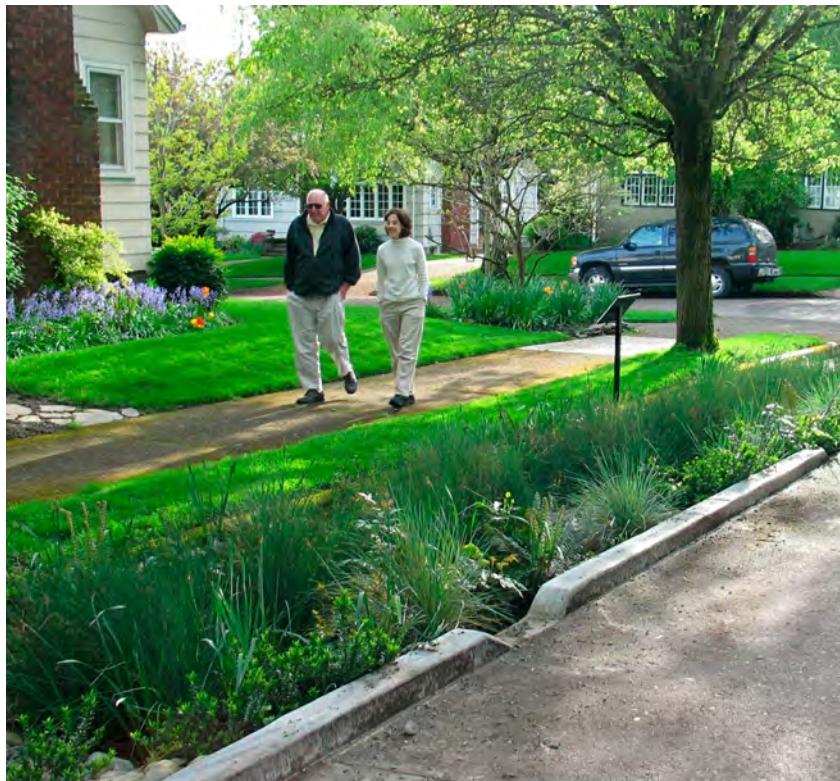


2021



Low Impact Development Approaches Handbook



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Chapter 1: Introduction

This handbook was developed to promote and encourage Low Impact Development Approaches (LIDAs) to protect natural resources. It is a practical tool for those who make or influence development decisions and will be updated as codes and policies change and new techniques and best practices emerge. The handbook was updated in June 2021.

The handbook is a collaborative product of the Tualatin Basin Natural Resources Coordinating Committee, which includes the land use jurisdictions within urban Washington County, and Clean Water Services, Tualatin Hills Park and Recreation District and Metro. Clean Water Services is a water resources management utility in urban areas of the Tualatin River Watershed that builds, maintains and enhances the public drainage system in partnership with Washington County and its member cities.

Clean Water Services (the District), the county and member cities manage stormwater runoff to meet public needs and comply with strict water quality regulations set for the Tualatin River basin by the Oregon Department of Environmental Quality (DEQ).

The District's Design and Construction Standards (the Standards) define the requirements for development to treat and detain stormwater runoff. Stormwater is the runoff from impervious surfaces such as streets, roofs and parking lots that flows to storm drains, ditches and culverts, and then to the nearest river, stream or wetland. When it rains, stormwater runoff may pick up oil, sediment, bacteria, grease and chemicals that can pollute local waterways and the Tualatin River. Stormwater runoff can also have a physical impact on waterways through hydromodification, which occurs when too much water moves off the land too fast.

LIDAs offer more options to comply with stormwater management requirements, and complement the water quality facilities and vegetated corridors that have been established as part of the Standards. The five objectives of LIDA are to:

1. Conserve Existing Resources
2. Minimize Disturbance
3. Minimize Soil Compaction
4. Minimize Imperviousness
5. Direct Runoff from Impervious Areas onto Pervious Areas

This handbook is intended to be used as a guidance for complying with the current [Clean Water Services Design & Construction Standards](#) as they relate to LIDA requirements and should be used in conjunction with them and other applicable regulations.

The Handbook is for use by all public agencies within the Tualatin Basin as a reference document. There may be other standards and requirements that are jurisdiction-specific and users are encouraged to check with the local jurisdiction for additional information.

Chapter 1: Introduction



LIDA swale



Green Roof



Porous Pavement



Vegetated Swale



Extended Dry Basin



Constructed Water Quality Wetland



Infiltration Planter



Flow-Through Planter



Vegetated Filter Strip

Chapter 1: Introduction

1.1 Why Use Low Impact Development Approaches (LIDAs)?

Typically, LIDA facilities are vegetated landscape elements such as planters, vegetated filter strips and swales that filter and/or infiltrate stormwater. Other types of LIDAs are porous pavements and green roofs that reduce impervious area and runoff volume. LIDAs are integrated with the site landscaping to provide stormwater management, visual amenities and habitat benefits. Low impact site design may preserve trees and vegetation, and conserve and reuse water. Site design approaches may include lot size averaging, density transfers and clustering or placement of buildings and parking areas to avoid impacts to habitat, vegetation and drainage courses. Low impact design may also reduce the need for and/or sizing of practices addressing hydromodification.

In addition to aesthetic and habitat benefits, LIDAs may:

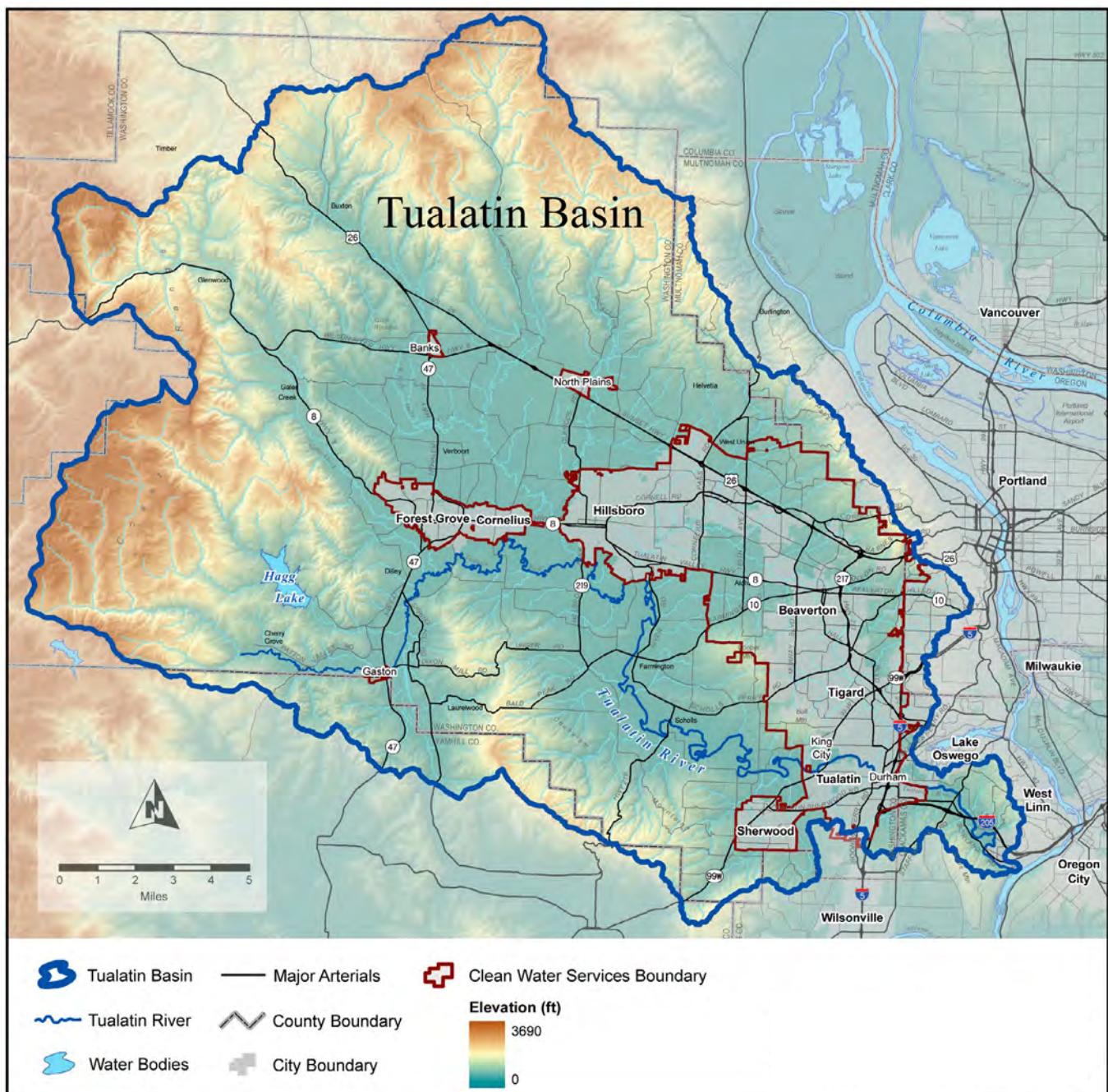
- Meet Clean Water Services' stormwater quality requirements for new development and redevelopment sites.
- Reduce area needed for water quality and/or hydromodification facilities by integrating LIDAs into landscaping, buildings and pavements, which may result in more buildable land.
- Reduce and slow stormwater runoff for better water quality and less hydromodification via erosion.
- Cut project costs by eliminating piping and other engineered structures.
- Reduce the piping and excavation needed to manage stormwater runoff because it is conveyed and treated above ground.
- Use the same areas for stormwater management and landscaping (e.g. a flow-through planter may count toward required site landscaping).
- Qualify for credits for green building, site design, etc.
- Qualify for development credits such as allowable building height increases, reduced set-backs or reduced lot sizes.
- Preserve trees and significant vegetation by incorporating them into LIDA facilities or protecting them in the site design.
- Provide mitigation of heat island effects and related climate change outcomes.

The LIDA facilities included in this Handbook are not considered to be Underground Injection Control (UIC) systems.. Check with the District or DEQ staff for additional information about UIC requirements.

1.2 How this Handbook Relates to Other Tualatin Basin Regulations

The LIDA handbook is intended to provide guidance when planning, designing and maintaining LIDA facilities. The District requires the use of Low Impact Development Approaches to meet stormwater quality requirements for development. The District implements stormwater requirements in unincorporated portions of its service area and within the Cities of Banks, Durham, King City and North Plains. In Beaverton, Cornelius, Forest Grove, Hillsboro, Sherwood, Tigard and Tualatin, the cities' staff implement and enforce the requirements. The current Design & Construction Standards should be consulted for more specific requirements and information.

Chapter 1: Introduction



Map of Clean Water Services District Boundaries

Chapter 1: Introduction

1.3 Design and Construction Standards

This handbook is a reference for all jurisdictions within the Tualatin Basin. Users are encouraged to consult with the local jurisdiction for additional requirements and standards. This handbook is a supplement and is to be used in conjunction with the Design and Construction Standards and other applicable regulations. LIDAs do not replace Water Quality Sensitive Areas or Vegetated Corridors.

The requirements included in the Design and Construction Standards protect water quality, stream corridors (including floodplains) and habitat functions from the impacts of development. Water Quality Sensitive Areas, including streams and wetlands, must be protected by Vegetated Corridors. Always check the county and city planning and development standards for additional site design requirements.

LIDAs may not be allowed by the local jurisdiction due to physical constraints, code restrictions or other issues. For example, a LIDA based on infiltration might not be allowed on unstable slopes, areas of high groundwater table, or soils with poor infiltration. Property owners, developers, designers and contractors must check with local permitting authorities to confirm that LIDAs are allowed for their projects.

LIDAs are intended to reduce and mitigate the environmental impacts of conventional development by mimicking natural hydrology instead of replacing it with imperviousness. LIDAs may meet water quality regulations and stormwater flow management goals, and may also qualify for development credits from local jurisdictions by protecting vegetation and habitat located outside of the required Vegetated Corridors.

1.3 Additional Information

Additional information is available from other jurisdictions, academia, state and federal governments, non-governmental organizations and others. Below is a brief list of where additional information on Low Impact Development and stormwater management may be available.

- Clean Water Services Design & Construction Standards
- City of Portland – Stormwater Management Manual
- City of Gresham – Stormwater Management
- City of Seattle – Stormwater Manual
- Western Washington Stormwater Manual

Additionally, information related to local building, plumbing and other codes may be found here:

- Wasington County Building Services
- Oregon Plumbing Code
- Oregon Department of Transportation

Chapter 1: Introduction

1.4 General Terms

Below are general terms with their definitions used throughout the handbook. Additional definitions of terms are included throughout this handbook.

Best Management Practices (BMPs) are techniques used to control stormwater runoff, sediment control and soil stabilization, as well as management decisions to prevent or reduce nonpoint source pollution. The EPA defines a BMP as a "technique, measure or structural control that is used for a given set of conditions to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner."

Low Impact Development Approaches (LIDA) mitigate the impacts of increased runoff and stormwater pollution using a set of planning, design, construction techniques and stormwater management approaches that promote the use of natural systems for infiltration, evapotranspiration and reuse of rainwater. LIDA can occur at a wide range of landscape scales (i.e., regional, neighborhood and site) and include, but are not limited to, green roofs, porous pavement and vegetated stormwater management approaches.

Green development practices: Stormwater management techniques that utilize the processes of retention, infiltration and evapotranspiration to treat runoff and reduce the volume of stormwater. (Gresham Development Code)

Low impact design: An approach for site development that protects and incorporates natural site features into erosion and sediment control and stormwater management plans. (Low Impact Design Manual for the Auckland Region 2000)

Low impact development aims to mimic natural hydrology and processes by using small- scale, decentralized practices that infiltrate, evaporate and transpire rainwater. Specifically, LID aims to:

- Minimize impervious surfaces;
- Disconnect hydrologic elements (roofs, downspouts, parking areas);
- Maintain/increase flow paths and times; and
- Utilize decentralized treatment practices. (NAHB Research Center Toolbase Services)

Also, a stormwater management and land development strategy applied at the parcel and subdivision scale that emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic predevelopment hydrologic functions. (Low Impact Development – Technical Guidance Manual for Puget Sound)

Retrofit Project: A project that addresses existing stormwater management issues where there were previously no requirements.

Chapter 2: Site Planning for LIDAs

2.1 Site Analysis

The first step in using LIDAs is a thorough site analysis to learn how water moves through the site and how natural hydrologic functions could be preserved. Inventory conditions on and adjacent to the site, including topography, soils, hydrology and vegetation. The site analysis includes site visits, topographical and vegetation/habitat surveys, review of maps and reports and development of a site base map.

In the site analysis, the physical attributes of the development or redevelopment site should be reviewed before placing streets, parking lots and buildings to optimize stormwater management and habitat protection. Existing features should be incorporated into the site design by working with rather than against site attributes and constraints. A site layout that integrates site amenities to manage stormwater and protect habitat may reduce permitting delays.

Site analysis should follow the order depicted in Figure 1 and answer the questions below.

1. Topography

Is the site flat, steep, or moderately sloped?

The steeper the slope, the more likely soil erosion or slides could occur. Generally, slopes greater than 25% should be avoided for clearing, grading and building. Steep slopes and slide prone areas are not advisable for infiltration LIDAs. A geotechnical engineering analysis may be necessary to determine appropriate LIDAs.

2. Soils

What is the site soil type, hydrologic group, infiltration capacity and are groundwater tables high?

Use soil maps, which are available from the Natural Resources Conservation Service (NRCS) Soil Survey for Washington County. Sizing may be adjusted for some LIDAs based on tested infiltration rates unless high groundwater is an issue. Engineered media may be used to facilitate infiltration and retention of stormwater in poor draining soils provided they are allowed by local code.

3. Hydrology

What are the flow patterns into, on, and from the site? Where will runoff drain? Does the site have FEMA floodplains or floodways, drainage hazard areas, or Water Quality Sensitive Areas, seeps or springs?

Working with the site's flow patterns may reduce grading and associated costs.

4. Vegetation & Habitat

Are there trees and vegetation, especially large trees (6" diameter or larger at 4-foot height) or native vegetation on the site?

Native trees and vegetation should be protected. Check local planning and development codes for habitat and tree protection requirements. Local codes also may offer incentives for protecting and avoiding trees and habitat. Preservation of vegetation and habitat may also reduce the over need for stormwater management on site.

5. Water Quality Sensitive Areas

Are there year-round or intermittent streams or channels or wetlands?

These features are protected by Corps of Engineers or Oregon Department of State Lands (DSL) environmental regulations, and the District Standards require Vegetated Corridors to protect them. Refer to National and Local Wetlands Inventory maps and consult with the District or local jurisdiction.

Chapter 2: Site Planning for LIDAs

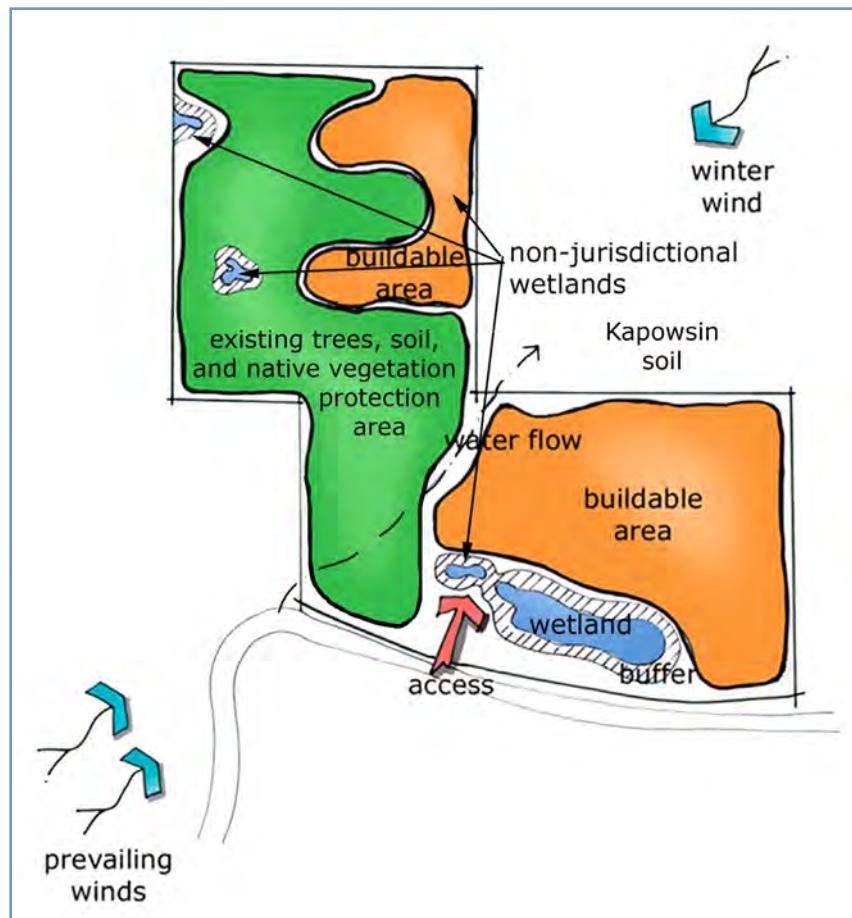


Figure 1

Site Analysis process diagram. Graphic from the LID Technical Guidance Manual for Puget Sound, courtesy of Puget Sound Partnership and AHBC, Inc.

Chapter 2: Site Planning for LIDAs

6. Land Use/Zoning

What type and density of development is allowed/required? Are there special or protective overlay zones? Can development be clustered or lot sizes altered?

7. Access

What are the options for auto, bike and pedestrian access, circulation and parking?

8. Utility Availability and Conflicts

What potential utility conflicts exist? Where are existing utility connections (water, sewer, storm drainage, electricity/phone/cable, etc.)? Where can new utilities be constructed with least impacts?

2.2 Site Planning

After completing the site analysis, prepare a site plan for permit submittal that addresses the five LIDA objectives listed below:

Site planning for LIDAs is based on these objectives, in order of importance:

1. Conserve Existing Resources
2. Minimize Disturbance
3. Minimize Soil Compaction
4. Minimize Imperviousness
5. Direct Runoff from Impervious Areas onto Pervious Areas

1. Conserve Existing Resources

The first and most important step in LIDA site planning is to preserve and protect existing water features and vegetated areas. Although the Standards require permanent protection of Water Quality Sensitive Areas and Vegetated Corridors, protection of mature trees and vegetation provides habitat, prevents erosion, captures significant rainfall, provides summer shading and reduces runoff volume and velocity, which protects and enhances downstream water quality. Preservation of trees and vegetation may qualify for local incentives, and may reduce a site's ultimate impervious area and the size of required water quality or LIDA facilities.

2. Minimize Disturbance

Protection of existing vegetation provides more water quality benefits than replanting areas that have been cleared. Undisturbed areas provide more rainfall interception, evapo-transpiration and runoff rate attenuation than replanting even with soil amendments.

Construction activities that compact native soils significantly reduce infiltration capacity and increase runoff. To minimize disturbances, identify areas required to be protected and other areas that will not be cleared or impacted during construction. On plan submittal drawings, identify site work zones and no-disturbance areas. On the site, use orange construction fencing to mark work zones, access points, materials storage and areas where no disturbances will be allowed.

