facility.

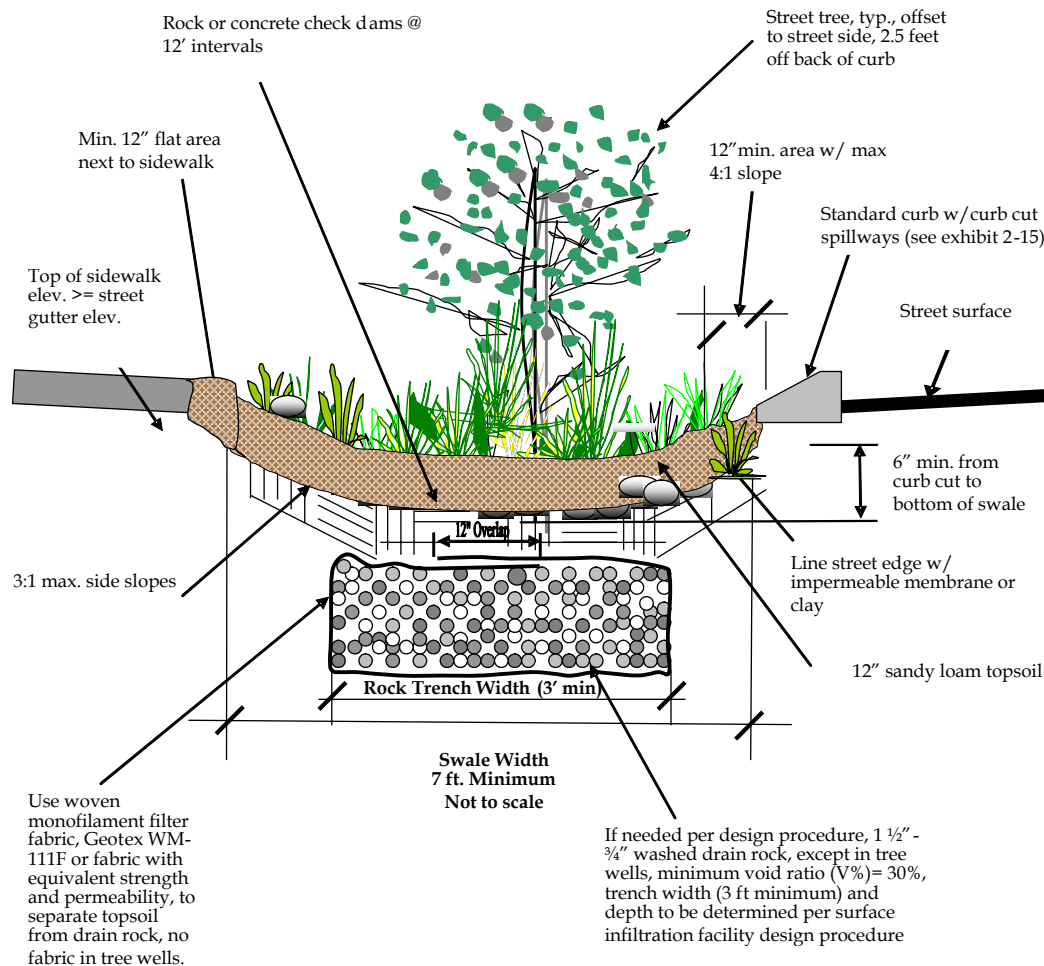
Surface Infiltration Facility Design Approach to Meet Destination Standards

Determine the preliminary facility size by calculating the runoff volume generated by the 5-year storm (3.6 inches of rainfall over 24 hours from Table C-1) or the volume can be approximated by the following formula:

$$\text{Runoff Volume (cubic feet)} = 0.3 \text{ feet} * \text{Impervious Area (square-feet)}$$

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.

Exhibit 2-3: Example Cross-Section of Infiltration Rain Garden, Modified To Receive Credit for Destination



SURFACE INFILTRATION FACILITY SIZING EXAMPLE

Facility Type: Rain Garden, Infiltrating

Objective: Find rain garden dimensions needed to meet destination standards.

Givens: Design Storm (P) = 5 year, 24 hour storm = 3.6 total inches = **0.3 feet**

Maximum Drawdown Time (Td) = **30 hours**

Infiltration Rate Safety Factor = **2**

Site Characteristics:

Impervious Area (Ai) = 200' x 28' = **5,600 square feet**

Measured Infiltration Rate (Im), using Double-Ring Infiltrometer Test = 6"/hr = **0.5'/hr**

Rain Garden width (Ws) = **8 feet**

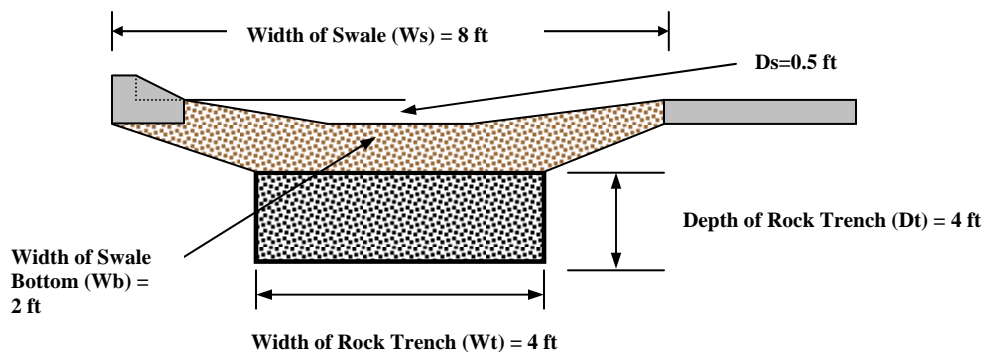
Rain Garden bottom width (Wb) = **2 feet**

Rain Garden 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 = 0.3 * Ai = 0.3 * 5,600 = **1,680 cubic feet**

Design Infiltration Rate (Id) feet per hour = Im / 2 = **0.25 ft/hr**

Rain Garden Storage Volume (Vs) = L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]