Chapter 2: Site Planning for LIDAs

3. Minimize Soil Compaction

Avoid any activity that could cause soil compaction in areas designated for infiltration LIDAs. In order to minimize soil compaction where LIDAs, water quality or detention facilities, or landscaping will be placed, fence off these areas and keep vehicles and equipment traffic out during construction. Clearing, grading and compaction by construction traffic reduces the natural absorption and infiltration capacities of the native soils. Subsequent tilling and/or addition of soil amendments such as compost can help, but will not restore the original infiltration capacity of the soils.

4. Minimize Imperviousness

Site design layout methods that reduce impervious footprints may include: shared parking areas; clustered buildings that require fewer driveways and pathways; reduced parking stalls, especially in transit-served areas; adding floors to buildings or parking garages; and reduced street width if allowed by local planning codes. In site design, strive to reduce the actual footprint of buildings and paving to reduce and slow runoff from built surfaces. Green roofs and porous pavement are effectively pervious; although they are not water quality facilities, they reduce the site impervious area and the volume of stormwater to be treated.

5. Direct Runoff from Impervious Areas onto Pervious Areas

This is the last line of defense against downstream impacts. While the first four objectives prevent runoff and pollution transport, this objective addresses pollutants in runoff from roofs, parking lots, streets and other impervious surfaces. Most LIDA facilities and water quality facilities fulfill this objective, including: planters, swales, vegetated filter strips, extended dry ponds and constructed water quality wetlands that serve as pervious, landscaped areas designed to receive runoff from impervious areas.

2.3 Selecting LIDAs to Match Site Conditions

LIDA facilities can be constructed on and adjacent to buildings, and integrated into site landscaping and hardscape such as parking lots and along streets. LIDA facilities can be used singly to manage rainfall and runoff from a drainage area, or constructed in a series of multiple facilities. The site analysis helps identify the types of LIDAs best suited to the site.

Owners and designers may use Table 1 as a quick reference to match each LIDA with common stormwater management objectives and site constraints to select the most appropriate facilities.

Chapter 2: Site Planning for LIDAs

Table 1
Summary of Approvable LIDA (Adapted from CWS D&C Standards Chapter 4)

Stormwater Management Approach	May be Approved for Public System ¹	Quantity for Conveyance Capacity	Hydromodification Approach	Water Quality Treatment Approach
Vegetated Swale	X			X
Extended Dry Basin	X	X	X	X
Constructed Water Quality Wetland	X	X	X	X
Structural Infiltration planter	X	X	X	X
Non-Structural Infiltration planter (Rain Garden)	X	X	X	X
Flow-Through Planter	X			X
LIDA Swale	X			X
Street-Side Planter	X	X	X	X
Landscape Filter Strip	X			X
Vegetated Corridor as a Filter Strip	X			X
Green Roofs		X	X	
Porous Pavement	X	X	X	

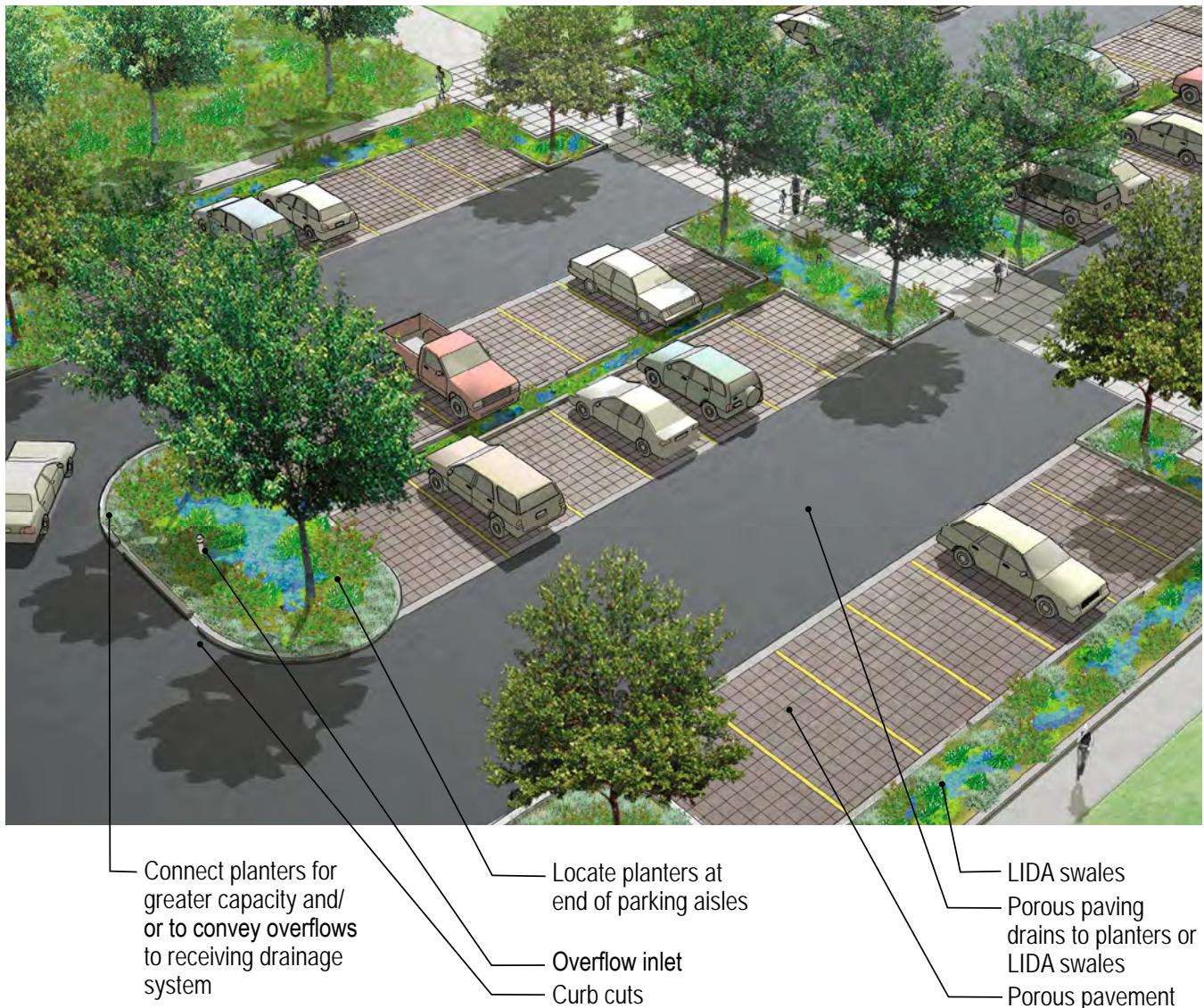
1 Approaches in the right-of-way must be approved by the local road authority.

Figures 2, 3 and 4 on the following pages illustrate how various LIDAs can be integrated into development sites, landscaping and street designs.

Chapter 2: Site Planning for LIDAs

LIDAs in Parking Areas

Figure 2



Chapter 2: Site Planning for LIDAs

LIDAs for Streets

Figure 3



Porous pavement in parking lanes

Catch basin receives overflows

Flow-through or infiltration planters at corners

Street trees for shading and stormwater interception

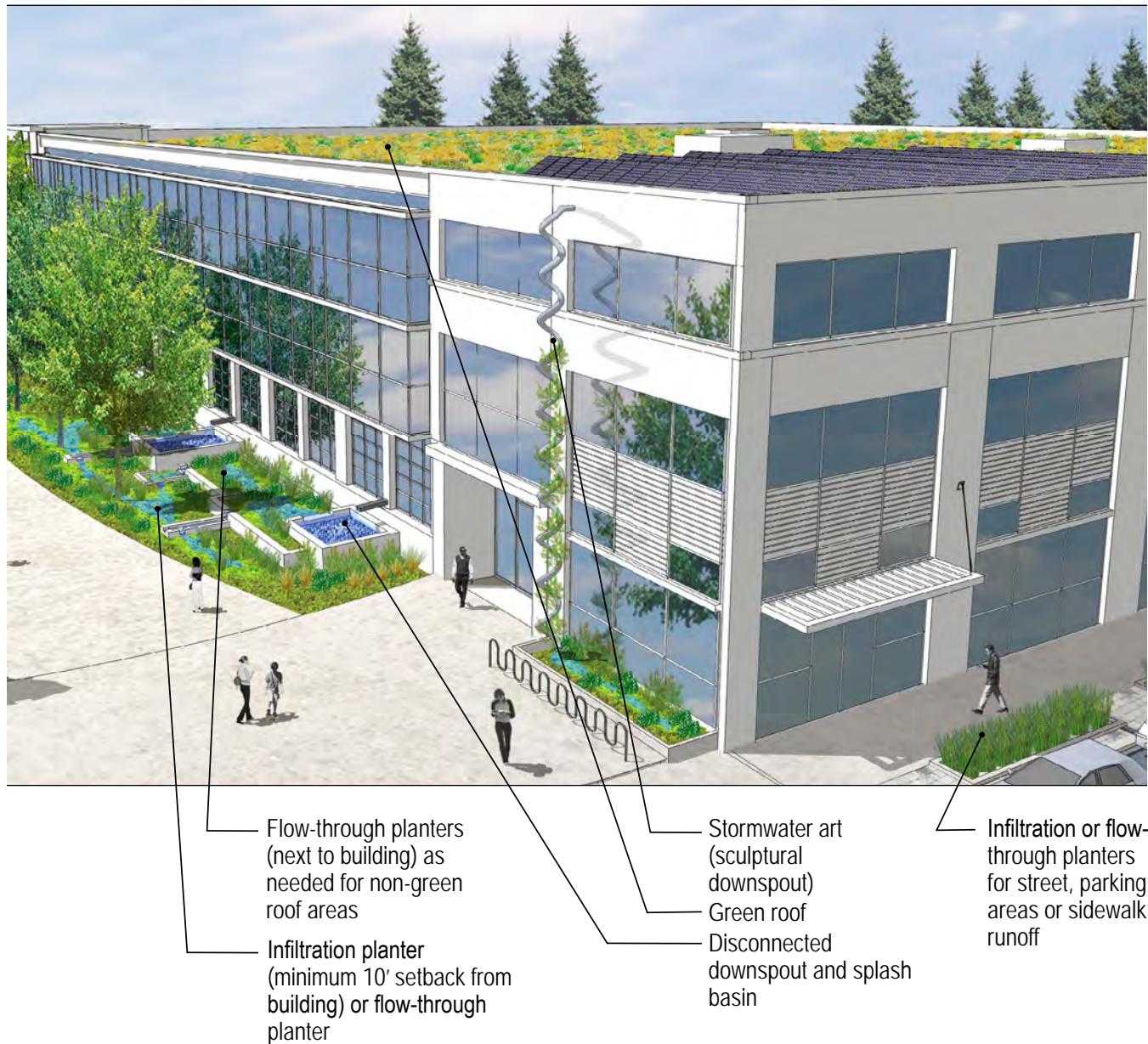
LIDA swales, flow-through planters or infiltration planters

Pedestrian crossing over swale

Chapter 2: Site Planning for LIDAs

LIDAs for Buildings and Adjacent Areas

Figure 4



Chapter 3: LIDA Design Process

3.1 Design Basis

Primary goals of LIDA site design are to reduce the volume of stormwater runoff and to treat pollutant loads where they are generated using appropriate site planning and by directing stormwater to small-scale natural systems throughout the site. Integrating LIDAs into landscaping and the site design may reduce the size of or eliminate the need for larger water quality facilities in separate land tracts, and may reduce underground piping, curbs and gutters.

The District requires stormwater treatment for nearly all development and other activities that create new impervious surfaces or increase the amount of stormwater runoff or pollution leaving the site. Refer to the Standards for specific requirements and how to calculate the impervious area requiring LIDA or water quality facilities.

Stormwater treatment to remove pollutants is required in the Tualatin River Basin by the Oregon Department of Environmental Quality to comply with the Clean Water Act. The District's Total Maximum Daily Load (TMDL) and National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit require new development and redevelopment to reduce pollution from stormwater runoff. This is achieved by constructing water quality facilities to remove pollution, or by using LIDAs to reduce runoff and pollutants.

The water quality storm runoff rate volume calculations for sizing water quality facilities are presented in Chapter 4 of the Design and Construction Standards. To determine the size of LIDA facilities, owners and designers may use the LIDA Sizing Form in Section 3.2. This form is based on the water quality design storm and typical soil conditions. For retrofit projects where there has been no stormwater treatment, the sizing requirements must be determined by District and city staff. Do not rely solely on the sizing methods in this handbook.

LIDA facilities are intended as stormwater quality facilities, though they may provide some detention benefits. Onsite stormwater quantity detention may be incorporated into LIDA facility design in some cases if required. Porous pavement, Structural Infiltration planters or rain gardens may be adapted to provide detention storage. Porous pavement may be constructed with vaults or gravel/rock storage galleries to detain excess runoff. Structural Infiltration planters or rain gardens may reduce stormwater runoff volume to meet all or part of a site's detention requirements if there is adequate native soil infiltration (greater than 2 inches per hour). Engineered media may be used if native soil infiltration is deemed inadequate depending on local code. Also, extended dry basins and constructed water quality wetlands (refer to the Water Quality Facilities section of the Design and Construction Standards) may be designed with additional capacity to provide both detention and water quality treatment. *When detention and treatment functions are to be combined, the analysis and design calculations must be done by a registered professional engineer.*

See the fact sheets in Chapter 4 for specific design criteria, photos and drawings of various LIDA facilities.

Chapter 3: LIDA Design Process

3.2 Design Steps for LIDA Facilities

For most development sites, LIDA facilities may be designed using District sizing factors. Complete stormwater plan submittal requirements are detailed in the Design and Construction Standards, and local jurisdictions may have additional requirements. For sites less than one acre, the impervious area requiring treatment may be reduced if LIDAs are used. This Handbook includes a LIDA Sizing Form to assist in sizing. The following steps describe the sizing process.

STEP 1: Determine impervious area requiring treatment

- Refer to Chapter 4 of the Design and Construction Standards for instructions to calculate the impervious area requiring water quality treatment for new development and redevelopment sites.

STEP 2: Deduct impervious area LIDA credits

- Deduct the site areas designed with porous pavement or green roofs from the impervious area calculated in Step 1.
- Check with the local jurisdiction about any additional credits (i.e. rainwater harvesting, tree protection, etc.)

STEP 3: Size LIDA facilities for remaining impervious area

- Use the LIDA Sizing Form to determine the size of LIDA facilities required to treat stormwater runoff from the remaining impervious area.
- Sizing factors for infiltration-based LIDAs assume an existing site soil infiltration rate of less than 2 inches per hour. Fact sheets for these facilities (in Chapter 4) provide information about soil infiltration testing that may be performed if the designer believes site soils have greater infiltration capacity and wants to produce information to support a smaller sizing factor.
- If more than one LIDA facility is used on the development site, each facility must be sized for the amount of impervious area draining into it.

STEP 4: If needed, design water quality facilities for large impervious areas or remaining untreated impervious area

- The sizing factors noted in this Handbook shall not be used for LIDA facilities treating runoff from more than 15,000 square feet of impervious area.
- For large development sites and impervious areas, a large water quality facility (vegetated swale, extended dry basin or constructed water quality wetland) or proprietary facility may be appropriate.

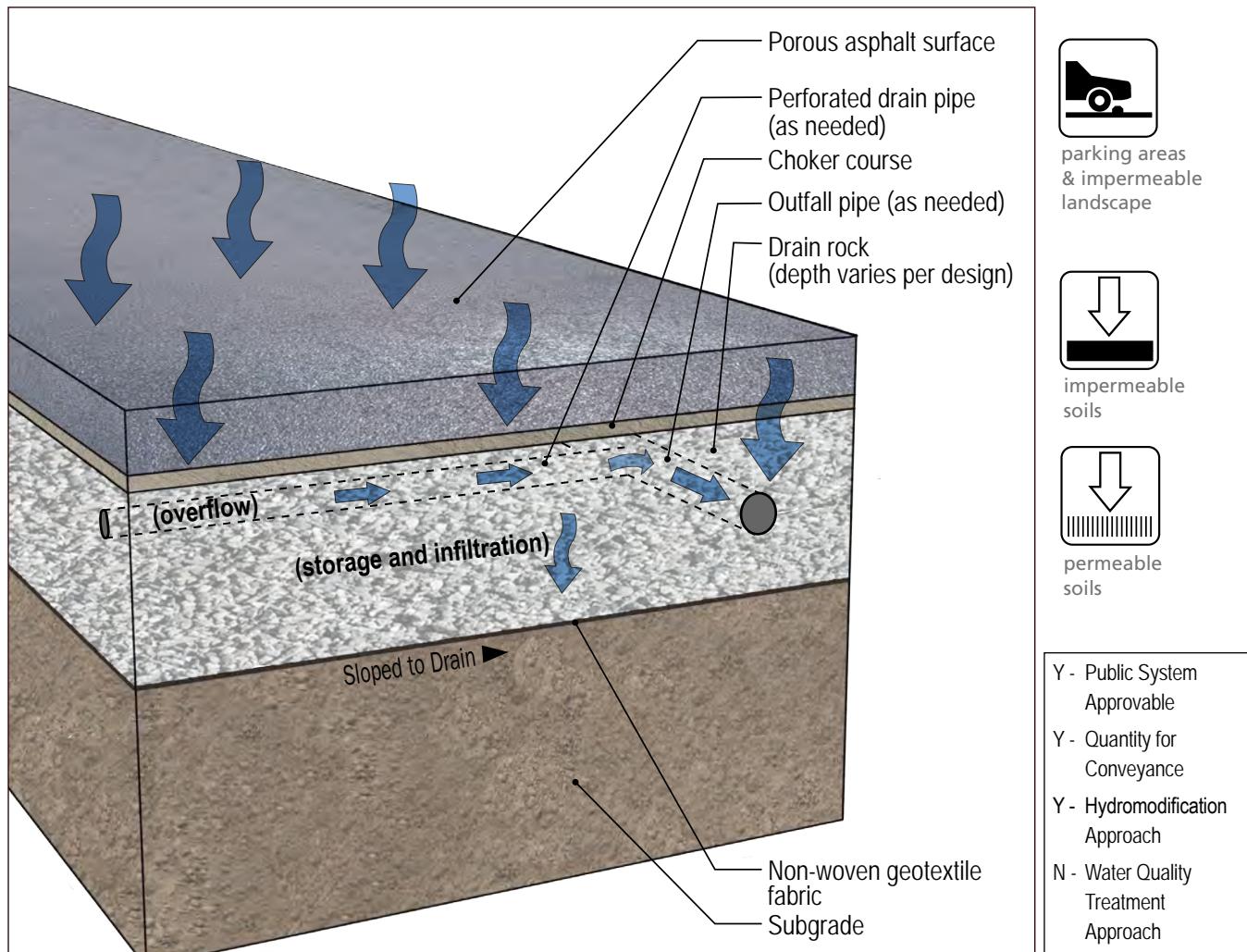
(*Must equal total from Step 2 or additional LIDA facilities or Water Quality Facilities must be added.)

Chapter 4: LIDA Fact Sheets

These fact sheets provide example photos, design layout sketches, use and design criteria, planting and maintenance information for the types of LIDAs allowed by District Standards. Table 2 lists the fact sheet content and whether to use the LIDA sizing form for a particular LIDA.

Table 2: LIDA Fact Sheet Table

	Content	Use LIDA Sizing Form?
Porous Pavement	Impervious area reduction using porous pavers, pervious asphalt or concrete	Yes
Green Roof	Impervious area reduction using green roof technology, for roofs with 1:3 pitch or flatter	Yes
Structural & Non-Structural Infiltration Planter/ Rain Garden	Planters, rain gardens, vegetated infiltration basins, for native soils with adequate infiltration	Yes
Flow-Through Planter	Planters for low infiltration soils or next to buildings, with liner as needed	Yes
Vegetated Filter Strip	Landscaped areas designed to receive distributed flow from impervious surfaces	Yes
Vegetated Swale	District water quality facility for larger drainage areas, minimum 100-foot length	No
Extended Dry Basin	District water quality facility for larger drainage areas, 2-cell design, 48-hour draw-down	No
Constructed Water Quality Wetland	District water quality facility for larger drainage areas, 2-cell design with permanent pool	No
Conveyance and Stormwater Art	Ideas for integrating LIDAs and related stormwater conveyance facilities into landscape, hardscape for aesthetics	n/a
Planting Design & Habitat	Plant selection criteria for LIDAs, including ideas for urban habitat creation	n/a



Description

Porous pavement is a water-permeable structural groundcover that infiltrates precipitation, attenuates stormwater runoff flows and volumes, and reduces temperatures. Porous pavement provides a stable, load-bearing surface without increasing a project's total impervious area.

The two main categories of porous pavements are 1) pervious concrete and asphalt and 2) permeable pavers. Pervious concrete and asphalt are poured in place and resemble their solid counterparts, except the fines (sand and finer material) are removed to create more void space for water to flow through.

Permeable pavers are solid, discrete units typically made of pre-cast concrete, brick, stone or cobbles and set to allow water to flow between them.

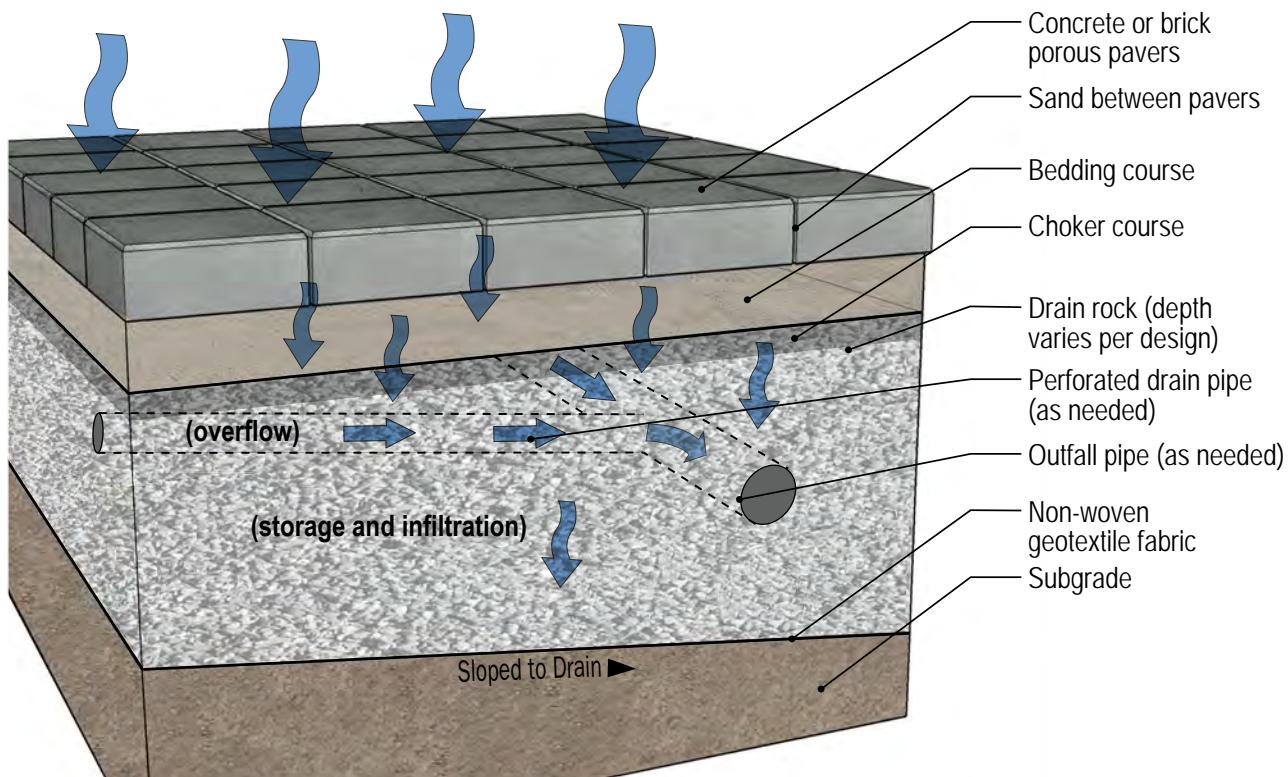
Application & Limitations

Porous pavement is not considered a water quality facility to provide treatment of runoff from other impervious surfaces. However, pollutants captured from direct rainfall on the porous

pavement area are treated through filtration, absorption and other microbial degradation actions in the subgrade. Porous pavement area may be considered 100% pervious in water quality calculations, thus reducing the size of required water quality facilities. Porous pavement may also be used to reduce the size of any hydromodification facilities required.

Pervious asphalt, pervious concrete and permeable pavers can be used in most pedestrian areas, residential driveways, public sidewalks and parking lots. Local jurisdictions may approve pervious asphalt and concrete for private streets and public roadways on a case-by-case basis.

Porous pavements should not be located over cisterns, utility vaults, underground parking or other impervious surfaces and should be applied only where the seasonal high-water table is at least 10 feet beneath the facility's bottom or drain rock layer. Porous pavement should not be applied in locations where there is a high risk of chemical spillage.



Design Factors

Sizing

Porous pavement replaces impervious area at a 1:1 ratio. All stormwater from the porous pavement surface must infiltrate directly into a crushed rock storage layer.

To deter clogging over time, porous pavement should capture only direct rainfall. If approved by the local jurisdiction, detention storage may be constructed beneath the porous pavement and sized by approved calculation. Water quality treatment must be provided for any stormwater flowing from adjacent impervious areas across the porous pavement.

Slopes

In general, porous pavement should not be used on slopes greater than 20H: 1V.

Piping

As needed, and where existing soils have low permeability and an infiltration rate of 0.5" per hour or less, provide an under-drain to an approved outlet structure.

Setbacks

Check with the local building department to confirm site-specific requirements. Impermeable liners are recommended between base rock and adjacent foundations and conventional Asphalt Cement Concrete (ACC) or Portland Cement Concrete (PCC) pavement.

Porous Pavement Design

For specific design mix, use the following references:

- Pervious asphalt
ODOT 2018 Standard Specification, or as updated. See National Asphalt Pavement Association Information Series 131 for additional information.
- Pervious concrete
Stormwater Management Manual, Pervious Pavement section, City of Portland Bureau of Environmental Services, 2020 or as updated.
- Pavers
Interlocking Concrete Pavement Institute specifications and Portland Department of Transportation 2010 Standard Specification Section or as updated.



Porous Pavers, Portland Community College, Rock Creek Campus



Porous Pavers



Porous Asphalt

Design Factors (continued)

Choker Course

The choker course beneath pervious asphalt or concrete pavement consists of 3/4" to 1/4" clean, crushed drain rock, minimum 2" depth.

Aggregate Base

The base course consists of clean, crushed 3/4" to 2" uniformly graded aggregate. The depth of the aggregate base course will vary per design.

Geotextile Fabric

Non-woven geotextile fabric should be placed between the subgrade (native soil) and the aggregate base for proper separation.

Subgrade

Excavate to the bed bottom elevation. Care should be taken to avoid compaction of the subgrade surface and all construction equipment should be kept off the subgrade. If based on the soil type, the excavation of the surface has been sealed, the surface should be lightly scarified or raked to provide infiltration values consistent with the design.

For traffic areas, compact the subgrade soil for public roadways, private streets, parking lots and fire lanes to ensure structural stability and minimize rutting. Compaction should be to 95%.

Because compaction reduces soil permeability it should be done with caution and scarified prior to setting the aggregate base. Protect the subgrade from truck traffic. It is imperative to protect the porous pavement subgrade from over-compaction.

If the subgrade is to be compacted, infiltration testing should be conducted during design of porous pavement to adequately account for reduced soil permeability.



Porous Concrete



Porous Recycled Concrete

Construction

Porous pavement is to be protected from fines infiltration during site construction by covering with visqueen or similar impervious material.



Porous Concrete, SW Broadway and Lombard, Beaverton



Porous Pavers, Tigard Library

Maintenance Assurance Period

- Check with the local jurisdiction about use of porous pavement for public facilities.
- If approved for use in the public right-of-way, the permittee must comply with local jurisdiction requirements for a maintenance assurance period.

Long-Term Maintenance

- If private, the property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement). This agreement may be with Clean Water Services and/or the local jurisdiction in which the pavement is applied.
- Porous pavement on private roads must be in a separate tract.
- Porous pavement requires regenerative air style vacuuming at least once a year, but twice a year is recommended to remove fine particulates from the infiltration spaces. Without this ongoing maintenance, the facility may become impervious.
- Over time, settling may occur and aggregate base, washed sand and/or pavers may need to be replaced or repaired.
- Sealing is a common maintenance practice with conventional asphalt. Pervious asphalt must not be sealed or it will lose its pervious function. Owners should take extra care not to seal pervious asphalt pavement. If porous pavement is sealed, additional stormwater treatment may be required.
- For detailed Operation and Maintenance Plans that describe proper maintenance activities, please refer to page 91.



Porous Concrete, Clean Water Services Field Operations Center



Porous Pavers, West Linn Willamette Park

References

- Clean Water Services Design and Construction



Clean Water Services Field Operations

- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach

Description

A green roof (or ecoroof) is a lightweight vegetated roof system with waterproofing material, drainage, growing medium and specially selected plants. A green roof can reduce site impervious area and manage stormwater runoff. Green roofs reduce peak runoff to near pre-development rates and reduce annual runoff volume by at least 50% (Cost Benefit Evaluation of Ecoroofs, Portland Bureau of Environmental Services, 2008). Green roofs also help mitigate runoff temperatures by keeping roofs cool and retaining most of the runoff in dry seasons. Green roofs typically have thin layers of lightweight growing medium (4 to 8 inches) and low-growing succulent vegetation. Alternatively, roof gardens that are designed to be walked on have deeper soils (8+ inches) and are more heavily planted. Professional design consultation may be necessary to ensure the structural requirements of building codes are met. The design must be low maintenance and use irrigation only to sustain the health of vegetation.

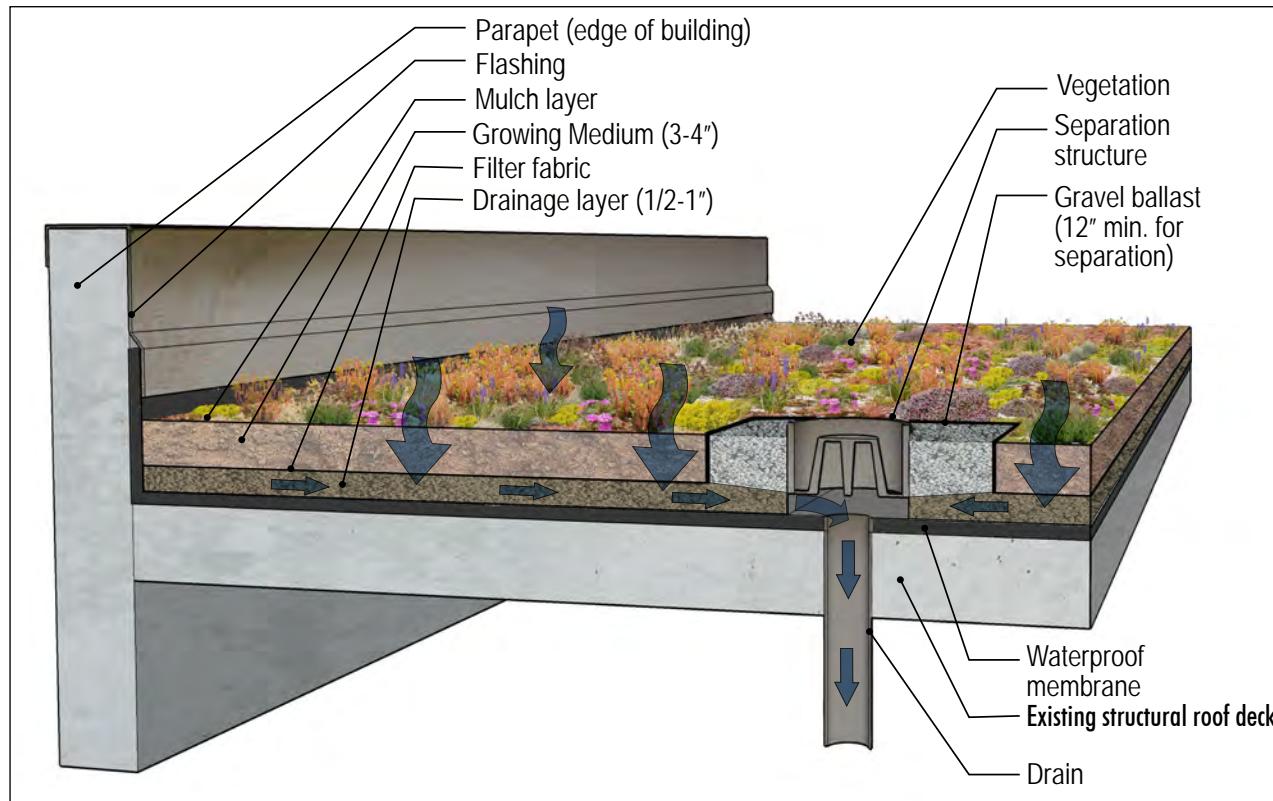
Application & Limitations

Green roofs may be considered 100% pervious in water quality calculations, thus reducing the size of water quality facilities.

Green roofs can be applied to a range of building types, from 'flat' rooftops (minimum of 1/4" slope per foot) to sloped rooftops with up to 4:12 pitch (3H:1V slope) or higher with adequate slope control. Depending on configuration and structure of the roof, the vegetated area may be partial or 100% coverage.

The structural roof support must hold the additional weight of the green roof. Greater flexibility and options are available for new buildings, but retrofits are possible. For retrofit projects, an architect, structural engineer or roof consultant can determine the condition of the existing building structure and what might be needed to support a green roof.

Generally, the building structure must hold an additional 15 to 30 pounds per square foot for saturated weight.



Design Factors

Sizing

Green roofs replace impervious area at a 1:1 ratio. They may not receive water from other impervious areas such as an adjacent conventional roof.

Slope

Maximum roof pitch is 4:12 (3H:1V slope) unless the applicant provides documentation of runoff retention and erosion control on steeper slopes.

Waterproofing

On the roof surface, use a good waterproofing material such as modified asphalt, synthetic rubber or reinforced thermal plastics. Waterproofing materials also may act as a root barrier. Waterproof membranes should be thoroughly tested to identify and remedy potential defects and leaks prior to installation of any green roof components.

Protection boards or materials (recommended)

These materials protect the waterproof membrane from damage and are usually made of soft fibrous materials. They may be required to maintain the waterproofing warranty, depending on the membrane used. Consult with roofing manufacturer for requirements.

Ballast (optional)

Gravel ballast may be placed along the roof perimeter and at air vents or other vertical elements to separate roofing elements and vegetation. The need for ballast depends on the type of roof and rooftop flashing details. Ballast or rooftop pavers may be used to provide access, especially to vertical elements that require maintenance.

Header/separation board (optional)

If needed, a header or separation board may be placed between gravel ballast and soil or drains.

Root barrier

A root barrier may be required, depending on the waterproofing material, warranty requirements and the types of vegetation proposed. Root barriers impregnated with pesticides, metals or other chemicals that could leach into stormwater should not be applied unless documentation that leaching does not occur is provided. If a root barrier is used it must extend under any gravel ballast and the growing medium, and up the side of any vertical elements.



Hamilton Apartments, Portland



Beranger Condominiums, Gresham

Vegetation and coverage

Green roof vegetation traits:

- Adapted to seasonal drought, excess heat, cold and high winds and other harsh conditions
- Fire resistant
- Requires little or no irrigation once established
- Predominately self-sustaining, low maintenance, with minimal fertilizer
- Perennial or self-sowing annuals that are dense and mat-forming
- Diverse palette to increase survivability and good coverage

Examples of appropriate species include: Sedum, ice plant, blue fescue, sempervivum and creeping thyme. Other herbs, forbs, grasses, and low groundcovers can provide additional benefits and aesthetics, but may need more watering and maintenance to survive and may be prone to additional fire risk if allowed to dry out. For a list of acceptable plants refer to page 76.

Establishment Period

Achieve 90% plant coverage within the 2 year establishment period. At least 70% of the green roof should be evergreen species. No more than 10% of the green roof may be non-vegetated components such as gravel ballast or pavers for maintenance access. Mechanical units may protrude through the green roof, but are not considered elements of the green roof and may be removed from square foot totals.

Irrigation during the 2-year establishment period should not exceed $\frac{1}{2}$ inch of water per week (7 days) for the irrigation season (May through October). Post-establishment irrigation should not exceed $\frac{1}{4}$ inch of water every 10 days during the irrigation season.

Exposed areas during establishment periods should be mulched with an approved, biodegradable mesh blanket, straw, gravel, and pebbles or pumice to protect exposed soil from erosion.

Design Factors (continued)

Drainage

A method of drainage should allow excess water to flow into drains when soils are saturated. A manufactured drain mat, filter fabric, aggregate or gravel layers, or the growing medium itself may be used if water drains when soils are saturated. Every green roof should have an approved discharge location and drain or drains. Check with the local jurisdiction.

Growing medium

The growing medium depth is 3 to 4 inches or more, depending on the project. This material should be lightweight and provide a good base for plant growth. Mixes range from 5% organic/95% inorganic to 30% organic/70% inorganic, depending on specific vegetation needs.

Growing media should be stable over time and not break down into fine particles that might increase compaction and clog drainage layers. Components include pumice, perlite, paper pulp, digested organic fiber, and water retention components such as expanded slate, diatomaceous earth, or polymers. For growing media specification, include all constituent elements and their % composition, and a saturated weight per cubic foot (pcf) that has been tested by a third party lab.



Bethany Athletic Club, Beaverton



Multnomah County Office Building, Portland



Clean Water Services Field Operations

Long-Term Maintenance

The property owner is responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement). This agreement may be with Clean Water Services and/or the local jurisdiction in which the pavement is applied.

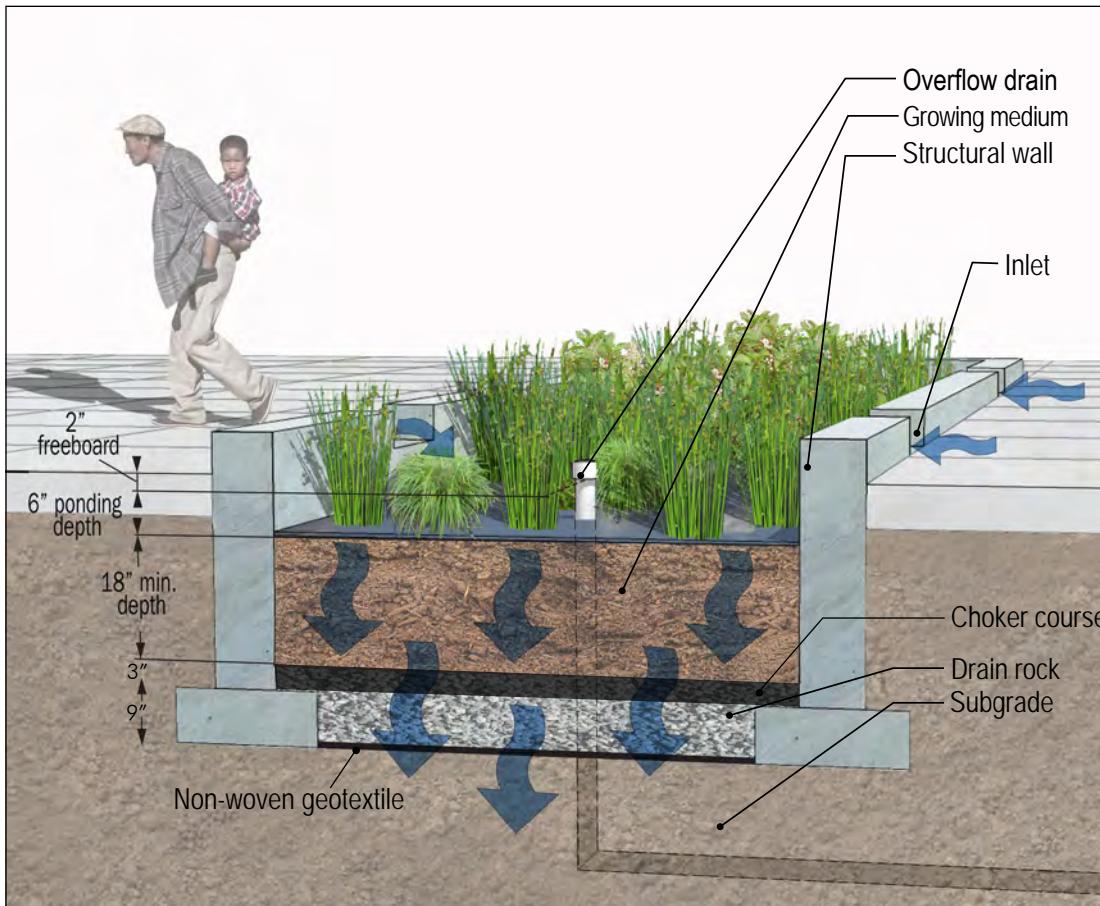
Green roofs should be low maintenance but will require some scheduled maintenance to avoid or resolve problems. The level of maintenance will vary depending on soil depth, vegetation type, and location.

- During the winter rainy season, check drains monthly and remove any accumulated debris.
- Remove dead plants and replant as needed in spring and fall to maintain the required 80% plant coverage.
- During the first growing season remove weeds and undesirable plant growth monthly, and in late spring and early fall in subsequent years.
- Pesticides and herbicides of any kind are prohibited, unless approved by the District to contain a detrimental outbreak of weeds or other pests.

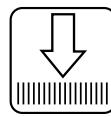
Due to the low level of organic material, fertilizers may be required for plant growth. These should be non-chemical, organic and slow release as approved by the District. Minimal irrigation may be necessary to maintain vegetation health and ecological function of green roofs. Harvested rainwater is highly recommended for landscape irrigation. Green roofs larger than 1,000 square feet should have an automatic irrigation system for more efficient coverage and to eliminate the need for hand watering. Those larger than 5,000 square feet also should have an irrigation flow meter to monitor water usage.