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

$$V_r \leq V_s$$

$$(0.3 * Ai) \leq L * [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]$$

To find L: $L = (0.3 * Ai) / [(0.5 * Ds * (Ws + Wb)) + (VR * Wt * Dt)]$

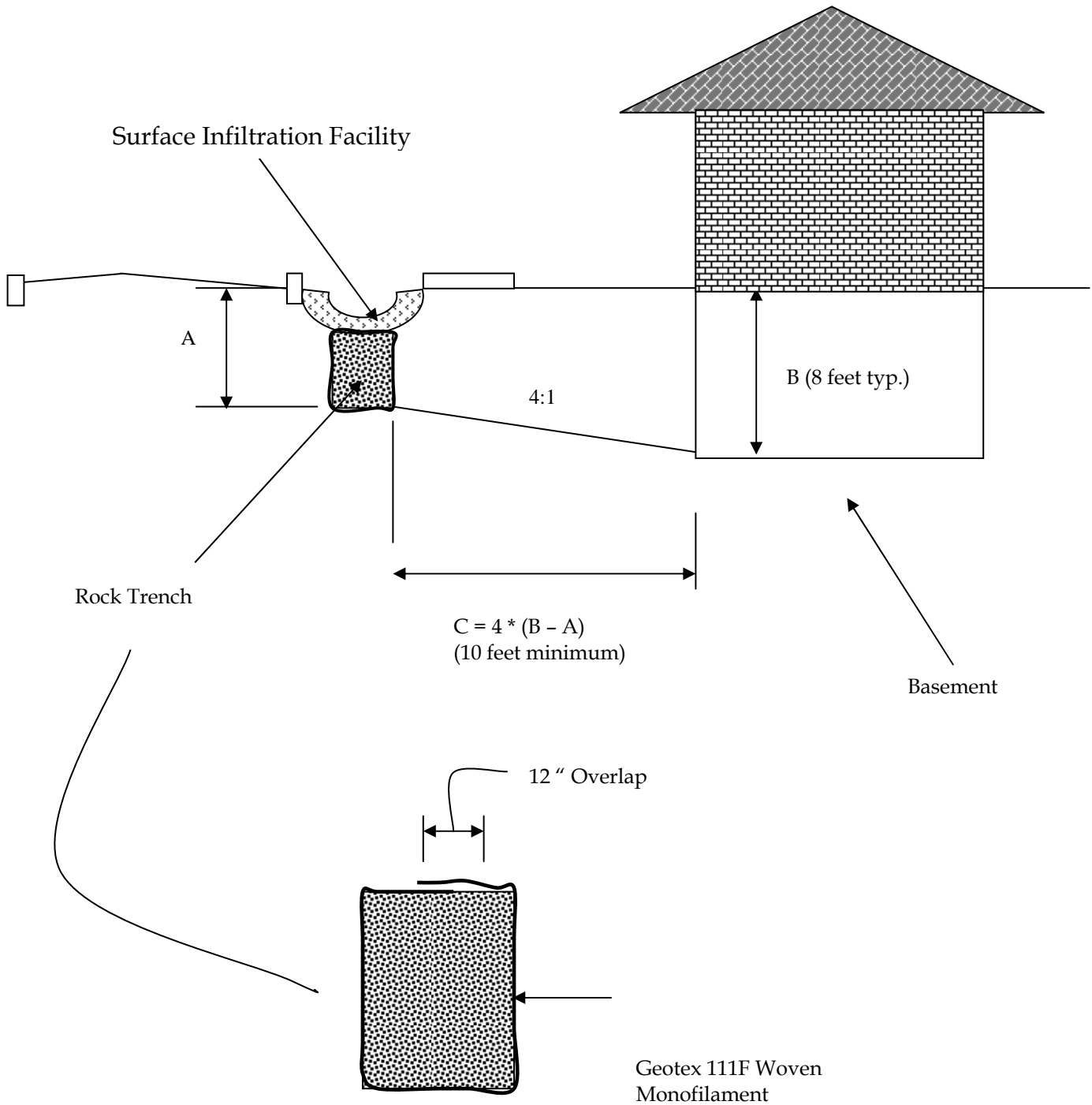
$$L = (0.3 * 5,600) / [(0.5 * 0.5 * (8 + 2)) + (0.30 * 4 * 4)] = \underline{\underline{230 \text{ feet}}}$$

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

$$(0.3 * Ai) / (Id * Wt * L) \leq 30 \text{ hours}$$

$$(0.3 * 5,600) / (0.25 * 4 * 230) = \underline{\underline{7.3 \text{ hours}}} < 30 \text{ hours, therefore OK}$$

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.

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 and capture and treat 80 percent of the average annual rainfall. Documented performance is required and shall include published data, with supporting cited research, demonstrating removal of target pollutants at required levels.
- Can be maintained to perform at the maintenance level set forth in **Chapter 3** of this Manual.

Performance Approach Application

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 is required by the City to evaluate the suitability of the proposed facility location. Projects using facilities designed under the performance approach must also fulfill Stormwater Destination requirements.

2.2.4 Green Street Approach

Appendix D provides examples for constructing green streets.

2.3 HYDROLOGIC ANALYSIS

With the exception of facilities approved using the Simplified Approach, stormwater management facilities should be designed for pollution reduction, flow control and destination using one of the hydrologic analysis methods described below. If one of the hydrologic analysis methods discussed below is not used, City staff 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 the City's review. This data is summarized in **Exhibit 2-2**.