References

- Clean Water Services Design and Construction Standards



parking areas
& impermeable
landscape



permeable
soils

Description

Structural Infiltration planters are landscaped reservoirs that collect, filter and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through planter soil and infiltrates into the ground. Structural Infiltration planters typically require less piping than flow-through planters and a smaller facility size than traditional swales where native soils allow for infiltration. Unlike Non-Structural Infiltration Planters, Structural Planters do have hard sides and sometimes a hard bottom. Depending on the site, Structural Infiltration planters can vary in shape and construction, with or without walls to contain the facility, or formed as a shallow, basin-like depression.

Application & Limitations

Structural Infiltration planters should be integrated into the overall site design and may help fulfill the landscaping area requirement. Structural Infiltration planters can be used to manage stormwater flowing from all types of impervious surfaces, from private property and within the public right-of-way. Check with the local jurisdiction if proposing to use Structural Infiltration planters in the public right-of-way. The size, depth and use of Structural Infiltration planters are determined by the infiltration rates of the site's existing soils.

Y - Public System Approvable Y - Quantity for Conveyance Y - Hydromodification Approach N - Water Quality Treatment Approach



Beaumont Village Lofts, NE Portland

Design Factors

Soil Suitability and Facility Sizing

The size and depth of the Structural Infiltration planter will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes the site infiltration rate is less than 2 in/hr.

For example, the size of an Structural Infiltration planter managing 1,500 square feet of total impervious area would be 90 square feet ($1,500 \times 0.06$).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased.

Geometry/Slopes

The shape may be circular, square, rectangular, etc. to suit the site design requirements. Regardless of the shape, a minimum planter width of 30 inches is needed to achieve sufficient time for treatment and avoid short-circuiting.

Planters in a relatively flat landscaped open area should not slope more than 0.5% in any direction.

Piping for Structural Infiltration planters

Follow Plumbing Code requirements for piping that directs stormwater from impervious surfaces to planters. Stormwater may flow directly from the public street right-of-way or adjacent parking lot areas via curb openings. For Structural Infiltration planters install an overflow drain to allow not more than six inches of water to pond. Structural Infiltration planter need an overflow drain to ensure no more than six inches of water will pond. On private property, follow Plumbing Code requirements for this overflow drain and piping, and direct excess stormwater to an approved disposal point as identified on permit drawings. Check with local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

Setbacks

Check with the local building department to confirm site-specific requirements.

- Generally, a minimum setback of 10 feet from building structures is recommended.
- Planters should not be located immediately upslope of building structures.



New Seasons, 20th and SE Division St., Portland

Design Factors (continued)

Before site work begins, clearly mark Structural Infiltration planter areas to avoid soil disturbance during construction. No vehicular traffic should be allowed within 10 feet of Structural Infiltration planter areas, except as necessary to construct the facility. Consider construction of Structural Infiltration planter areas before construction of other impervious surfaces to avoid unnecessary traffic loads. To avoid erosion, use approved erosion control BMPs.

Soil Amendment/Mulch

Amended soils with appropriate compost and sand provide numerous benefits: infiltration, detention, retention, better plant establishment and growth, reduced summer irrigation needs, reduced fertilizer need, increased physical/chemical/microbial pollution reduction and reduced erosion potential. Primary treatment will occur in the top 18 inches of the Structural Infiltration planter. Amended soil in the treatment area is composed of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

Vegetation

Planted vegetation helps to attenuate stormwater flows and break down pollutants by interactions with bacteria, fungi, and other organisms in the planter soil. Vegetation also traps sediments, reduces erosion, and limits the spread of weeds. Appropriate, carefully selected plantings enhance the aesthetic and habitat value. For a complete list of allowable plants, refer to page 76.

The entire water quality treatment area should be planted appropriately for the soil conditions. Walled infiltration run-on planters will be inundated periodically. Therefore the entire planter should be planted with herbaceous rushes, sedges, perennials, ferns and shrubs that are well suited to wet-to-moist soil conditions.

If the Structural Infiltration planter has side slopes (basin without vertical walls), soil conditions will vary from wet to relatively dry; several planting zones should be considered. The flat bottom area will be moist-to-wet, and the side slopes will vary from moist at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will depend upon the designed maximum water depth, total depth of the planter and steepness of the side



Mississippi Commons, NE Portland



12th and Montgomery St., Portland

Design Factors (continued)

slopes. This moisture gradient is a transition zone and should be planted with species that tolerate occasional standing water, with plants that prefer drier conditions toward the top of the slope. Areas above the side slopes, immediately adjacent to the basin and above the designed high water line will not be inundated and should be planted with self-sustaining, low maintenance grasses, perennials and shrubs suitable for the local climate.

Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional value are acceptable with approval. All vegetation should be planted densely and evenly to ensure proper hydrological function of the Structural Infiltration planter. For a complete list of allowable plants refer to page 76.

Quantities per 100 square feet:

- 115 herbaceous plants, 1' on center spacing, 6" or $\frac{1}{2}$ -gal container size; or
- 100 herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size 2' on center.

Trees are not allowed in Structural Infiltration planters. Small trees are allowed in raingardens and should be selected by their adaptability to wet-to-moist conditions and full size at maturity. Trees should be placed along the side slopes of the facility rather than at the bottom. Trees should be a minimum 2 gallon by 2 feet tall. Dig planting area twice the width of tree rootball and the depth of the rootball plus 12" (or total depth of 30", whichever is greater) should be backfilled with amended soil for optimal growth, with no sub-surface rock layer.

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the Structural Infiltration planter for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For detailed Operation and Maintenance Plans that describe proper maintenance activities please refer to page 91.

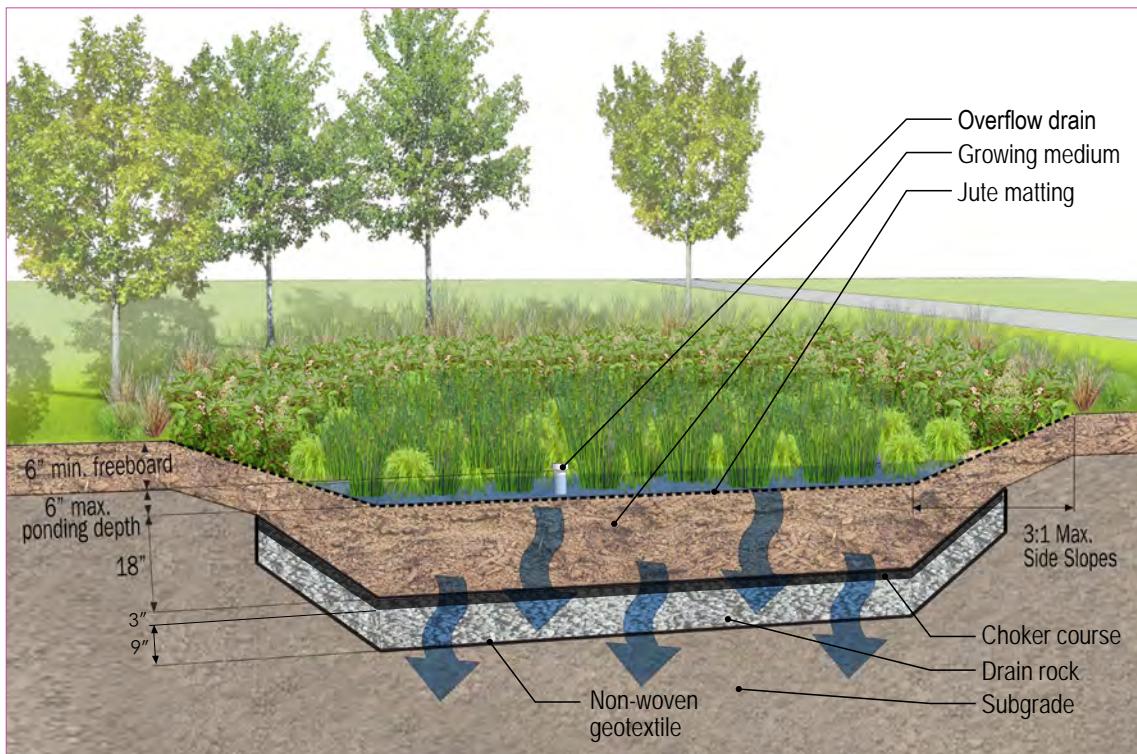
All publicly maintained facilities not located in the public right-of-way must have a public easement to ensure access for maintenance.

References

Clean Water Services Design and Construction Standards.

Non-Structural Infiltration Planter/Rain Garden

Page 1 of 3



parking areas
& impermeable
landscape



permeable
soils

Description

Non-Structural Infiltration planters (also known as rain gardens) are landscaped reservoirs that collect, filter, and infiltrate stormwater runoff, allowing pollutants to settle and filter out as the water percolates through planter soil and infiltrates into the ground. Non-Structural Infiltration planters typically require less piping than flow-through planters and a smaller facility size than traditional swales where native soils allow for infiltration. Depending on the site, Non-Structural Infiltration planters can vary in shape and construction, with or without walls to contain the facility, or formed as a shallow, basin-like depression.

Application & Limitations

Non-Structural Infiltration planters should be integrated into the overall site design and may help fulfill the landscaping area requirement. Non-Structural Infiltration planters can be used to manage stormwater flowing from all types of impervious surfaces, from private property and within the public right-of-way. Check with the local jurisdiction if proposing to use Non-Structural Infiltration planters in the public right-of-way. The size, depth, and use of Non-Structural Infiltration planters are determined by the infiltration rates of the site's existing soils.

- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- Y - Water Quality Treatment Approach



Orenco Woods Park



Design Factors

Soil Suitability and Facility Sizing

The size and depth of the Non-Structural Infiltration planter will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes the site infiltration rate is less than 2 in/hr.

For example, the size of a Non-Structural Infiltration planter managing 1,500 square feet of total impervious area would be 90 square feet (1,500 x 0.06).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased

Geometry/Slopes

The shape may be circular, square, rectangular, etc. to suit the site design requirements. Regardless of the shape, a minimum planter width of 30 inches is needed to achieve sufficient time for treatment and avoid short-circuiting. Planters in a relatively flat, landscaped open area should not slope more than 0.5% in any direction.

Piping for Non-Structural Infiltration planters

Follow Plumbing Code requirements for piping that directs stormwater from impervious surfaces to planters. Stormwater may flow directly from the public street right-of-way or adjacent parking lot areas via curb openings. For Non-Structural Infiltration planters install an overflow drain to allow not more than 6 inches of water to pond. On private property, follow Plumbing Code requirements for this overflow drain and piping, and direct excess stormwater to

an approved disposal point as identified on permit drawings. Check with local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

Setbacks

Check with the local building department to confirm site-specific requirements.

- Generally, a minimum setback of 10 feet from building structures is recommended.
- Planters should not be located immediately upslope of building structures.

Before site work begins, clearly mark Non-Structural Infiltration planter areas to avoid soil disturbance during construction. No vehicular traffic should be allowed within 10 feet of Non-Structural Infiltration planter areas, except as necessary to construct the facility. Consider construction of Non-Structural Infiltration planter areas before construction of other impervious surfaces to avoid unnecessary traffic loads. To avoid erosion, use approved erosion control BMPs.

Soil Amendment/Mulch

Amended soils with appropriate compost and sand provide numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer needs; increased physical, chemical and microbial pollution reduction; and, reduced erosion potential.

Primary treatment will occur in the top 18 inches of the Non-Structural Infiltration planter. Amended soil in the treatment area is composed of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

Vegetation

Planted vegetation helps to attenuate stormwater flows and break down pollutants by interactions with bacteria, fungi, and other organisms in the planter soil. Vegetation also traps sediments, reduces erosion, and limits the spread of weeds. Appropriate, carefully selected plantings enhance the aesthetic and habitat value. For a complete list of allowable plants refer to see page 76.

The entire water quality treatment area should be planted appropriately for the soil conditions. Walled infiltration run-on planters will be inundated periodically. Therefore, the entire planter should be planted with herbaceous rushes, sedges, perennials, ferns and shrubs that are well-suited to wet-to-moist soil conditions.



Fowler Middle School, Tigard

If the Non-Structural Infiltration planter has side slopes (basin without vertical walls), soil conditions will vary from wet to relatively dry; several planting zones should be considered. The flat bottom area will be moist-to-wet, and the side slopes will vary from moist at the bottom to relatively dry near the top where inundation rarely occurs. The moisture gradient will depend upon the designed maximum water depth, total depth of the planter, and steepness of the side slopes. This moisture gradient is a transition zone and should be planted with species that tolerate occasional standing water, withand plants that prefer drier conditions toward the top of the slope. Areas above the side slopes, immediately adjacent to the basin, and above the designed high-water line will not be inundated and should be planted with self-sustaining, low- maintenance grasses, perennials, and shrubs suitable for the local climate.

Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional value are acceptable with approval. All vegetation should be planted densely and evenly to ensure proper hydrological function of the Non-Structural Infiltration planter. For a complete list of allowable plants refer to page 76.

Quantities per 100 square feet:

- 115 herbaceous plants, 1' on center spacing, $\frac{1}{2}$ -gal container size; or
- 100 herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size 2' on center.

Small trees are allowed in raingardens and should be selected based on their adaptability to wet-to-moist conditions and full size at maturity. Trees should be placed along the side slopes of the facility rather than at the bottom. Trees should be a minimum 2 gallon by 2 feet tall. Dig planting area twice the width of tree rootball and the depth of the rootball plus 12" (or total depth of 30",— whichever is greater) should be backfilled with amended soil for optimal growth, with no sub-surface rock layer.

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the Non-Structural Infiltration planter for a minimum of two years following construction and acceptance of the facility.

Long- Term Maintenance

If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For detailed Operation and Maintenance Plans that describe proper maintenance activities, please refer to page 91.

All publicly maintained facilities not located in the public right-of-way must have a public easement to ensure access for maintenance.

References

Clean Water Services Design and Construction Standards.



- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach

Description

Flow-through planters are structural landscaped reservoirs that collect stormwater and filter out pollutants as the water percolates through the vegetation, growing medium and gravel. These are appropriate where soils do not drain well or there are site constraints. A liner may be required when located adjacent to buildings, over contaminated soils and on unstable slopes. Excess stormwater collects in a perforated pipe at the bottom of the flow-through planter and drains to an approved discharge point.

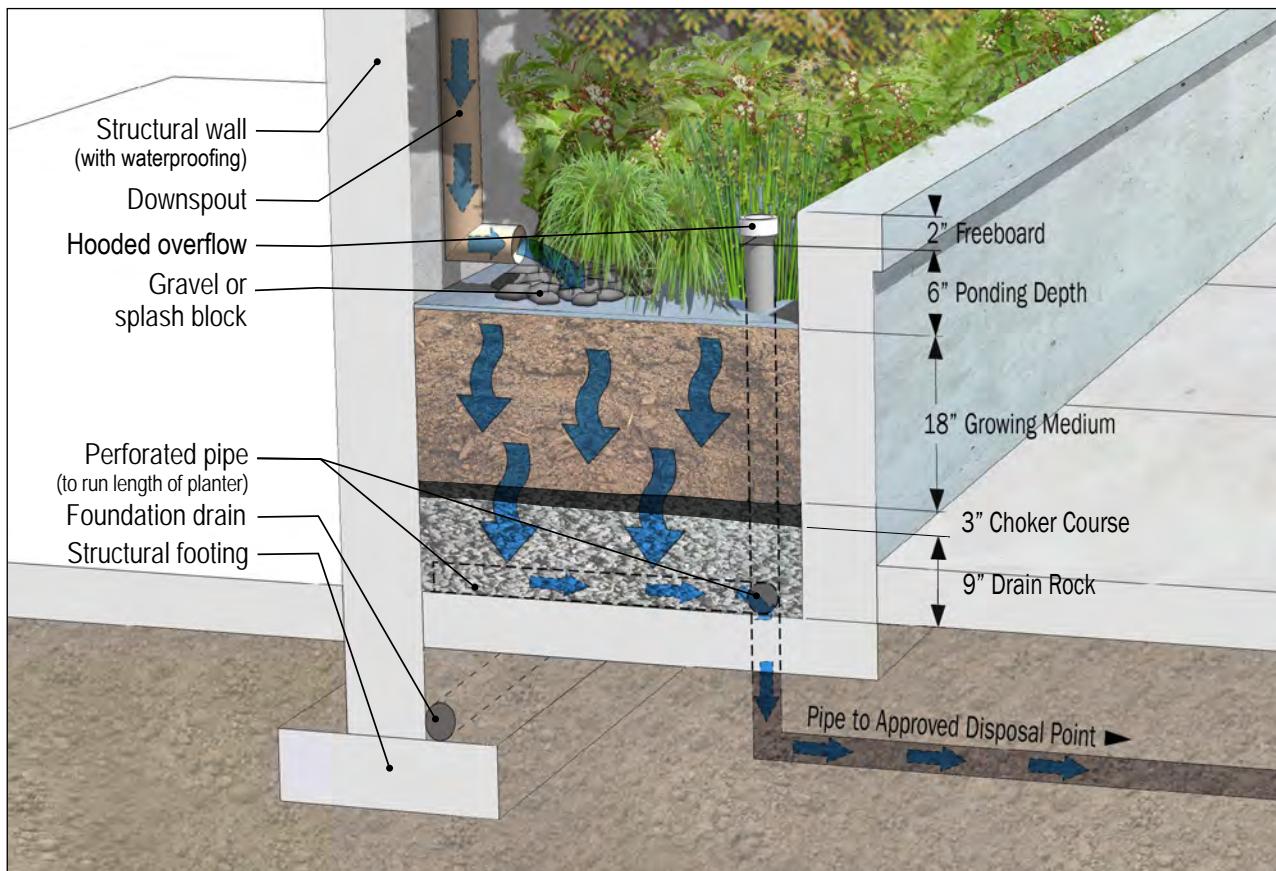
Tree box filters are flow-through planters with a concrete "box" that contains filtering growing media and a tree or large shrub. Tree box filters are used singly or in multiples, often adjacent to streets where runoff is directed to them to treat stormwater runoff before it enters a catch basin.

Application & Limitations

Flow-through planters may help fulfill a site's landscaping area requirement and can be used to manage stormwater runoff from all types of impervious surfaces on private property and within the public right-of-way. Check with the local jurisdiction if proposing to use a flow-through planter in the public right-of-way. Flow-through planters can be placed next to buildings and are ideal for sites with poorly draining soils, steep slopes or other constraints. Design variations of shape, wall treatment and planting scheme will fit the character of any site.



Headwaters at Tryon Creek, Portland



Design Factors

Sizing

To calculate the planter size, multiply the impervious surface (rooftops, driveways, parking lots, etc.) area by 6%. The square footage is the peak water surface prior to overflow. For example, a 1,200-sf rooftop and 300-sf driveway (1,500 sf total impervious area) requires a 90-sf stormwater planter (1,500 x 0.06). This could be accomplished with one 9-foot by 10-foot flow-through planter. Note, pretreatment is required for any contributing impervious area greater than 15,000 sf.

Geometry/Slopes

- Stormwater planters may be any shape, and can be designed as square, rectangular, circular, oblong or irregular.
- Regardless of the shape, a minimum planter width of 30 inches is needed to achieve sufficient time for treatment and to avoid short-circuiting.
- The minimum treatment depth of 18 inches is achieved in the growing medium.
- Planters are designed to evenly distribute and filter flows. Surface longitudinal slopes should be less than 0.5%.

Piping for Flow-Through Planters

Follow Plumbing Code requirements for piping that directs stormwater from impervious surfaces to flow-through planters. Stormwater may flow directly from the public street right-of-way or adjacent parking lot areas via curb openings. The overflow drain allows not more than six inches of water to pond in the planter prior to overflow. A perforated pipe system under the planter drains water that has filtered through the topsoil to prevent long-term ponding. On private property, the overflow drain and piping must meet Plumbing Code requirements and direct excess and filtered stormwater to an approved disposal point. Check with the local jurisdiction or use Clean Water Services Design and Construction Standards for additional information on piping material for use in the public right-of-way.

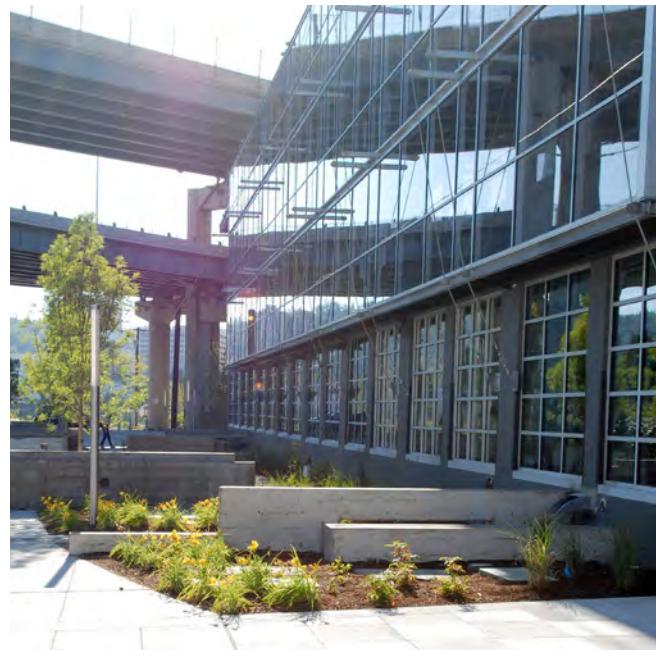
Setbacks

Check with the local building department to confirm site-specific requirements.