Flow Rate-Based Facilities: The Rational Method with rainfall intensities presented in **Section 1.5.2** is the preferred analysis method for sizing rate-based pollution reduction facilities. The following are flow-rate-based facilities:

- Swales
- Manufactured Treatment Technologies
- Spill Control Manholes

Flow Volume-Based Facilities: The design professional may use the Santa Barbara Urban Hydrograph (SBUH) Type 1A - 24 hour, NRCS TR-55, HEC-1, or SWMM design analyses for sizing volume-based facilities. Volume-based pollution reduction facilities included in this Manual are required to use the pre-determined volume of 1.4 inches over 24 hours with a V_b/V_r ratio of 2 to be in presumptive compliance. The following are flow volume-based facilities:

- Wet, Extended Wet, and Dry Detention Ponds
- Constructed Treatment Wetlands

Combination Rate/Volume Facilities: Software design programs based on the SBUH Type 1A - 24 hour method, or a continuous simulation model with Eugene rainfall data, is the preferred analysis method for sizing of flow rate-based pollution reduction facilities that also rely on a storage volume component. When using SBUH, a 1.4 inch, 24-hour storm with NRCS type 1A rainfall distribution shall be used for pollution reduction design. When designing for destination, the Flood Control Design Storm for 24-hour period shall be used. The design professional may also use the NRCS TR-55, HEC-1, or SWMM.

- Stormwater Planters
- Rain Gardens
- Sand Filters

2.3.1 Conveyance

The Rational Method shall be used to size pipes and surface conveyance facilities for drainage areas of 40 acres and less. HEC-1 or SWMM may be used for projects greater than 40 acres in size.

2.3.2 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.

Note: Facilities that are sized using an infiltration rate of 0.5 inches per hour and that will be located in NRCS soil types A or B are not required to perform infiltration testing.

Facilities that are sized using an infiltration rate greater than 0.5 inches per hour or that will be located in NRCS soil types C or D must perform infiltration testing.

The following general criteria apply to all proposed infiltration facilities:

- 1) For all infiltration facilities, a minimum infiltration rate of 0.5 inches per hour is required. Infiltration rates shall be determined by performing the constant head-, the falling head-, or the double-ring infiltration testing.
- 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) Design testing includes (1) a test pit to determine soil formations, groundwater and bedrock levels, and (2) an infiltration test.
- 4) Testing shall be conducted or observed by a qualified professional. A Qualified Professional includes registered professional engineers, soil scientist, geologist, architect, landscape architect, professional testing service with specific training and/or experience in determining the permeability of soils, or others as approved by the City.
- 5) Testing data shall be documented, including a description of the infiltration testing method.
- 6) Initial feasibility testing need not be conducted if the NRCS Lane County Soil Mapping shows the soils of the development site are a hydrologic group A or B.
- 7) Testing for groundwater elevation is not required for soakage trenches and surface infiltration facilities which (1) are located in areas with a depth to groundwater of 6' or greater, as shown on the **Infiltration Limited Areas** map, and which (2) are shown not to exceed a maximum facility depth of 2 feet.
- 8) Well log data within 200 feet of the site may be used to demonstrate ground water elevation.

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:

- Septic percolation testing on-site, within 200 feet of the proposed facility location and on the same contour; or
- Previous written geotechnical reporting on the site location as prepared by a qualified geotechnical expert; or
- NRCS Lane County Soil Mapping showing unfeasible conditions such as a hydrologic group “D” soil in a low-lying area.

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**. Public Works will waive design-testing if existing testing data is on file with the City for the site. 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)
Drywell System	Required	Minimum one test pit and one test.	Recommended
Soakage Trench	Required	Minimum one test pit and one test per soakage trench.	Not applicable.
Infiltration Sump System	Required	Testing of an existing sump in the vicinity, or construction and testing of one sump.	Recommended
Surface Infiltration Facility	Required	Minimum one test per facility area.	Recommended

2.4.2 Design Testing

The following **test pit** procedure shall be followed:

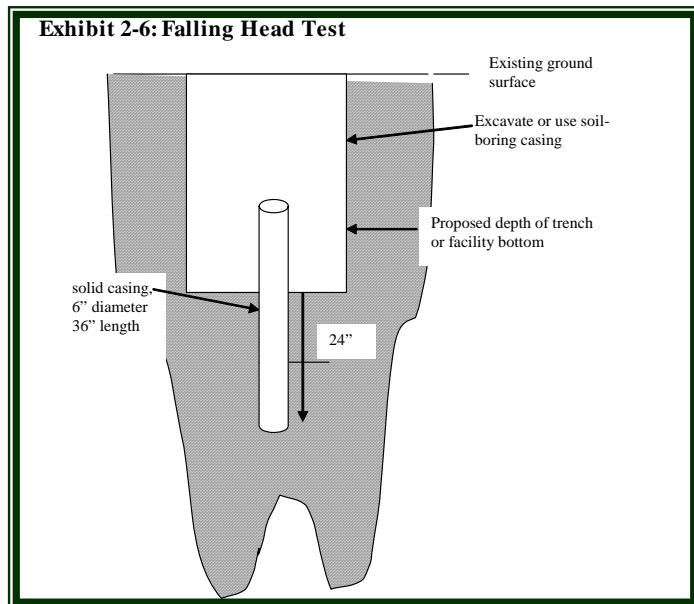
- 1) Excavate a test pit or dig a standard soil boring to a minimum depth of the proposed facility bottom elevation.
- 2) Determine depth to highest seasonal groundwater table (if less than 4 feet to the proposed bottom of all surface infiltration facilities and soakage trenches, and less

than 10 feet to the proposed bottom of all other underground injection system facilities).

- 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 10 feet of proposed bottom).
- 5) The soil description should include all soil horizons.
- 6) The location of the test pit or boring shall be within 50 feet of the facility location and having the same NRCS soil formation; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such. Existing well log data within 200 feet of the proposed facility may be used to indicate the depth to groundwater.
- 7) At least 1 test pit or borehole per 50-foot length of trench shall be tested.

Falling head infiltration test procedure:

- 1) Install casing (solid 6-inch diameter, 36-inch length) to 24 inches below proposed facility bottom (see **Exhibit 2-6**).
- 2) Place 2 inches of $\frac{1}{2}$ - to $\frac{3}{4}$ - inch gravel in the test pipe to protect the bottom from scouring action when the water is added.
- 3) Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate. Remove all loose material from the casing.
- 4) All test pits and boreholes shall be "field saturated" prior to test. The test pipe shall be filled with at



- least 12 inches of clear water. This depth shall be maintained for at least 4 hours. If, after filling the pipe twice with the 12 inches of water, the water seeps completely away in less than 10 minutes, the test can proceed immediately.
- 5) 24 hours later, refill casing with another 12 inches of clean water 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.
- 6) Testing may be done through a boring or open excavation.
- 7) The location of the test shall correspond to the facility location.
- 8) Upon completion of the testing, the casings shall be immediately pulled, and the test pit shall be back-filled.