- For planters without an impermeable liner, generally the minimum setback from building structures is 10 feet.



PSU Stephen Epler Hall, Portland



RiverEast Center, SE Portland

Design Factors (continued)

- Typically, no building setback is required for planters lined with waterproofed concrete or 60 mil. PVC liner to prevent infiltration.

Soil Amendment/Mulch

Amended soils with appropriate compost and sand provide numerous benefits: infiltration; detention; retention; better plant establishment and growth; reduced summer irrigation needs; reduced fertilizer need; increased physical/chemical/microbial pollution reduction; and, reduced erosion potential. Primary treatment will occur in the top 18 inch flow-through planter. Amended soil in the treatment area is composed of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMPs for flow- through planters.

Vegetation

Planted vegetation helps to attenuate stormwater flows and break down pollutants by interactions with bacteria, fungi, and other organisms in the planter soil. Vegetation also

traps sediments, reduces erosion, and limits the spread of weeds. Appropriate, carefully selected plantings enhance the aesthetic and habitat value. For a complete list of allowable plants refer to page 76.

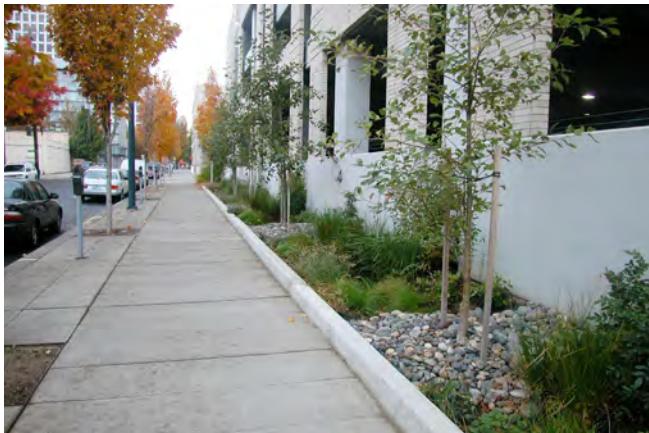
The entire water quality treatment area should be planted appropriately for the soil conditions.

Because the entire facility will be inundated periodically, plant the water quality treatment area with herbaceous species such as rushes sedges, perennials, ferns appropriate for wet-to-moist soil conditions. Most moisture-tolerant plants can withstand seasonal droughts during the dry summer months and do not need irrigation after they become established.

Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional value are acceptable upon approval from local jurisdiction. All vegetation should be planted densely and evenly to ensure proper hydrological function of the flow-through planter.

Quantities per 100 square feet:

- 115 herbaceous plants, 1' on center spacing, 6" or $\frac{1}{2}$ -gal container size; or
- 100 herbaceous plants, 1' on center, and 4 shrubs, 1-gal container size 2' on center.



Rose Quarter parking structure, NE Portland



Washougal Town Square



Aloha Dog and Cat Clinic, Washington County



Buckman Terrace Apartments, Portland

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the flow-through planter for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

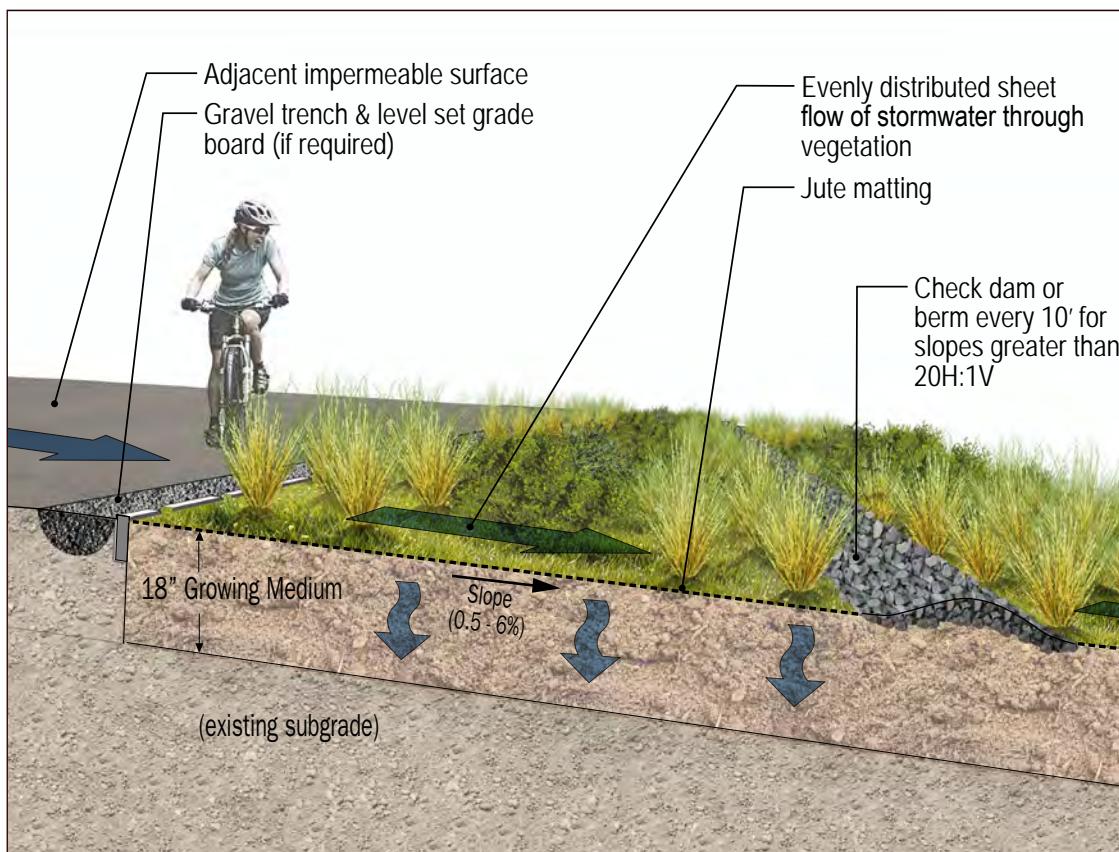
If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For detailed Operation and Maintenance Plans that describe proper maintenance activities please refer to page 91.

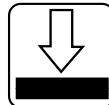
All publicly maintained facilities not located in the public right-of-way must have a public easement to ensure access for maintenance.

References

Clean Water Services Design and Construction Standards



parking areas
& impermeable
landscape



impermeable
soils



permeable
soils

Description

Vegetated filter strips are gently sloped areas designed to receive sheet flows from adjacent impervious surfaces. Filter strips are vegetated with grasses and groundcovers that filter and reduce the velocity of stormwater. Peak stormwater flows are attenuated as stormwater travels across the filter strip and infiltrates or is stored temporarily in the soils below.

For residential driveways, center filter strips typically are 3-feet-wide between two 3-foot-wide paved sections. The strip treats and infiltrates stormwater only from the impervious area of the drive aisles which slope toward the center filter strip. The driveway center filter strip must be maintained to the design requirements for vegetated filter strips.

Application & Limitations

Vegetated filter strips should be integrated into the overall site design and may help fulfill a site's landscaping area requirement. Vegetated filter strips can be used to manage stormwater runoff from a variety of impervious surfaces such as walkways and driveways on private property and within the public right-of-way. Check with the local jurisdiction if proposing to use a vegetated filter strip in the public right-of-way.



Oregon Zoo parking lot, Portland

- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach



Oregon Zoo parking lot

Design Factors (continued)

Sizing

Vegetated filter strips are appropriate for all soil types and have 18" depth of growing medium. The size of the filter strip will depend upon the infiltration rate of existing soils. A sizing factor of 0.06 assumes that the site has an infiltration rate less than 2 in/hr.

For example, a facility managing 1,500 square feet of total impervious area would require a 90 sq ft filter strip (1,500 x 0.06).

Size may be decreased if:

- Demonstrated infiltration rate is greater than 2 in/hr using ASTM D3395-09 method; or
- Amended soil depth is increased

Geometry/Slopes

The minimum width of a vegetated filter strip is 5 feet measured in the direction of stormwater flow. The slope is between 0.5 and 6%, and the slope of the impervious area draining to the strip is less than 6%.

Check dams may be required to maintain shallow slopes if the existing site slopes exceed 5%. Typically, check dams are 3 to 5 inches high and are placed every 10 feet where

slopes exceed 5%. If a level spreader such as a grade board or sand/gravel trench is required to disperse runoff evenly across the filter strip, the top must be horizontal and at an appropriate height to direct sheet flow to the soil without scour. Grade boards may be any material that withstands weather and solar degradation but should not be old railroad ties, used utility poles or other pollutant source.

Non-infiltrated flows/overflows from the vegetated filter strip are collected and conveyed to an approved system or outlet structure.

Setbacks

Check with local building department to confirm site-specific requirements.

Soil Amendment/Mulch

Amended soils with appropriate compost and sand provide numerous benefits: infiltration, detention, retention, better plant establishment and growth, reduced summer irrigation needs, reduced fertilizer need, increased physical/chemical/microbial pollution reduction and reduced erosion potential. Primary treatment will occur in the top 18 inches of the



Arata Creek School, Troutdale

Design Factors (continued)

vegetated filter strip. Amended soil in the treatment area is composed of organic compost, gravelly sand and topsoil. Compost is weed-free, decomposed, non-woody plant material; animal waste is not allowed. Check with the local jurisdiction or Clean Water Services for Seal of Testing Approval Program (STA) Compost provider.

To avoid erosion, use approved erosion control BMPs for vegetated filter strip.

Vegetation

Herbaceous plants, shrubs and grasses can provide the vegetation needed to remove sediment and pollutants. The vegetated filter strip is planted or seeded with a mix of grasses, wildflowers and groundcovers well suited to moist-to-dry soil conditions. All vegetation should be self-sustaining and drought tolerant.

Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional value are acceptable upon approval. For a complete list of allowable plants, refer to page 76.

Trees are not required for vegetated filter strips, but are encouraged where applicable. Tree species should be selected by their adaptability to moist-to-dry conditions and full size at maturity.

Do not plant trees in bottom of facility. The filter strip should be wide enough to accommodate tree growth. The filter strip conveys evenly-distributed sheet flows of water through vegetation for treatment. Because unplanted areas may decrease stormwater treatment, the entire filter strip must have 100% vegetation coverage to ensure proper hydrologic function.

If check dams are required, plants suited to wet-to-moist conditions may be supplemented on the upslope side of the check dam where occasional inundation and pooling of water may occur.

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the vegetated filter strip for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

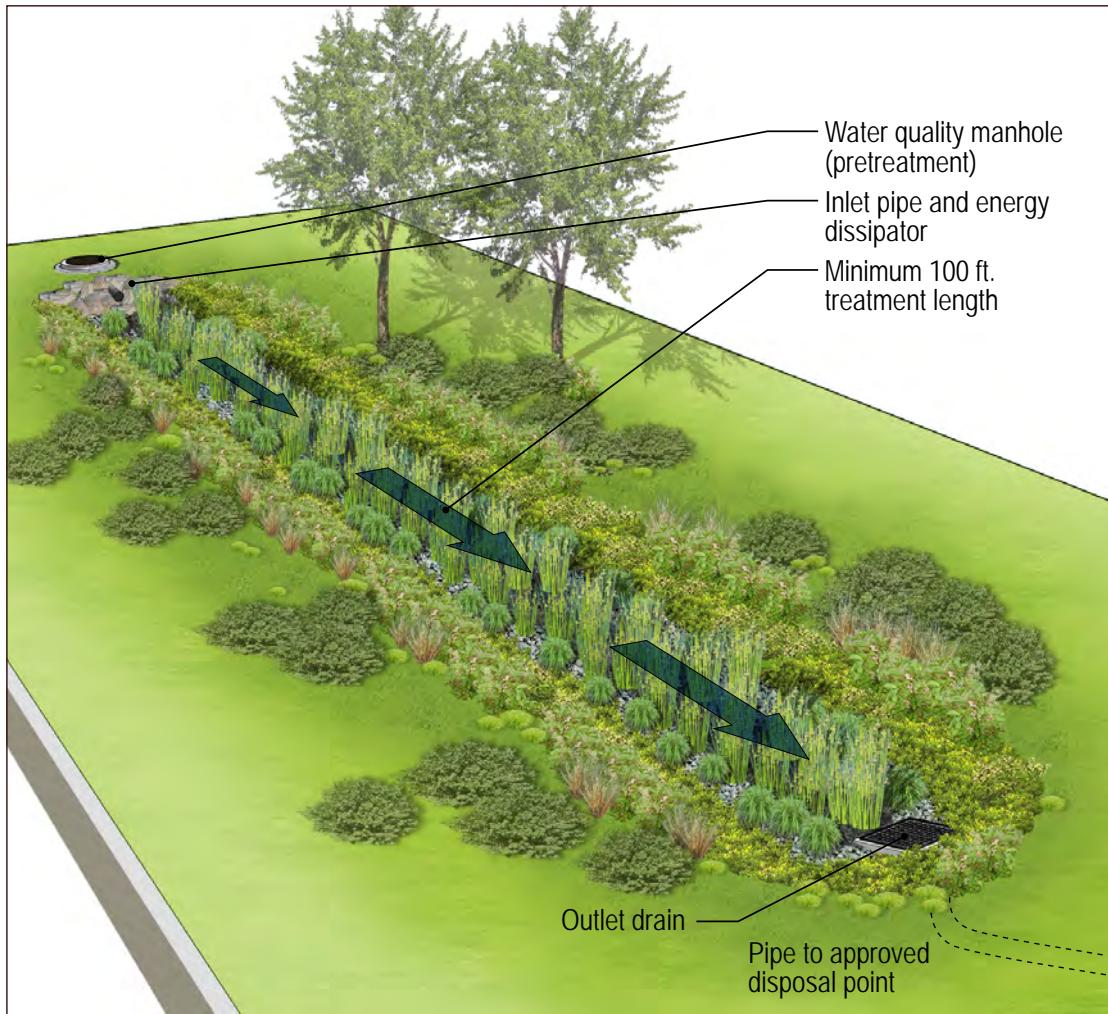
If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For Detailed Operation and Maintenance Plans Refer to page 91 for maintenance .

All publicly maintained facilities not located in the public right-of-way must have a public easement to ensure access for maintenance.

References

Clean Water Services Design and Construction Standards



Description

A vegetated swale is a gently sloping landscaped depression that collects and conveys stormwater runoff, and is narrow and at least 100 feet in length. The densely planted swale filters stormwater as it flows the length of the swale and allows infiltration of water into the ground. The vegetated swale may discharge to a storm sewer or other approved discharge point where soils do not drain well.

Vegetated swales have a required minimum length, width and stormwater residence time. See Clean Water Services Design and Construction Standards Details 700 and 710.

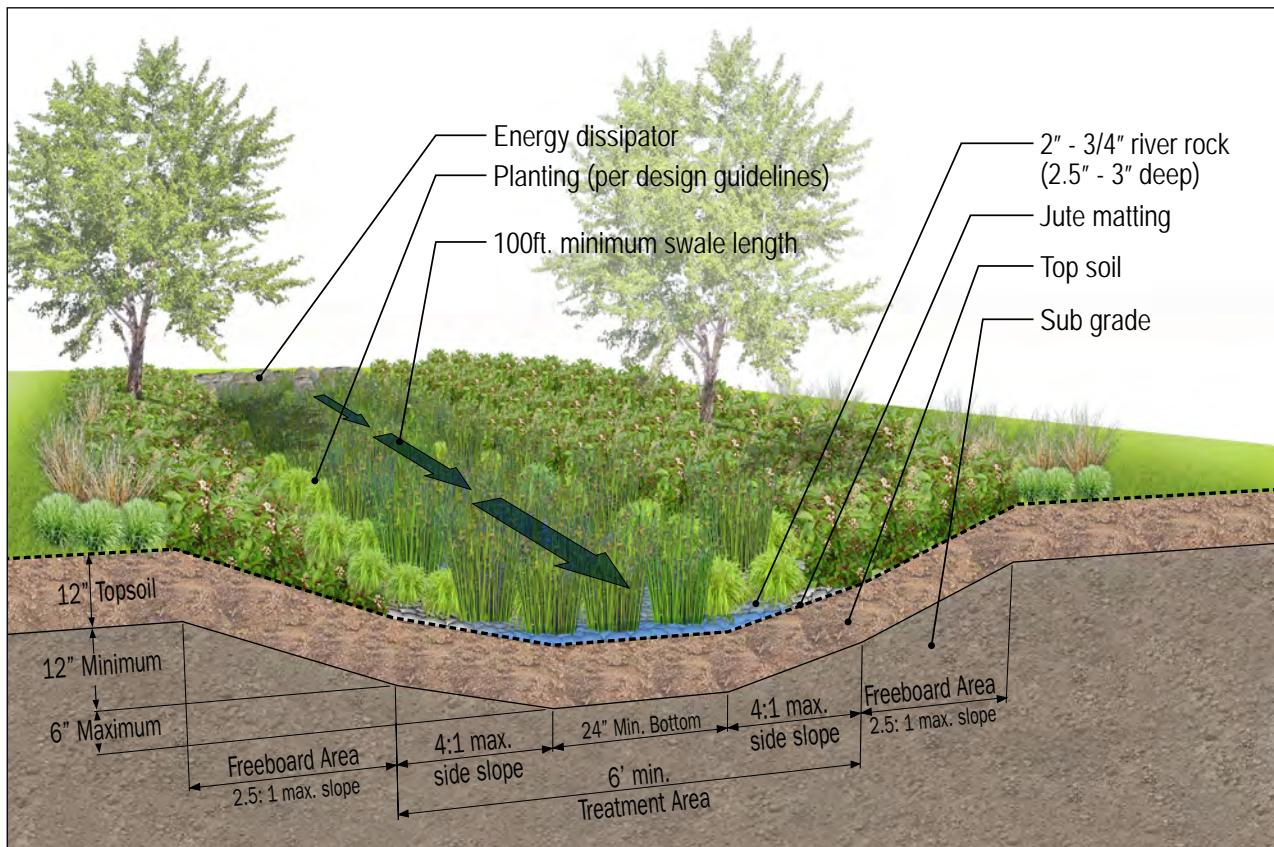
- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach

Application & Limitations

Vegetated swales may help fulfill a site's landscaping area requirement. Vegetated swales are approved to treat stormwater from all types of impervious surfaces including private property and the public right-of-way, rooftops, parking lots and streets.



Westhaven Subdivision, Washington County, Oregon



Design Factors

Sizing

A vegetated swale must be at least 100 feet in length and detain stormwater for at least nine minutes for treatment as specified in Clean Water Services Design and Construction Standards.

Geometry/Slopes

A vegetated swale's slope end to end is at least 0.5% and the maximum velocity for a 25-year storm flow is 2 feet per second. Side slopes within the treatment area are 25% (4 horizontal: 1 vertical) or less; side slopes of the freeboard area above the treatment zone are 40% (2.5 horizontal: 1 vertical) or less. While the bottom of the swale is at least 2-feet wide, the treatment area is at least 6-feet wide and no more than ½ foot in depth. The freeboard area has at least one foot of vertical height. All swales have an energy dissipater such as boulders at the entrance to reduce velocities and spread the flow across the treatment area. The minimum length of the energy dissipater is 4 feet. See Clean Water Services Design and Construction Standards – Standard Details.

Piping for Vegetated Swales

Flows coming into the vegetated swale facility are pretreated by a water quality manhole in accordance with the Design and Construction Standards. Other pretreatment may include an approved proprietary treatment device, filter strip, trapped catch basin, or other method approved by the District or City. An approved outlet structure must be provided for all flows. If location would make access for maintenance difficult, the swale may be a flow-through facility with unsumped structures.



Arbor Oaks Subdivision, Washington County, Oregon



Tanasbourne Office Building, Washington County



Aloha Huber Park Elementary School, Washington County

Design Factors (continued)

Setbacks

Check with the local building department to confirm site-specific requirements.

Soil Amendment/Mulch

The treatment area has $\frac{3}{4}$ " to 2-inch river run rock placed 2.5 to 3 inches deep on high density jute or coconut matting over 12 inches of native topsoil. The river rock, topsoil and high density jute or coconut matting extends to the top of the treatment area; topsoil and low density jute matting extends to the edge of the water quality tract or easement area.