- 9) Charts, graphs, calculations, and supporting narrative, specifically listing the infiltration rate to be used for the underground injection system designs.

If used, 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.

2.4.3 Post-Construction Testing

If post-construction infiltration testing is performed, test data shall be kept on file with the operation and maintenance records. Post-construction testing on city-maintained facilities shall be performed as directed by the privately engineered public improvement permit.

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 it is documented. The use of laboratory testing to establish infiltration rates is prohibited.

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.

Detention control structures shall be either weir structures or orifice structures. Weir structures may be enclosed in a catch basin, manhole, or vault, or may be installed in the open, provided they are accessible for maintenance and are not exposed to damage. Riser type restrictor devices also provide some incidental oil/water separation and spill control. Weir structures provide some oil/water separation when fitted with a baffle plate located upstream of the weir.

2.5.1 Design Methodologies

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 flood control design storm performance for a detention system. However, extremely low flow rates may result in small orifices (< 2 inches) 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. 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/sec²

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.

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

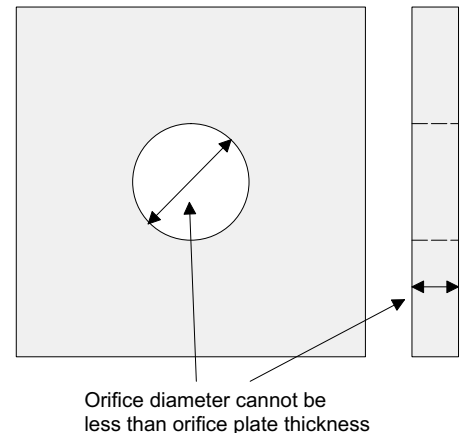
where:

Q = flow, cfs

d = orifice diameter, inches

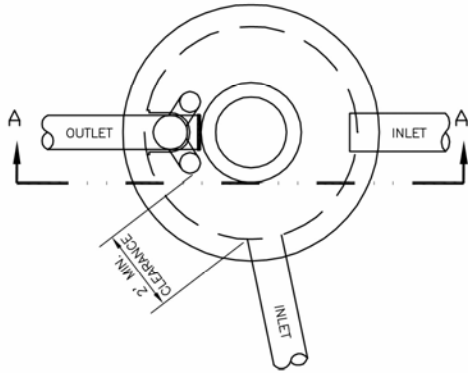
h = hydraulic head, feet

- 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 ¾" 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).



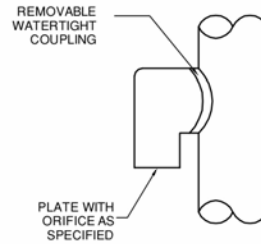
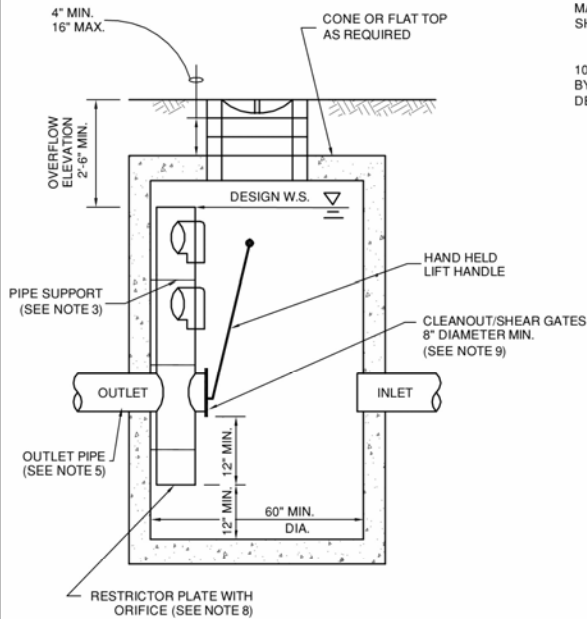
- If less than 3", the orifice shall not be made of concrete. A thin material (e.g., stainless steel, HDPE or PVC) shall be used to make the orifice plate; the plate shall be attached to the concrete or structure.

PLAN VIEW



NOTES:


1. EXCEPT AS SHOWN OR NOTED, UNITS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGER PRECAST CONCRETE MANHOLE PER STANDARD PLAN.
2. FOR DETAILS SHOWING GRADE RING, MANHOLES, AND TOP SLABS, SEE STANDARD PLAN.
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. MULTI-ORIFICE ELBOWS MAY BE LOCATED AS SHOWN OR ALL ON ONE SIDE OF RISER. SIZE OF ELBOWS AND PLACEMENT TO BE CLEARLY LABELED ON PLANS.
8. RESTRICTOR PLATE WITH ORIFICE AS SPECIFIED ON PLANS. SPECIFIED OPENING TO BE CUT ROUND AND SMOOTH.
9. 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.
10. GATE SHALL NOT OPEN BEYOND THE CLEAR OPENING BY LIMITED HINGE MOVEMENT, STOP TABS, OR SOME OTHER DEVICE.