Vegetation

The entire facility including freeboard and treatment areas is vegetated according to the Standards with vegetation appropriate for the soil conditions. Planting conditions vary from wet to relatively dry within the swale. The flat bottom will be inundated frequently and should be planted with species such as rushes, sedges, perennials and ferns. Shrubs that are well-suited to moist soil conditions can

be planted on the side slope where moisture gradient varies from moist toward the bottom and relatively dry near the top.. The moisture gradient will vary depending upon the designed water depth, swale depth and side slope steepness. The transition zone from the bottom of the swale to the designed high-water line or top of freeboard should be planted with sedges, rushes, perennials and ferns, as well as shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the vegetated swale will not be regularly inundated and should be planted with self-sustaining, low-maintenance grasses, perennials and shrubs suitable for the local climate and site. Native plants are encouraged, but non-invasive ornamentals that add aesthetic and functional value are acceptable upon approval. All vegetation should be densely and evenly planted to ensure proper hydrological function of the swale. For a complete list of allowable plants refer to page 76.



Broadview, Seattle



PCC Rock Creek Campus, Beaverton

Design Factors (continued)

Plant Spacing

A) Vegetated swales in tracts or easements less than 30 feet wide are planted as follows to achieve the specified per acre densities:

- i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
- ii. Total number of shrubs per acre = area in square feet $\times 0.05$
- iii. Groundcover = plant and seed to achieve 100% coverage

B) Vegetated swales in tracts or easements 30 feet wide or more are planted as follows to achieve the specified per acre densities:

- i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
- ii. Total number of trees per acre = area in square feet $\times 0.01$
- iii. Total number of shrubs per acre = area in square feet $\times 0.05$
- iv. Groundcover = plant and seed to achieve 100% coverage

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.



Sandy Boulevard, Portland

- If public, the permittee is responsible for the maintenance of the vegetated swale for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

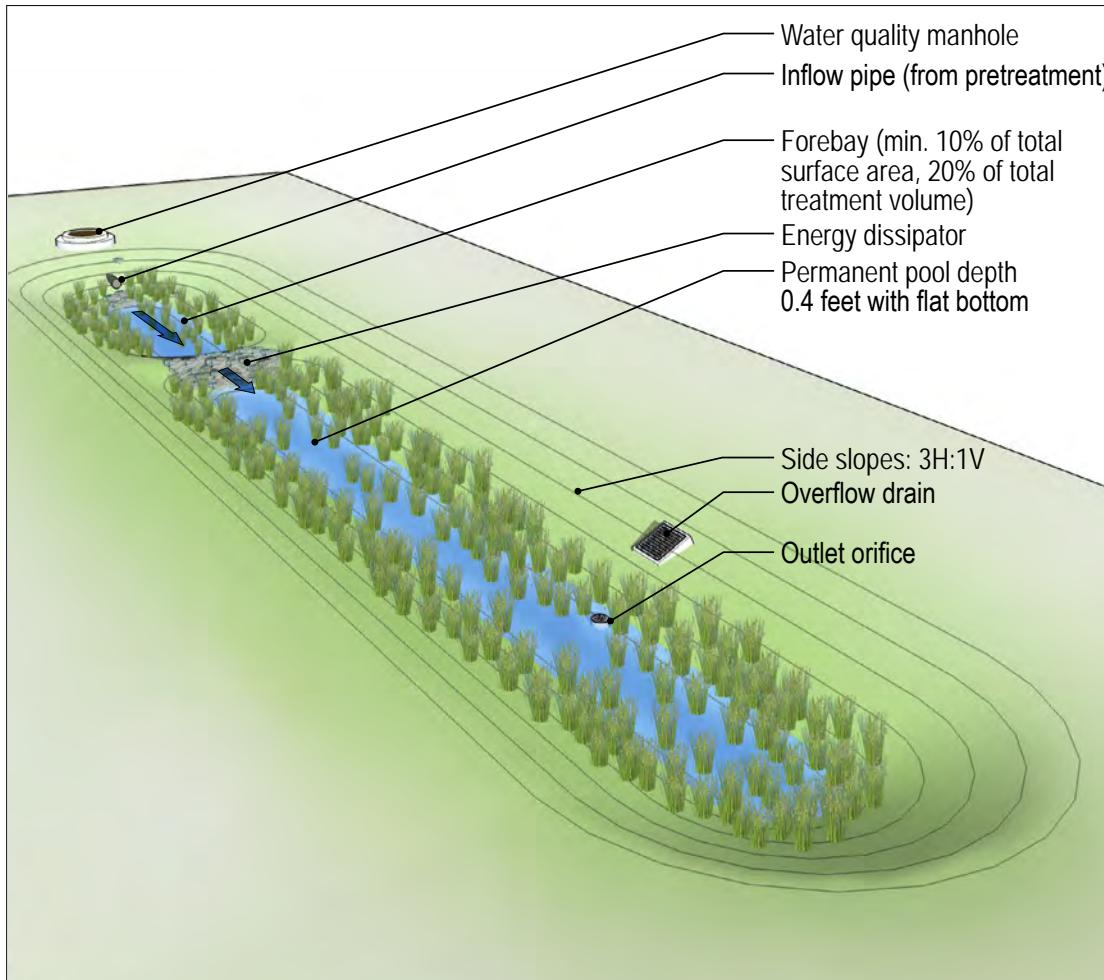
If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For detailed Operation and Maintenance Plans that describe proper maintenance activities, please refer to page 91.

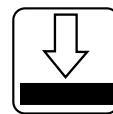
All publicly maintained facilities not located in the public

References

Clean Water Services Design and Construction Standards



parking areas
& impermeable
landscape



impermeable
soils



permeable
soils

Description

An extended dry basin is a shallow landscaped depression with a flat bottom that collects and holds stormwater runoff, allowing pollutants to settle and filter out as the water infiltrates into the ground or is discharged to an approved location. An extended dry basin has two or more cells (the first cell is the forebay). An inflow pipe conveys stormwater into the basin where it is temporarily stored. Extended dry basins may infiltrate stormwater where soils have high infiltration rates, or may overflow to an approved discharge point.

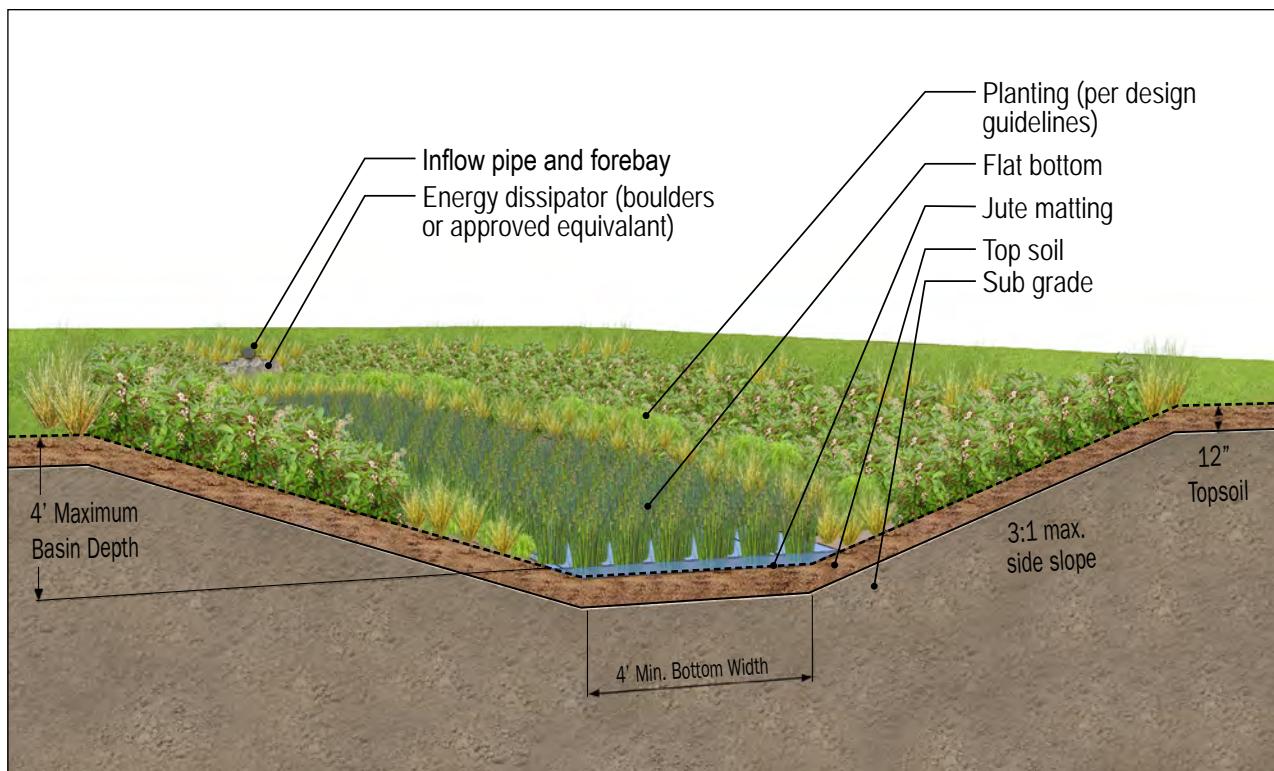
- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach

Application & Limitations

Extended dry basins may help fulfill a site's landscaping area requirement. This type of water quality facility is approved to treat stormwater from all types of impervious surfaces, including private property and the public right-of-way, rooftops, parking lots and streets.



Home Depot, Glenn Widing Drive, North Portland



Design Factors

Sizing

Sizing of the detention basin is determined by the volume of runoff and the detention period required for treatment. At a minimum, the detention basin must accommodate the water quality design storm and be sized for a 48-hour drawdown time.

The minimum water quality detention volume is equal to (1) x the water quality volume (WQV). The outlet orifice size is determined by the following equation:

$$D = 24 * [(Q / (C[2gH]0.5) / \pi) 0.5]$$

Where:

$$\begin{aligned} D (\text{in}) &= \text{diameter of orifice } Q(\text{cfs}) = WQV(\text{cf}) / (48 * 60 * 60) \\ &= 0.62 \end{aligned}$$

$$H(\text{ft}) = 2/3 \times \text{temporary detention height to centerline of orifice}$$

Geometry/Slopes

An extended dry basin has two or more cells. The first cell, the forebay, is at least 10% of the entire surface area and constitutes 20% of the treatment volume. The minimum width of the bottom of the extended dry basin is 4 feet, and the permanent pool depth is 0.4 feet and covers the entire bottom of the basin. The maximum depth of the water quality pool, not including the permanent pool, is 4 feet unless otherwise limited by the jurisdiction.

The maximum side slopes of the basin treatment area are 3H: 1V (33.33%); the minimum freeboard is 1 foot above the 25-year design water surface elevation.

Piping for Extended Dry Basins

Incoming flows are pretreated using a water quality manhole in accordance with the District Standards. Other pretreatment may include proprietary devices, filter strip, trapped catch basin or methods approved by the District or the city. An approved outlet structure is provided for all flows.

Setbacks

Check with the local building department to confirm site-specific requirements.

Soil Amendment/Mulch

If required, place 3/4" to 2-inch river run rock 2.5 to 3 inches deep where sustained flow is anticipated. River rock (if required), topsoil and high density jute or coconut matting extend to the top of the treatment area. Topsoil and low density jute matting extend to the edge of the water quality tract or easement area.



Washington County

Design Factors (continued)

Vegetation

The entire facility area (side slopes and treatment areas) is planted with vegetation appropriate for the varying planting conditions within the extended dry basin. Planting conditions vary from saturated soil to relatively dry, and several planting zones should be considered. The flat bottom of the extended dry basin to the top of the 0.4 foot permanent pool is a saturated zone and will be consistently inundated with water. The saturated zone should be planted with rushes, sedges and other wetland species (oxygenators) that are well suited to water-saturated, oxygen-deprived (anaerobic) planting conditions.

The side slopes above the permanent pool depth will vary from wet at the bottom to relatively dry near the top where inundation rarely occurs. This moisture gradient will vary depending upon the designed maximum water depth, basin depth and side slope steepness. This wet-to-moist transition zone from the top of the permanent pool to the designed high-water line or top of freeboard should be planted with sedges, rushes, perennials, ferns and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. The areas above the designed high water line and immediately adjacent to the extended dry basin will not be regularly inundated. The dry zone should be planted with self-sustaining, low maintenance grasses, perennials and shrubs suitable for the local climate and site.

The use of native plants is encouraged, but appropriate, adapted non-invasive ornamentals are acceptable for added aesthetic and functional value upon approval. All vegetation should be densely and evenly planted to ensure proper hydrological function of the extended dry basin. For a complete list of allowable plants, refer to page 76.

Plant Spacing

A) Extended Dry Basins in tracts or easements less than 30 feet wide are planted as follows to achieve the specified per acre densities:

- i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
- ii. Total number of shrubs per acre = area in square feet x 0.05
- iii. Groundcover = plant and seed to achieve 100% coverage

B) Extended Dry Basins in tracts or easements 30 feet wide or more are planted as follows to achieve the specified per acre densities:

- i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
- ii. Total number of trees per acre = area in square feet x 0.01
- iii. Total number of shrubs per acre = area in square feet x 0.05
- iv. Groundcover = plant and seed to achieve 100% coverage



Home Depot, Glenn Widing Drive, North Portland



Washington County

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the extended dry basin for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

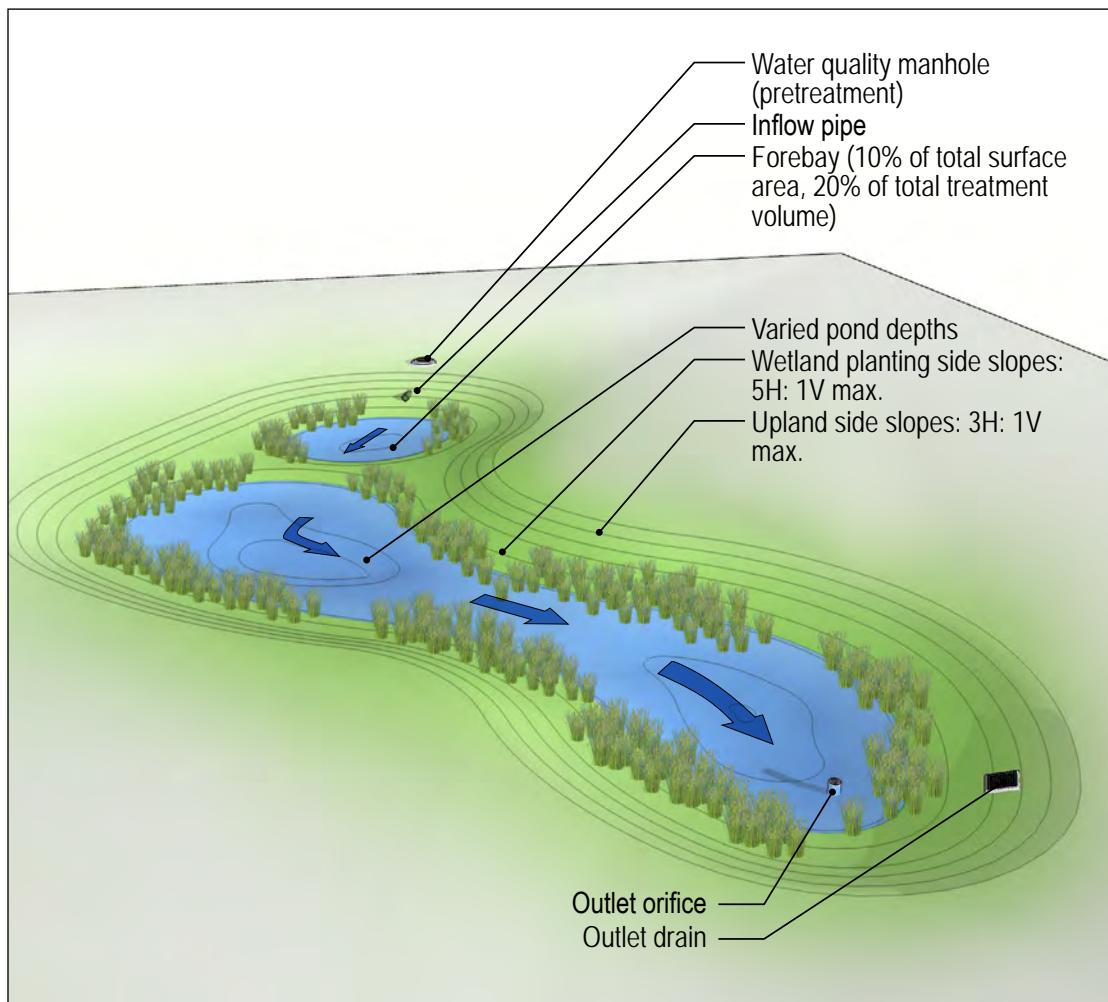
If private, the property owner will be responsible for ongoing maintenance per a recorded maintenance agreement (see page 88 for example maintenance agreement).

For detailed Operation and Maintenance Plans that describe proper maintenance activities please refer to page 91.

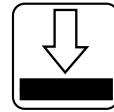
All publicly maintained facilities must have a public easement.

References

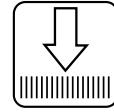
Clean Water Services Design and Construction Standard.



parking areas
& impermeable
landscape



impermeable
soils



permeable
soils

Description

A constructed water quality wetland is a shallow landscaped depression that collects and holds stormwater runoff and allows pollutants to settle and filter out during storm events. Constructed wetlands have a permanent pool of water and also an **extended detention area** above that fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to reduce pollution by settling and biological processes. The extended detention area is sized to meet flow control requirements.

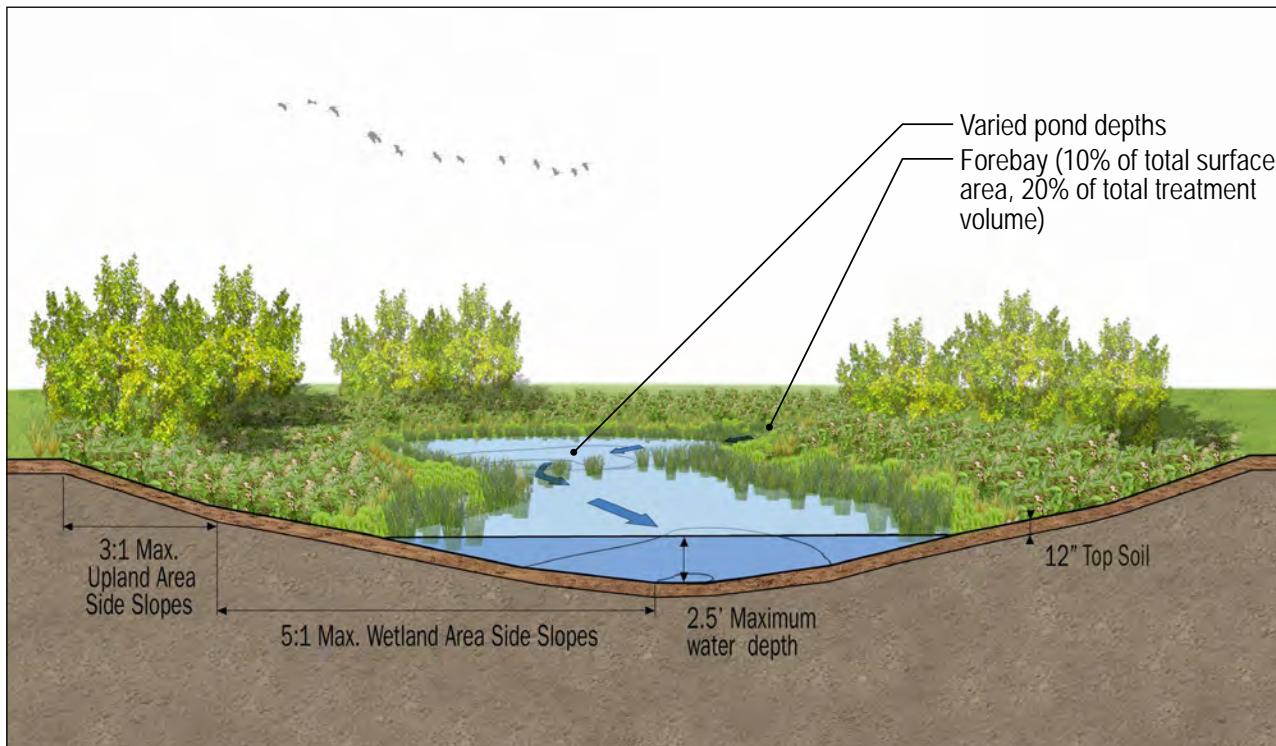
- Y - Public System Approvable
- Y - Quantity for Conveyance
- Y - Hydromodification Approach
- N - Water Quality Treatment Approach

Application & Limitations

Constructed water quality wetlands may help fulfill a site's landscaping area requirement. Constructed wetlands are approved to treat stormwater from all types of impervious surfaces, including private property and the public right-of-way, runoff from rooftops, parking lots and streets.



Ronler Acres, Hillsboro



Design Factors

Sizing

Sizing of the constructed water quality wetland is determined by the volume of runoff and the required detention time for treatment.

At a minimum, the detention basin must accommodate the water quality design storm and be sized for a 48-hour drawdown time. The minimum water quality detention volume is equal to (1)x the water quality volume (WQV). The outlet orifice size is determined by the following equation:

$$D = 24 * [(Q / (C[2gH]^{0.5}) / \pi)]^{0.5}$$

Where:

$$D \text{ (in)} = \text{diameter of orifice } Q(\text{cfs}) = WQV(\text{cf}) / (48 * 60 * 60)$$

$$C = 0.62$$

$$H(\text{ft}) = 2/3 \times \text{temporary detention height to centerline of orifice}$$

Geometry/Slopes

Constructed water quality wetlands have two or more cells. The first cell, known as the forebay, is at least 10% of the entire surface area and constitutes 20% of the treatment volume. If space is limited, one cell with a forebay at the inlet will settle sediments and distribute flow across the wet pond.

Unlike the flat bottom of an extended dry basin, in a constructed wetland the pool depth varies throughout the pond. Not including the permanent pool, the maximum depth of the water quality pool is 2.5 feet unless otherwise approved by the jurisdiction.

Side slopes for wetland planting areas should not exceed 5H: 1V (20%) and side slopes for non-wetland planting areas should not exceed 3H: 1V (33.33%). The minimum freeboard height is 1 foot from the 25-year design water surface elevation. A perimeter 10 to 20 feet wide provides inundation during storm events.

Piping for Constructed Water Quality Wetlands

Incoming flows to the water quality wetland facility are pretreated by a water quality manhole or other approved pretreatment method in accordance with District Standards. Other pretreatment methods may include proprietary devices, filter strip, trapped catch basin, or other methods as approved by the District or the city. An approved outlet structure is provided for all flows.

Setbacks

Check with the local building department to confirm site-specific requirements.



Oleson Woods Apartments, Tigard

Design Factors (continued)

Soil Amendment/Mulch

A minimum of 12" of topsoil should be applied to all treatment areas.

Vegetation

The entire facility area (permanent pool, side slopes and perimeter zone) are planted with vegetation appropriate for the varying planting conditions within the constructed wetland. Planting conditions within the wetland vary from saturated soil to relatively dry, and several planting zones should be considered. The zone between the bottom of the constructed wetland and the top of the permanent pool will be constantly inundated with water and have saturated soils. This wet zone should be planted with rushes, sedges and other wetland species that are well suited to water-saturated, oxygen-deprived (anaerobic) planting conditions. The variable depth of the bottom of the wetland will create a series of micro-planting conditions. Within this wet zone, areas of open water may be too deep to support significant vegetation.

The side slopes above the permanent pool depth to the outer edges of the perimeter zone will have a moisture gradient that varies from wet near the bottom to relatively dry near the edge of the perimeter area where inundation rarely

occurs. This moisture gradient will vary depending upon the maximum designed water depth, constructed wetland depth and side slope steepness. This moist-to-wet transition zone from the top of the permanent pool to the designed high-water line or top of freeboard should be planted with sedges, rushes, perennials, ferns and shrubs that can tolerate occasional standing water and wet-to-moist planting conditions. Areas above the designed high water line and immediately adjacent to the water quality wetland is a dry zone and will not be regularly inundated. The dry zone should be planted with self-sustaining, low maintenance grasses, perennials and shrubs suitable for the local climate.

The planting design should minimize solar exposure of open-water areas to reduce heat gain in the water. Lower water temperatures help to maintain healthy oxygen levels and minimize algae blooms. Trees or other appropriate vegetation should be planted at the perimeter of the pond to maximize shading.

The use of native plants is encouraged, but adapted, non-invasive ornamentals are acceptable for added aesthetic and functional value.

All vegetation should be densely and evenly planted to ensure proper hydrological function of the water quality wetland.



Synopsys, Hillsboro



Ronler Acres, Hillsboro

Design Factors (continued)

Plant Spacing

Constructed Water Quality Wetlands in tracts or easements are to be planted as follows to achieve the specified per acre densities:

- i. Treatment area = 6 plugs per square foot (min. 1-inch diameter by 6-inch tall)
- ii. Total number of trees per acre = area in square feet x 0.01
- iii. Total number of shrubs per acre = area in square feet x 0.05
- iv. Groundcover = plant and seed to achieve 100% areal coverage

Required Maintenance Period

- Water-efficient irrigation should be applied for the first two years after construction of the facility, particularly during the dry summer months, while plantings become established. Irrigation after these two years is at the discretion of the owner.
- If public, the permittee is responsible for the maintenance of the constructed water quality wetland for a minimum of two years following construction and acceptance of the facility.

Long-Term Maintenance

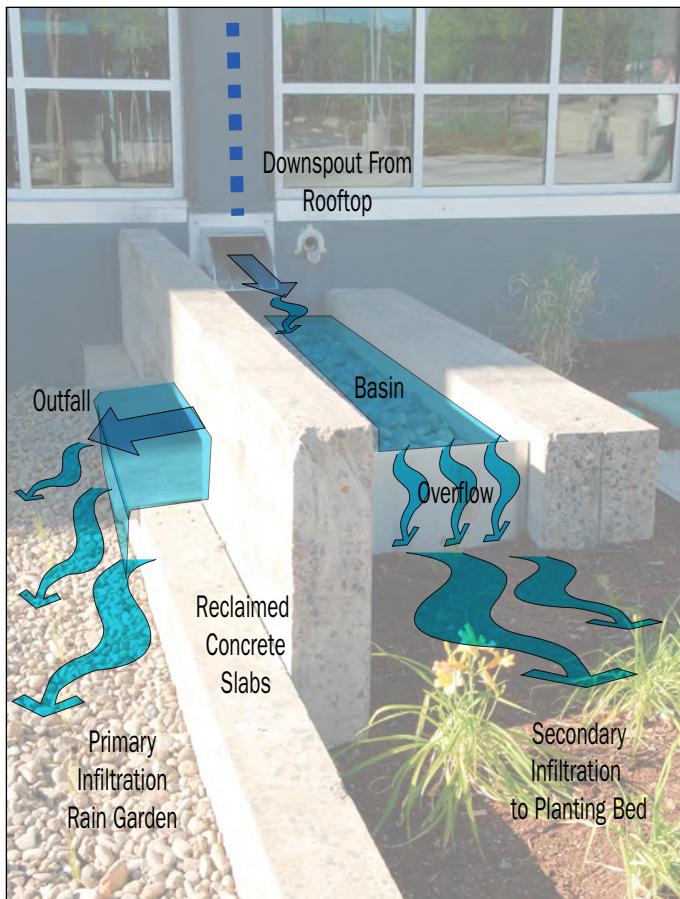
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For detailed Operation and Maintenance Plans that describe proper maintenance activities please refer to page 91.

All publicly maintained facilities must have a public easement.

References

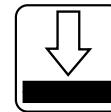
Clean Water Services Design and Construction Standards.



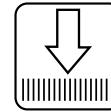
buildings



parking areas & impermeable landscape



impermeable soils



permeable soils

RiverEast Center, Portland. Stormwater from the rooftop is conveyed by a downspout into a sculptural basin made with reclaimed concrete from the retrofit of the building. The basin detains and slows runoff before it flows into a series of adjacent rain gardens, grated runnels and swales.

Description

Stormwater conveyance is the flow, movement or transfer of stormwater from one location to another. Stormwater conveyance techniques deliberately transport water from where it falls to where it will be treated. All Low Impact Development Approaches (LIDA) convey stormwater, and the movement and slowing of water through these facilities improves water quality and attenuates peak stormwater flows.

There are design standards for each type of LIDA, but there is flexibility to allow creativity and site-specific adaptation for how stormwater enters and passes through these facilities to meet required performance criteria



Application & Limitations

There are two general methods of stormwater conveyance, underground and above ground.

1. Underground conveyance channels stormwater in pipes below-ground and typically requires a plumbing permit. (See Design and Construction Standards for additional details and requirements.)
2. Above-ground conveyance moves water on the surface of the ground. In applicable locations, such as LIDA facilities, the benefits of above-ground conveyance may include:
 - Lower construction costs due to less excavation and underground piping
 - Less site disturbance
 - Improved oxygenation and cleansing of water
 - More opportunities for artistic and creative design
 - Enhanced public awareness of urban stormwater

Conveyance and Stormwater Art

Page 2 of 4



New Seasons, 20th and Division, Portland. A whimsical steel sculpture conveys stormwater from a grocery store rooftop into an infiltration planter.



Estacada Library. Stormwater is conveyed from the rooftop to an infiltration basin. As the basin fills with water, it overflows into a connected series of swales and additional infiltration basins that convey stormwater around the library.



Headwaters at Tryon Creek, SW Portland. Headwaters is a residential development where senior housing, town homes, and an apartment building were designed to be integrated with the daylighting (removal from an underground piping system) of a tributary of Tryon Creek.



North Main Village, Milwaukie. Stormwater is the featured design element for this residential courtyard. Water from rooftops is conveyed by steel scuppers into decorative planters to meandering runnels and water quality swales.

Conveyance and Stormwater Art

Page 3 of 4



"Downspout 101", Seattle (artist Buster Simpson). The branching downspout is part of a public art project called "Growing Vine Street" that uses visual and provocative conveyance techniques to raise awareness of the stormwater flowing through the neighborhood.



PSU Stephen Epler Hall. Stormwater from the impermeable plaza area is directed to bands of granite stone that are strategically placed at low drainage points to convey stormwater to a series of flow-through planters.



Team Estrogen Warehouse, Washington County. Stormwater from the warehouse roof is conveyed by a scupper into a concrete splash basin. The velocity of the water is slowed before the water flows into a vegetated swale.



Block 11, Washougal, WA. Stormwater from surrounding rooftops is directed into the plaza's vertical sculpture before entering flow-through planters.

Conveyance and Stormwater Art

Page 4 of 4



Glencoe Elementary School Rain Garden, Portland. Stormwater from neighboring streets is conveyed into an infiltration rain garden filled with native plants and rock berms that slow the flow of water. The rain garden is also a visual amenity and educational component for the elementary school (photo courtesy of 2008 Portland Stormwater Manual).



Headwaters at Tryon Creek, SW Portland. The rounded and stepped design of these infiltration planters are molded to the specific conditions of the site. The concrete walls are a creative interpretation of check dams that are used to convey water across flat surfaces over steep topography.



New Seasons, Beaverton. Two decorative scuppers collect and convey roof stormwater into an infiltration basin.



10th @ Hoyt, Portland. The design of this urban courtyard is inspired by Persian gardens. Downspouts convey stormwater from the surrounding rooftops into a series of channels and colorful fountains.



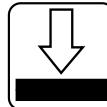
Local 49, Portland. Stormwater is conveyed from the rooftop by a decorative stainless steel metal scupper into the courtyard. Water flows from the scupper into a concrete runnel, detention basin and planters.



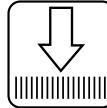
buildings



parking areas
& impermeable
landscape



impermeable
soils



permeable
soils

Tanner Springs Park, Portland. Stormwater from surrounding impermeable surfaces is conveyed and recirculated through a constructed wetland and filter strip to be cleansed and aerated. The filter strip and wetland edge is planted with a variety of native plants based on their suitability to the different planting conditions.

Description

A habitat is a space that provides food, water and shelter for the survival and reproduction of an organism. Low Impact Development Approaches (LIDA) facilities mimic the natural habitats, processes and hydrology of a particular site. The environmental benefits of LIDA facilities include:

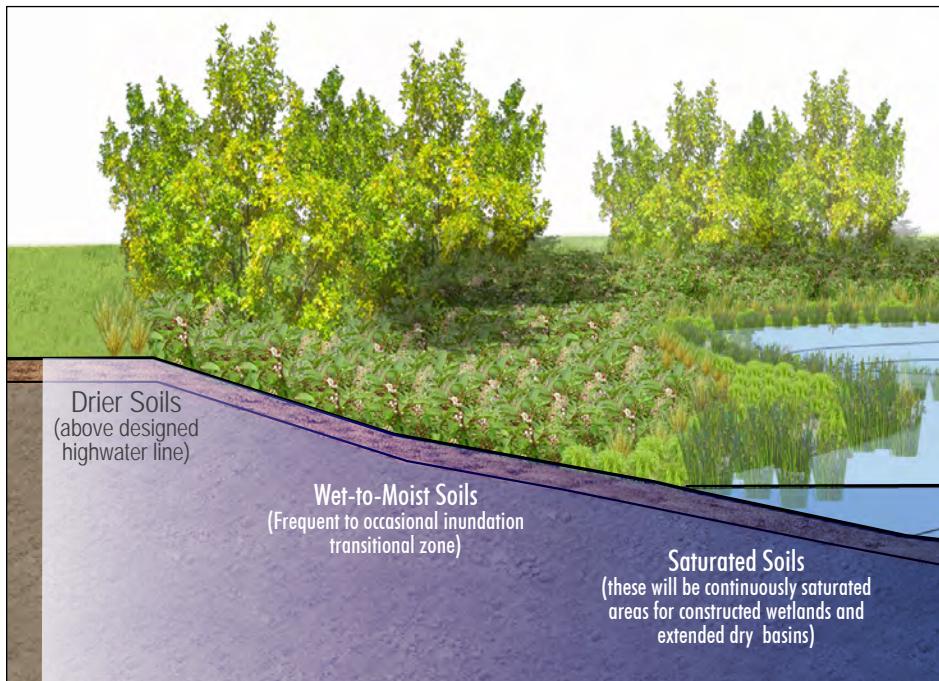
- Less disturbance to sites than conventional stormwater management methods
- Reduced and delayed peak stormwater flows
- Reduced discharge of pollutants
- Increased planted space and habitat
- Creation of a multifunctional landscape that enhances visual and functional amenities

All of these on-site benefits generate a variety of off-site benefits that preserve and enhance riparian and wetland habitats "downstream" from the facility by reducing the negative environmental affects associated with urban development.

Application & Limitations

Nearly all LIDA facilities have the potential to create and improve habitat on and near the site. Water is one of the most important factors in the creation of habitat; because most LIDA facilities receive large amounts of stormwater, they offer a great opportunity to create habitat. Planting vegetation is one of the most practical ways to create habitat within a LIDA facility.

Each LIDA facility has planting design guidelines such as required plant spacing and plant types, but there is flexibility to maximize habitat for a variety of organisms such as invertebrates, amphibians, small mammals and birds.



Planting conditions and habitats are varied for LIDA facilities with side slopes, such as vegetated swales, LIDA swales, extended dry basins and water quality wetlands.

Design Factors

Relationship of Form and Hydrology

Careful consideration of the planting conditions within a LIDA facility will help to ensure the success of a planting design.

Planting conditions for sloped, basin-like stormwater facilities such as swales, extended dry basins, constructed water quality wetlands and infiltration basins have a variety of moisture levels. Soil conditions at and near the bottom of the facility are wet due to frequent or constant inundation, and side slopes vary from wet at the bottom to relatively dry near the top. The moisture gradient varies with the designed maximum water depth, the time it takes for a facility to drain after a storm event and the steepness of the side slopes. The zone from the bottom of the facility to the designed high-water line or top of freeboard should be planted with plants that tolerate occasional standing water and wet-to-moist conditions. Above the designed high-water line vegetation is not affected by stormwater entering the facility and should be planted with species well suited to the local climate and context.

Planting conditions are more uniform for flow-through and Structural Infiltration planters because of the relatively flat surface



Planting conditions for LIDA facilities without sloped edges (such as concrete flow-through planters and infiltration planters) are largely uniform.



Beaumont Village, Portland



Oregon Convention Center Rain Garden, Portland



Mt. Tabor Middle School, Southeast Portland

Design Factors (continued)

Climate and Microclimate

All stormwater facility vegetation should be well adapted to both the Northwest regional climate and the facility's microclimate.

Although regional climate dictates average seasonal temperatures, amount of rainfall and available daylight, site-specific microclimates can vary considerably and should be factored into the planting design, particularly in an urbanized environment. For example, sword fern is a plant native to woodlands of the Pacific Northwest that likely would not survive if placed in a south-facing flow-through planter with direct sun exposure most of the day and heat radiating off the building. However, sword fern placed in a flow-through planter on the north side of the building likely would thrive.

Native and Adapted Plants

The use of native plants is strongly recommended. They are well adapted to the local climate and offer more habitat value for native organisms. Non-native or adapted plants may be used in stormwater facilities for added color and habitat value as long as they are noninvasive and appropriate for the facility. Local nurseries offer a wealth of information about native and adapted plants.

Habitat Diversity and Layering of Plants

Natural environments in the Pacific Northwest are characterized by diverse, layered plant habitats. A forest typically has three broad habitats vertically arranged one on top of the other: low-growing groundcovers, topped by shrubs, topped by arborescent shrubs (shrubs that look like small trees) and trees. These layers vary in composition and form from one habitat type to another, such as the Northwest habitats of forest, wetland and riparian. Different organisms occupy different niches within these habitats, creating greater biodiversity. A range of habitats can be created in LIDA facilities by selecting a variety of complementary vegetation to plant together, such as groundcovers, perennials, shrubs, and trees. The structural variety of a diversified planting design can also be very pleasing to the eye.

Irrigation

Water-efficient irrigation should be applied for at least the first two years after construction of the facility, particularly during the dry summer months, while plantings become established.



Oleson Woods Apartments, Tigard



Rock Creek Greenway

Maintenance

- Check regularly for weeds. Remove weeds or invasive plants such as blackberries and ivy, and implement a weed control program as needed.
- Check mulch regularly to maintain uniform coverage. Most LIDA facilities specify a mulch cover such as river rock to prevent erosion and moisture loss during dry periods.
- Replant bare patches as necessary to comply with the facility's coverage requirements and maintenance plan.

References

- Clean Water Services Design and Construction Standards
- Gardening with Native Plants poster; Clean Water Services



Ronler Acres, Hillsboro

Appendix Planting Templates and Plant Lists

62 Planting Zones

65 PUBLIC Facility Plant Lists Only

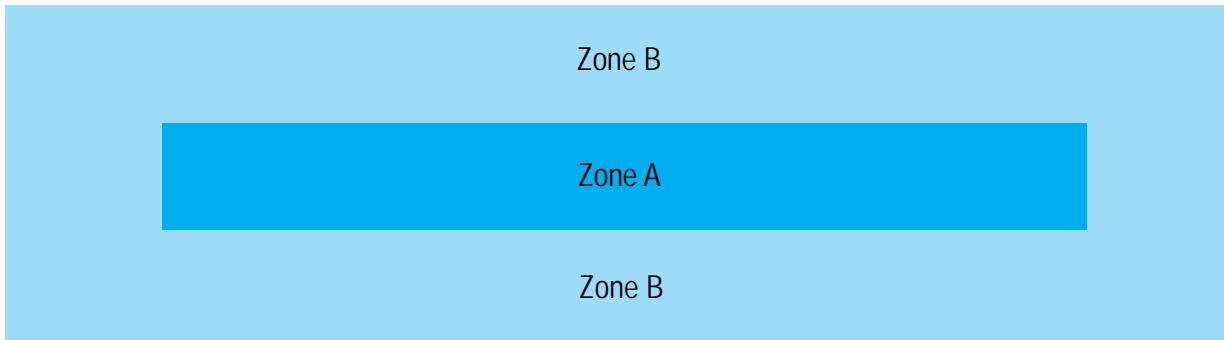
68 PRIVATE Facility Plant Lists Only

Appendix Planting Templates and Plant Lists

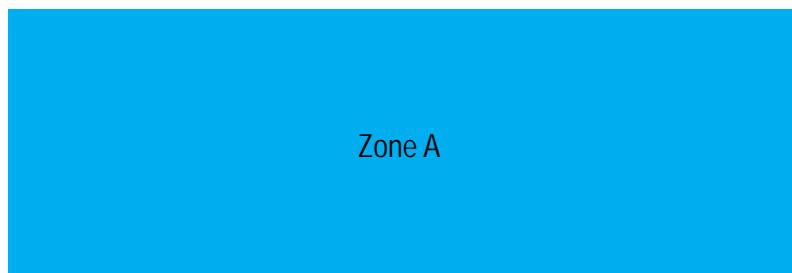
Zone A: Area of the facility defined as the bottom of the facility to the designed high water mark. This area has moist to wet soils and plants located here shall be tolerant of mild inundation.

Zone B: Area of the facility defined as the side slopes from the designed high water line up to the edge of the facility. This area typically has dryer to moist soils, with the moist soils being located further down the side slopes. Plants here should be drought tolerant and help stabilize the slopes.