ELBOW DETAIL

SECTION A-A

CITY OF EUGENE
EXHIBIT DRAWING



ORIFICE LOCATION TEE RISER

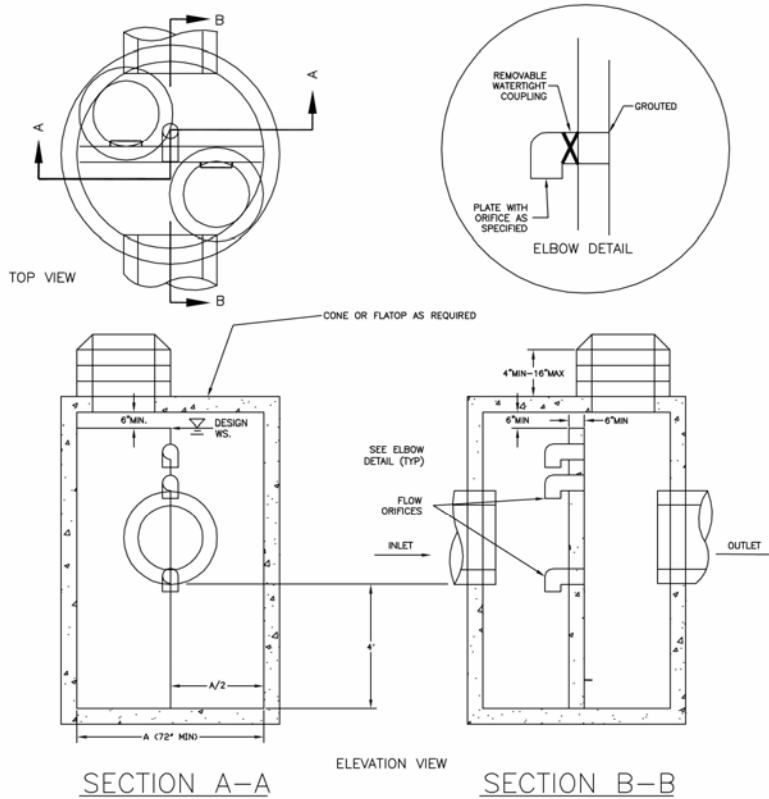
REVISIONS	
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6/06


EXHIBIT 2-7

NOTES

1. EXCEPT AS SHOWN OR NOTED, UNIT SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE REQUIREMENTS FOR LARGE PRE CAST CONCRETE MANHOLES.
2. SEE PROJECT PLANS FOR SIZE AND LOCATION OF ORIFICES.
3. PIPE SIZES, SLOPES AND ALL ELEVATIONS AS SHOWN IN THE PLANS.
4. BAFFLE WALL SHALL HAVE #4 BAR AT 12" SPACING EACH WAY.
5. PRE CAST BAFFLE WALL SHALL BE KEYED AND GROUTED IN PLACE.
6. ORIFICE PLATES TO BE 1/4" THICK MIN. HDPE OR APPROVED EQUAL AND ATTACHED WITH 1/2" STAINLESS STEEL BOLTS.



CITY OF EUGENE
EXHIBIT DRAWING

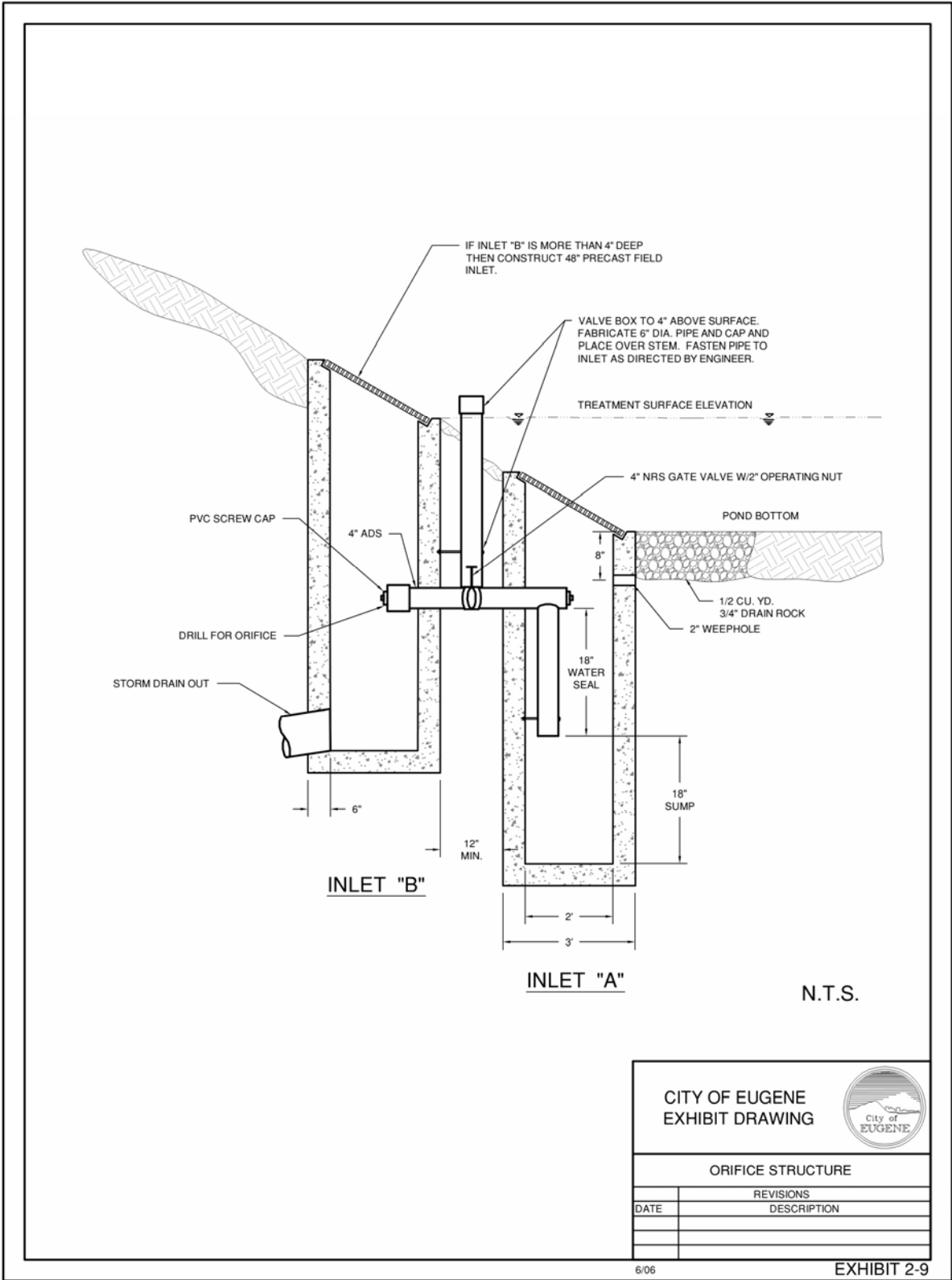


ORIFICE LOCATION BAFFLE RISER

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EXHIBIT 2-8



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

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

Where:

Q = Weir discharge, cfs

C_d = Contraction coefficient, feet (suggested value = 2.5 for 90 degree weir)

θ = Internal angle of notch, degrees

H = Height from weir bottom to crest, feet

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 10 feet wide, not to exceed 10 percent in slope, and shall be located adjacent to public rights-of-way wherever feasible. Access routes greater than 100 feet in length shall provide a vehicle turn-around (see *Public Improvement Design Standards Manual*) for the maintenance vehicles. 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

2.7.1 Landscaping Applications

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.
- A stormwater management matrix listing the facility square footage and the required numbers of plants required per plant type (Evergreen or Deciduous Trees, Large Shrubs/Small Trees, etc.). Quantities shall be rounded to the integer.
- A stormwater management plant list/table, including scientific name, size at time of planting, quantity, type of container, evergreen or deciduous, appropriate planting season, 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 Prevention Code and its corresponding Administrative Order(s)*. Soil analysis for all topsoil to be used within the facility area.

2.7.2 Landscaping Design and Management

Vegetation is a key element in the pollution reduction performance for many stormwater management facilities. Facility-specific planting practices are shown in **Section 2.9**. These practices are based on 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 an Alternative Revegetation approach, which allows smaller materials to be planted in larger quantities. If this approach is chosen, the following practices 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 Eugene 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 G** 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.

Stormwater facilities located in the public street right-of-way are not required to use evergreen trees to meet landscaping requirements. Also, all planting in the rights-of-way and adjacent to rights-of-way shall plant appropriate plantings that do not interfere with vision and sight clearances and will not become a nuisance growing out over the public sidewalks.

In some cases, other landscaping that is required by Eugene Code may be counted toward meeting the facility-specific landscape requirements for stormwater management, if the plantings are located within the facility area. Similarly, in some cases, plantings that meet the schedules in this chapter may also meet other Eugene Code landscape requirements.

It is critical that selected plant materials are appropriate for soil, hydrologic, and other facility and site conditions. Each of the vegetated stormwater facilities has individual planting requirements. Lists of recommended plants are provided in **Appendix G**. Designers may choose other plant species amenable to this climate provided they are

meet the appropriate the size criteria. The appropriate sizing criteria for the plant materials listed in the individual facility landscaping requirements are described as:

Large Grass-like Plant: a large grass-like plant shall reach a minimum of over 1' in height at maturity and shall be grass-like in form.

Shrub (Shrub v. Large Shrub): Shrubs are multi-stemmed woody plants. For the purposes of implementing this Manual, the term "shrub" refers to shrub species having a documented mature height of 12 feet and under. "Large shrub" refers to shrub species having a documented mature height greater than 12 feet.

Trees (Large v. Small): For the purposes of implementing this Manual, the term "small trees" refers to tree species having a documented mature height of 20 feet and under. "Large trees" refer to tree species having a documented mature height greater than 20 feet.

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.

For City-maintained facilities located outside of the public right-of-way, all plants within the facility area shall be appropriate native species from the recommended plant lists in **Appendix G** (no nuisance or prohibited plants).

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 some other means to complete the specified plantings and protect against erosion before water is allowed to enter the facility.

2.8 OUTFALL DESIGN

Outfalls should be located above the downstream mean low water level, unless a pipe velocity of 3' per second can be maintained with the pipe outfall located below the water surface level. **Exhibit 2-10** shows a typical outfall layout. Publicly accessible outfalls greater than 15 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.

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.

Drainage ways and rivers may have steep slopes or banks and may have unstable landforms (i.e. slump). Geotechnical investigation and analysis to determine the stability of the stream or river bank shall be provided with the stormwater study.

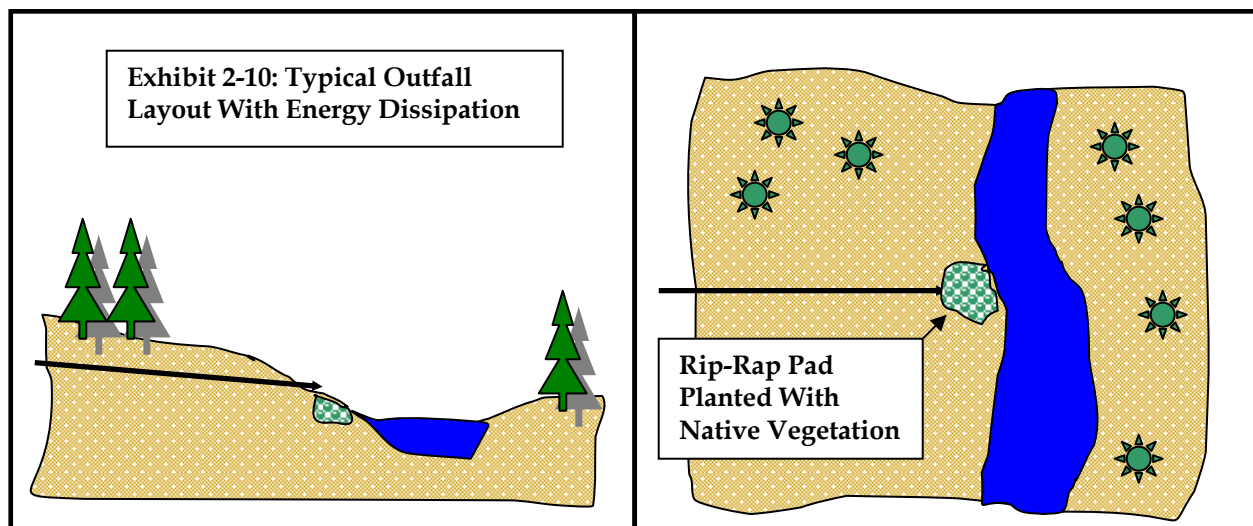


Exhibit 2-11
ROCK PROTECTION AT OUTFALLS FOR PIPES GREATER THAN 6 INCHES IN DIAMETER

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. whichever is greater	As calculated	Crown + 1 ft.
11	To	20	Gabion or Riprap*	2 x (max stone size)	Diameter + 6 ft. or 4x dia. whichever 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's *Standard Construction Specifications*

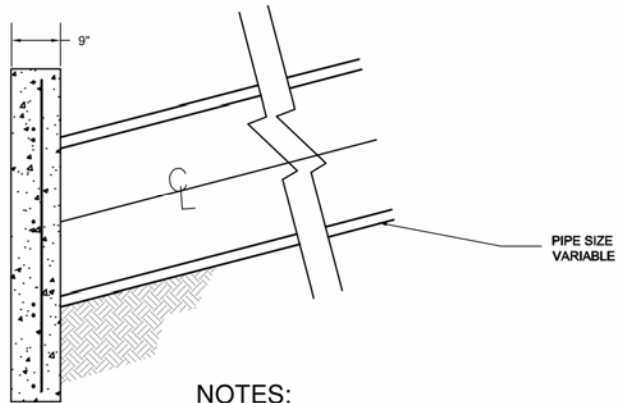
V = Average velocity (ft/s) *Riprap size $ds=0.25*Do*Fo$ (6" minimum)
Do = Pipe diameter (ft) Depth=2*ds (1 foot minimum)
ds = Riprap diameter (ft) **Apron length $Lsp= Do(8+17*Log Fo)$
Lsp = Apron length (ft)
depth = Thickness (ft)
 $Fo = V/(g*Do)^{0.5}$ $g = 32.2 \text{ ft/s}^2$

***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

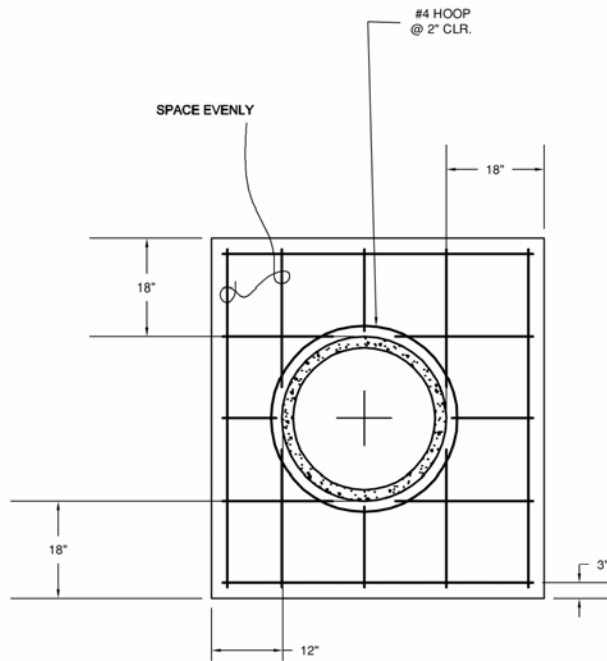
Weight (lbs)	Spherical Size (inches)	% by Weight	Average Stone Size (inches)
Class 50			6.3
30 – 50	8.5 – 10	20	
15 – 30	6.7 – 8.5	30	
2 – 15	3.5 – 6.7	40	
0 – 2	0 – 3.5	10	
Class 100			7.6
60 – 100	10.6 – 12.8	20	
25 – 60	8.0 – 10.6	30	
2 – 25	3.5 – 8.0	40	
0 – 2	0 – 3.5	10	
Class 250			11.3
200 – 250	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



NOTES:

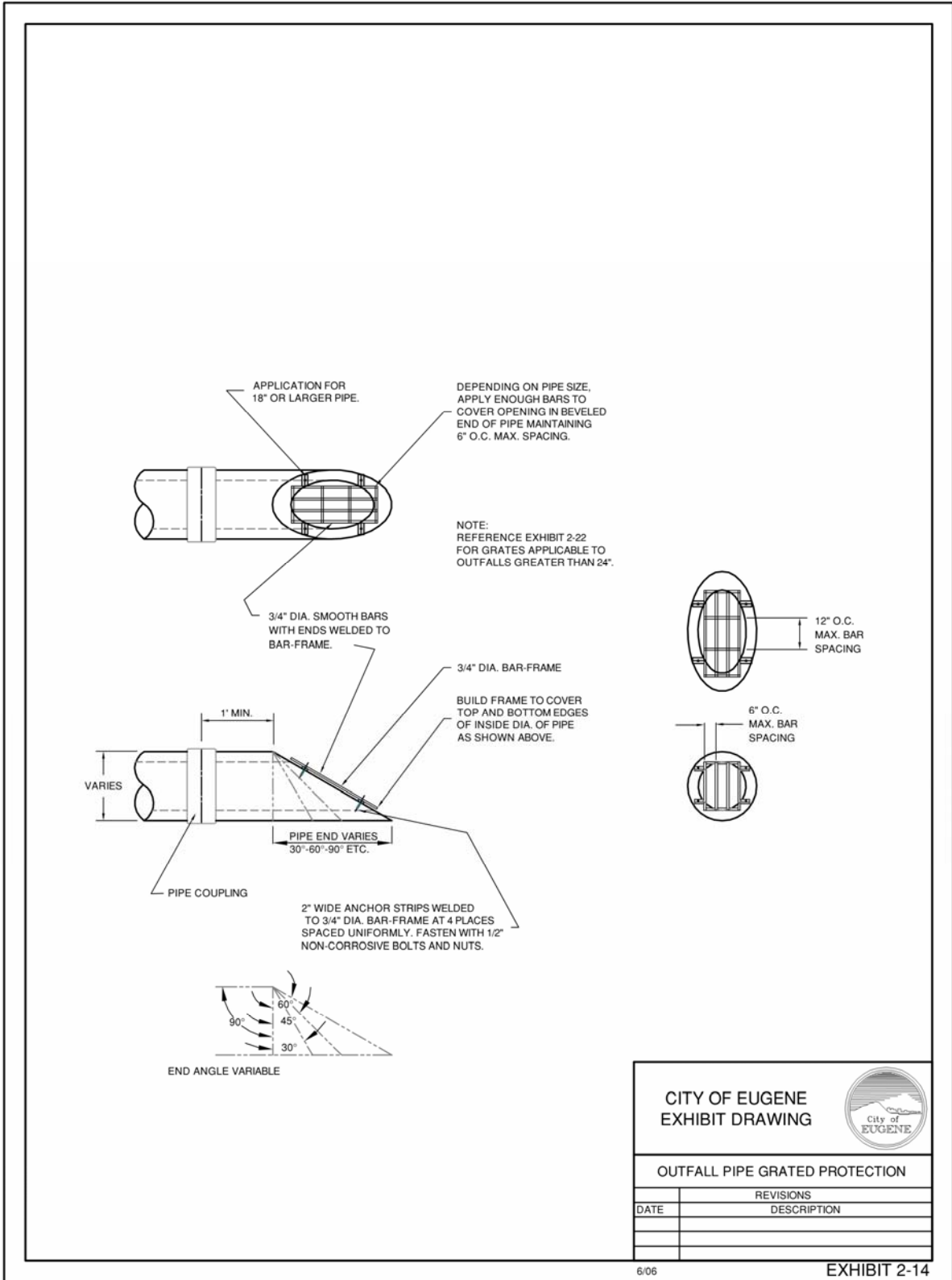
1. FILL AROUND ENDWALLS TO 6" BELOW TOP OF WALL.
2. BASE OF OUTFALL SHALL BE POURED AGAINST UNDISTURBED SOIL.



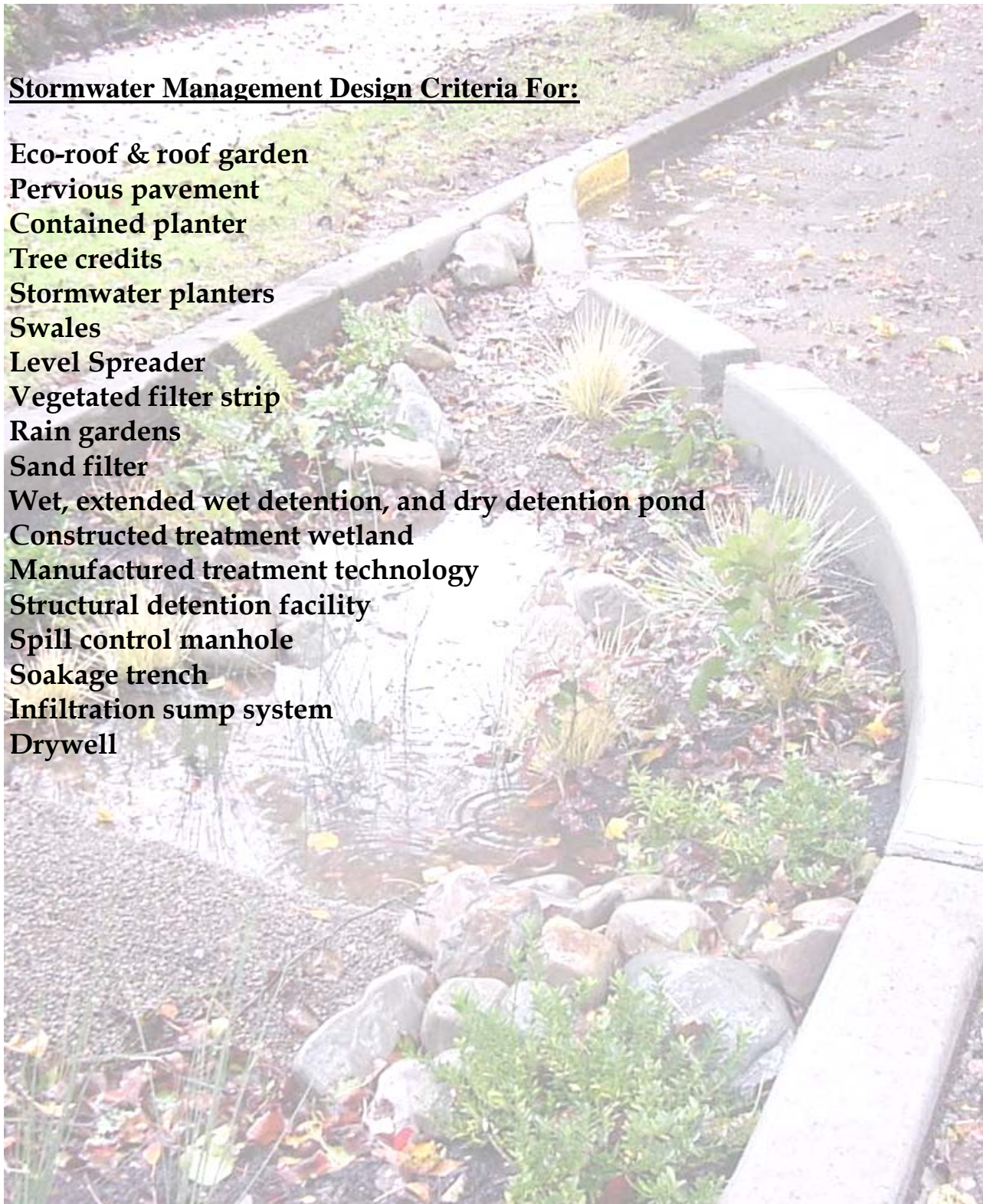
CITY OF EUGENE EXHIBIT DRAWING		
END WALL DETAIL		
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EXHIBIT 2-13



2.9 FACILITY SELECTION AND DESIGN



Stormwater Management Design Criteria For:

Eco-roof & roof garden

Pervious pavement

Contained planter

Tree credits

Stormwater planters

Swales

Level Spreader

Vegetated filter strip

Rain gardens

Sand filter

Wet, extended wet detention, and dry detention pond

Constructed treatment wetland

Manufactured treatment technology

Structural detention facility

Spill control manhole

Soakage trench

Infiltration sump system

Drywell

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