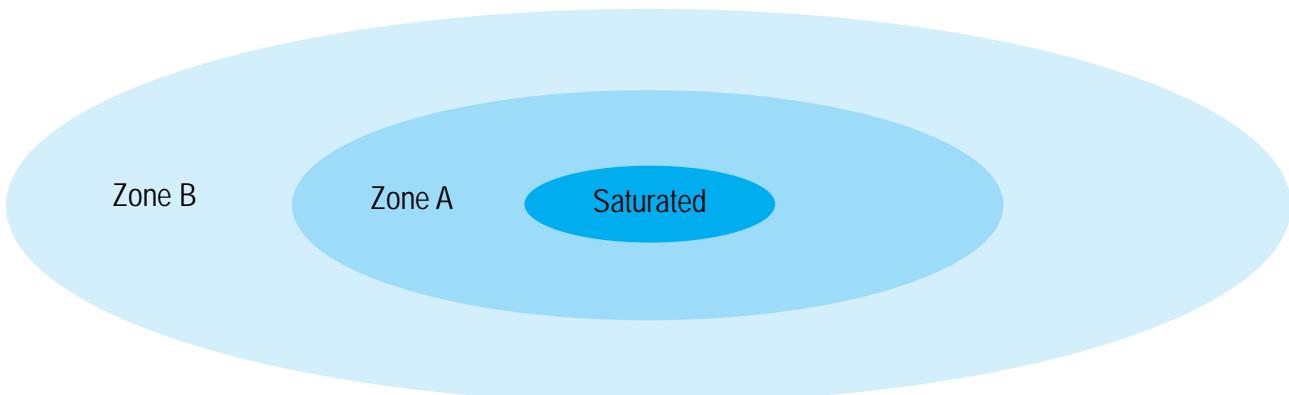
Swale Planting Zones



Planter Planting Zones

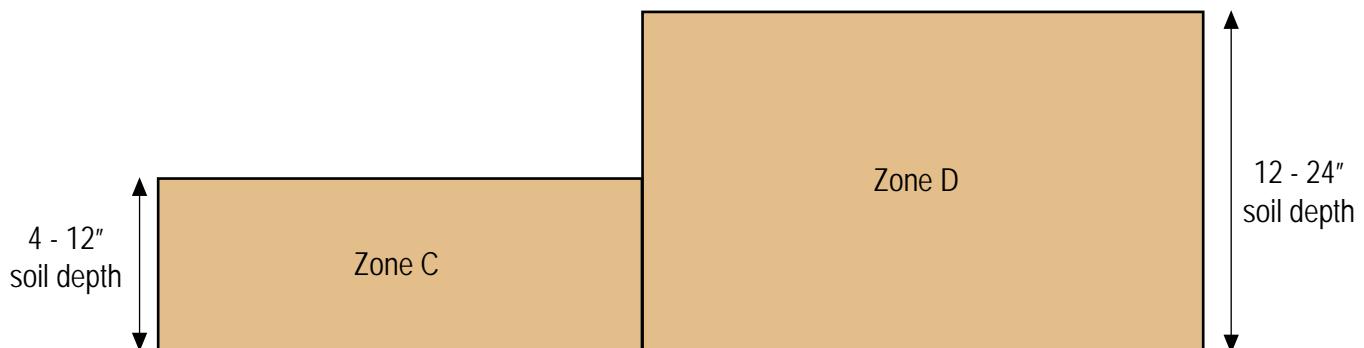


Basin Planting Zones



Appendix Planting Templates and Plant Lists (continued)

Ecoroof Planting Zones



Public and Private Facility Plant Lists

Legend

Planting Zone A - Treatment Area- standing or flowing water/nearly constant saturation; anaerobic soils

Planting Zone A/B - Upper Treatment Area/Midslope - moist, periodically saturated; anaerobic and/or aerobic soils.

Planting Zone B - Upper Slope- dry and infrequent inundation/saturation, if any; aerobic soils

Planting Zone C - Green Roof Only- 4-12" soil depth

Planting Zone D - Green Roof Only - 12"-24" soil depth

 **SUN** = (at least 6 hours of direct sun)

 **PART SHADE** = (3 - 6 hours of sun each day)

 **SHADE** = (less than 3 hours of direct sun)

- * Note: Large Shrubs and Small Trees will not be allowed in street side swales
- ** Note: Trees will not be allowed in stormwater facilities that are in tracts or easements less than 30 feet wide.

Seed Mix

Low Grow Seed Mix for Veg Swale, Extended Dry Basin, Veg Filter Strip. Dwarf Tall Fescue 40%, Dwarf Perennial Rye 30%, Creeping Red Fescue 25%, Colonial Bent Grass 5%. Apply at a rate of 120 pounds/acre

Public Facility Plant List

Plant Name Botanic name, Common name	Proposed Facility Type						Characteristics			
	Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	NW Native	Preferred Light	Potential Height	Planting Zone
Herbaceous Plants										
<i>Camassia leichtlinii</i> , Camas Lily				X	X	Y	SUN PART SHADE	24"	A	
<i>Camassia quamash</i> , Common Camas				X	X	Y	SUN PART SHADE	24"	A/B	
<i>Carex densa</i> , Dense Sedge	X	X	X	X	X	Y	SUN PART SHADE	24"	A	
<i>Carex obnupta</i> , Slough Sedge	X	X	X	X	X	X	SUN PART SHADE	4"	A	
<i>Carex stipata</i> , Sawbeak Sedge	X	X	X	X	X	X	SUN PART SHADE	20"	A	
<i>Carex vesicaria</i> , Inflated Sedge	X	X	X	X	X	X	SUN PART SHADE	36"	A	
<i>Carex vulpinoidea</i> , Fox Sedge	X	X	X		X	X	SUN PART SHADE	24"	A	
<i>Deschampsia cespitosa</i> , Tufted Hair Grass				X	X	Y	SUN PART SHADE	36"	A/B	
<i>Hebe 'Autumn Glory'</i> , Hebe					X	N	SUN PART SHADE	14"	B	
<i>Iris douglasiana</i> , Douglas Iris				X	X	X	SUN	18"	B	
<i>Iris tenax</i> , Oregon Iris				X	X	X	SUN	18"	B	
<i>Juncus balticus</i> , Baltic Rush			X		X		SUN PART SHADE	20"	A	
<i>Juncus effusus</i> var. <i>pacificus</i> , Soft rush	X	X	X	X	X	X	SUN PART SHADE	36"	A	
<i>Juncus ensifolius</i> , Dagger-leaf Rush	X	X	X	X	X	X	SUN PART SHADE	10"	A	
<i>Juncus patens</i> , Spreading Rush	X	X	X	X	X	X	SUN PART SHADE	36"	A	
<i>Juncus tenuis</i> , Slender Rush	X	X	X	X	X	X	SUN PART SHADE	36"	A	
<i>Scirpus microcarpus</i> , Small Fruited Bulrush	X		X	X	X	Y	SUN PART SHADE	24"	A	
<i>Symphytum subspicatum</i> , Douglas' Aster				X	X	Y	SUN	36"	B	
Large Shrubs and Small Trees*										
<i>Acer circinatum</i> , Vine Maple	X		X	X		Y	SUN PART SHADE	15'	B	
<i>Amelanchier alnifolia</i> , Western Serviceberry	X		X	X	X	Y	SUN	20'	B	
<i>Ceanothus sanguineus</i> , Oregon Redstem Ceanothus	X		X	X	X	Y	SUN PART SHADE	7'	B	
<i>Cornus sericea</i> , Red-twig Dogwood			X	X	X	Y	SUN PART SHADE	20'	A/B	
<i>Physocarpus capitatus</i> , Pacific Ninebark	X		X	X	X	Y	SUN PART SHADE	10'	A/B	
<i>Ribes sanguineum</i> , Red-Flowering Current	X		X	X	X	Y	SUN	8'	B	
<i>Rosa pisocarpa</i> , Cluster Rose			X	X		Y	SUN PART SHADE	8'	A/B	
<i>Rubus parviflorus</i> , Thimbleberry	X		X	X	X	Y	SUN PART SHADE	8'	B	
<i>Rubus spectabilis</i> , Salmonberry	X		X	X	X	Y	PART SHADE	10'	A	
<i>Sambucus cerulea</i> , Blue Elderberry	X		X	X	X	Y	SUN PART SHADE	10'	B	

Public Facility Plant List (continued)

Plant Name	Proposed Facility Type						Characteristics			
Botanic name, Common name	Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	NW Native	Preferred Light	Potential Height	Planting Zone
<i>Sambucus racemosa</i> , Red Elderberry	X		X	X	X	Y		SUN PART SHADE	10'	B
Small Shrubs										
<i>Spirea douglasii</i> , Douglas Spirea	X	X	X	X	X	X	Y	SUN PART SHADE	6'	A/B
<i>Viburnum edule</i> , Highbush Cranberry	X		X	X	X		Y	SUN PART SHADE	6'	A/B
<i>Holodiscus discolor</i> , Oceanspray	X		X	X			Y	SUN	6'	B
<i>Oemleria cerasiformis</i> , Indian Plum	X		X	X			Y	SHADE	6'	B
<i>Philadelphus lewisi</i> , Wild Mock Orange	X		X	X			Y	SUN PART SHADE	6'	B
<i>Lonicera involucrata</i> , Black Twinberry	X		X	X			Y	SUN PART SHADE	5'	B
<i>Ceanothus velutinus</i> , Snowbrush	X	X	X	X	X	Y	SUN PART SHADE	4'	B	
<i>Cornus sericea 'Kelseyi'</i> , Kelsey Dogwood	X	X	X	X	X	N	SUN PART SHADE	24"	B	
<i>Gaultheria shallon</i> , Salal		X				X	Y	PART SHADE SHADE	24"	B
<i>Mahonia aquifolium</i> , Oregon Grape	X	X	X	X	X	Y	SUN	5'	B	
<i>Mahonia nervosa</i> , Dull Oregon Grape	X	X	X	X	X	Y	PART SHADE SHADE	24"	B	
<i>Paxistima myrsinifolia</i> , Oregon Box Leaf	X	X	X		X	Y	PART SHADE SHADE	3'	B	
<i>Symphoricarpos alba</i> , Common Snowberry	X	X	X	X	X	Y	SUN PART SHADE SHADE	6'	B	
Groundcovers										
<i>Arctostaphylos uva-ursi</i> , Kinnickinnick		X					Y	SUN	6"	B
<i>Fragaria chiloensis</i> , Coastal Strawberry	X			X	X	Y	SUN PART SHADE	6"	B	
<i>Fragaria vesca</i> , Woodland Strawberry						Y	SUN PART SHADE	10"	B	
<i>Fragaria virginiana</i> , Wild Strawberry						Y	SUN PART SHADE	10"	B	
<i>Helictotrichon sempervirens</i> , Blue Oat Grass					X	N	SUN	24"	B	
<i>Mahonia repens</i> , Creeping Oregon Grape	X	X			X	Y	SHADE	12"	B	
Trees **										
<i>Abies grandis</i> , Grand Fir	X		X	X		Y	SUN PART SHADE	150'	B	
<i>Acer macrophyllum</i> , Big Leaf Maple						Y	SUN PART SHADE	60'	B	
<i>Alnus rubra</i> , Red Alder						Y	SUN	80'	A/B	
<i>Crataegus douglasii</i> , Black Hawthorn	X		X	X		Y	SUN	40'	A/B	
<i>Malus fusca</i> , Pacific Crabapple	X		X	X		Y	SUN PART SHADE	30'	A/B	
<i>Populus tremuloides</i> , Quaking Aspen	X		X	X		Y	SUN	40'	A/B	
<i>Prunus emarginata var. mollis</i> , Bitter Cherry	X		X	X		Y	SUN	50'	A/B	

Public Facility Plant List (continued)

Plant Name	Proposed Facility Type						Characteristics				
Botanic name, Common name	Vegetated Swale	LID/A Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	NW Native	Preferred Light		Potential Height	Planting Zone
<i>Pseudotsuga menziesii</i> , Douglas Fir	X			X X		Y		 SUN	 PART SHADE	200'	B
<i>Quercus garryana</i> , Oregon White Oak	X			X X		Y		 SUN		100'	B
<i>Rhamnus purshiana</i> , Cascara	X			X X		Y		 SUN		30'	A/B
<i>Thuja plicata</i> , Western Red Cedar	X			X X		Y				150'	A/B
<i>Tsuga heterophylla</i> , Western Hemlock	X			X X		Y		 SUN	 PART SHADE	125'	A/B
<i>Salix scouleriana</i> , Scouler's willow	X			X X		Y		 SUN		30'	B
<i>Tsuga mertensiana</i> , Mountain Hemlock	X			X X		Y		 SUN	 PART SHADE	125'	B

Private Facility Plant List

Plant Name	Botanic name, Common name	Proposed Facility Type					Characteristics				
		Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	Green Roof	NW Native	Preferred Light	Potential Height
Sedums and Succulents											
<i>Delosperma ssp.</i> , Ice Plant						X	N		SUN	4"	C
<i>Malephora crocea var. purpureo crocea</i>						X	N		SUN	10"	C
'Tequila Sunrise', Coppery Mesemb											
<i>Sedum Autumn Joy</i>						X	N		SUN	24"	C
<i>Sedum acre</i> , Biting Stonecrop						X	N		SUN	2"	C
<i>Sedum album</i> , White Stonecrop						X	N		SUN	3"	C
<i>Sedum divergens</i> , Pacific Stonecrop						X	N		SUN	3"	C
<i>Sedum hispanicum</i> , Spanish Stonecrop						X	N		SUN	3"	C
<i>Sedum kamtschaticum</i> , Kirin- so						X	N		SUN	6"	C
<i>Sedum oreganum</i> , Oregon Stonecrop						X	Y		SUN PART SHADE	4"	C
<i>Sedum sexangulare</i> , Tasteless Stonecrop						X	N		SUN	4"	C
<i>Sedum spathulifolium</i> , Stonecrop						X	Y		SUN	4"	C
<i>Sedum spurium</i> , Two-row Stonecrop						X	N		SUN PART SHADE	6"	C
<i>Sempervivum tectorum</i> , Hens and Chicks						X	N		SUN	6"	C
Herbaceous Plants											
<i>Achillea millefolium</i> , Common Yarrow						X	N		SUN	36"	C
<i>Achillea tomentosa</i> , Wooly Yarrow						X	N		SUN	8"	C
<i>Arenaria montana</i> , Sandwort						X	N		SUN	4"	C
<i>Artemesia 'Silver Mound'</i> , Artemesia						X	N		SUN	12"	C
<i>Aurinia saxatilis</i> , 'Compacta'						X	N		SUN	6"	C
Blechnum spicant, Deer Fern	X			X		Y			PART SHADE SHADE	24"	B
<i>Camassia leichtlinii</i> , Camas Lily	X	X		X		Y			SUN PART SHADE	24"	A
<i>Camassia quamash</i> , Common Camas	X	X		X		Y			SUN PART SHADE	24"	A/B
<i>Castilleja foliosa</i> , Indian Paintbrush					X	Y			SUN	10"	C
<i>Carex densa</i> , Dense Sedge	X	X	X	X	X	X	Y		SUN PART SHADE	24"	A
<i>Carex obnupta</i> , Slough Sedge	X	X	X	X	X	X	Y		SUN PART SHADE	4'	A
<i>Carex stipata</i> , Sawbeak Sedge	X	X	X	X	X	X	Y		SUN PART SHADE	20"	A
<i>Carex vesicaria</i> , Inflated Sedge	X	X	X	X	X	X	Y		SUN PART SHADE	36"	A
<i>Carex vulpinoidea</i> , Fox Sedge	X	X	X	X	X	X	Y		SUN PART SHADE	24"	A

Private Facility Plant List (continued)

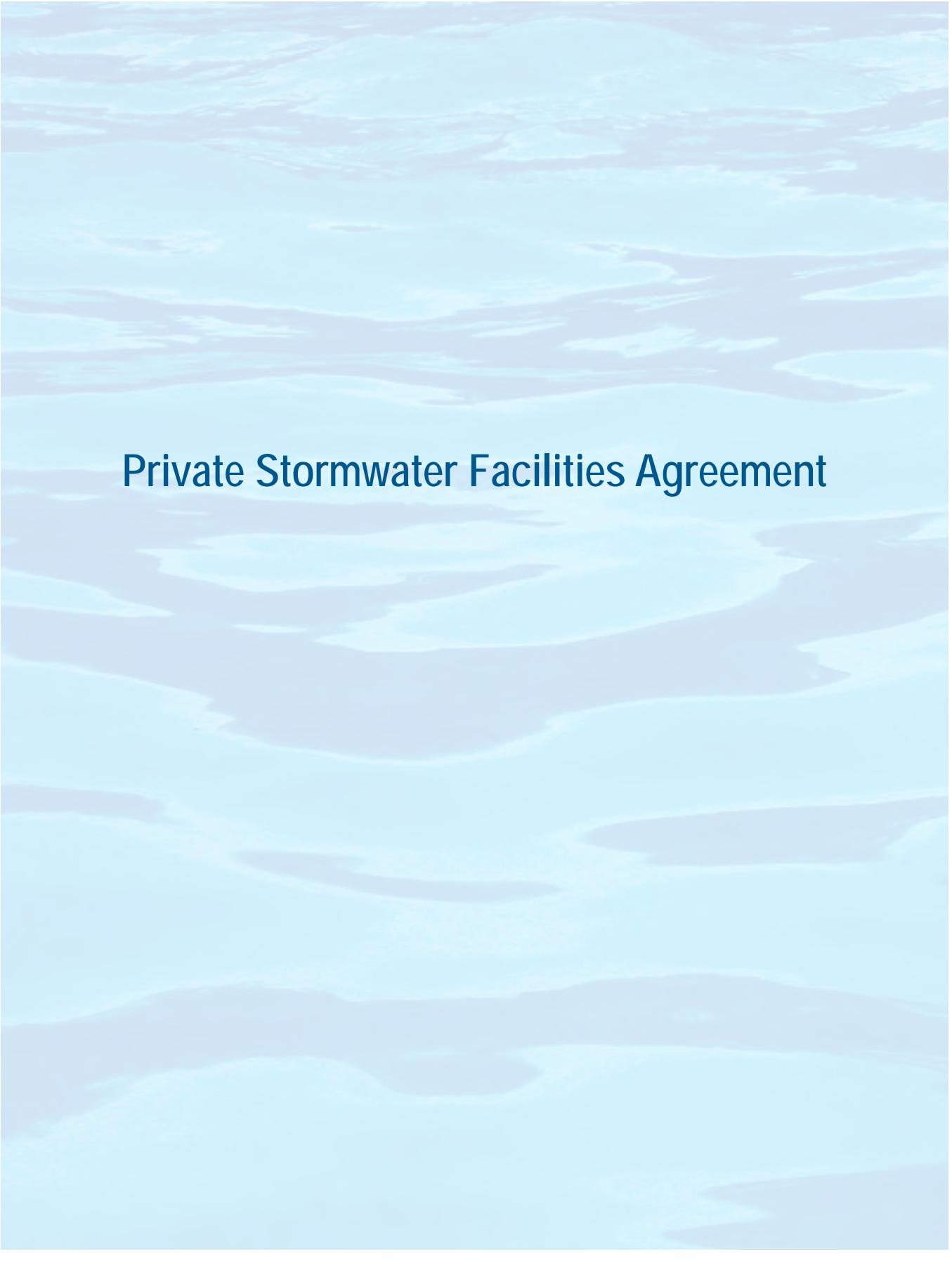
Plant Name	Proposed Facility Type						Characteristics				
Botanic name, Common name	Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	Green Roof	NW Native	Preferred Light	Potential Height	Planting Zone
<i>Deschampsia cespitosa</i> , Tufted Hair Grass	X	X			X		Y		SUN PART SHADE	36"	A/B
<i>Dianthus</i> ssp.							X	N	SUN PART SHADE	12"	C
<i>Erigeron discoideus</i> , Fleabane							X	N	SUN PART SHADE	12"	C
<i>Festuca glauca</i> , Blue Fescue							X	Y	SUN PART SHADE	12"	C
<i>Fragaria chiloensis</i> , Coastal Strawberry							X	Y	SUN PART SHADE	10"	C
<i>Gaillardia aristata</i> , Birds-eye gilia							X	N	SUN PART SHADE	20"	C
<i>Gazania linearis</i> 'CO Gold', Gazania							X	N	SUN	6"	C
<i>Gilia capitata</i> , Blue Thimble Flower							X	Y	SUN	12"	C
<i>Hebe</i> 'Autumn Glory', Hebe	X				X		N		SUN PART SHADE	14"	B
<i>Iris douglasiana</i> , Douglas Iris	X				X		Y		SUN	18"	A/B
<i>Iris tenax</i> , Oregon Iris	X				X		Y		SUN	18"	A/B
<i>Juncus balticus</i> , Baltic Rush			X	X			Y		SUN PART SHADE	20"	A
<i>Juncus effusus</i> var. <i>pacificus</i> , Soft rush	X	X	X	X	X	X	Y		SUN PART SHADE	36"	A
<i>Juncus ensifolius</i> , Dagger-leaf Rush	X	X	X	X	X	X	Y		SUN PART SHADE	10"	A
<i>Juncus patens</i> , Spreading Rush	X	X	X	X	X	X	Y		SUN PART SHADE	36"	A
<i>Juncus tenuis</i> , Slender Rush	X	X	X	X	X	X	Y		SUN PART SHADE	36"	A
<i>Koeleria macrantha</i> , June Grass							X	N	SUN PART SHADE	24"	C
<i>Linaria reticulata</i> , Purple-net Toadflax							X	N	SUN	20"	C
<i>Lobularia maritima</i> , Sweet Alyssum							X	N	SUN	12"	C
<i>Polypodium glycyrrhiza</i> , Licorice Fern							X	Y	SUN PART SHADE	12"	C
<i>Polystichum munitum</i> , Sword Fern							X	Y	SUN PART SHADE	24"	C
<i>Potentilla nepalensis</i> , Nepal Cinquefoil							X	N	SUN PART SHADE	14"	C
<i>Potentilla neumanniana</i> , Cinquefoil							X	N	SUN	14"	C
<i>Scirpus microcarpus</i> , Small Fruited Bulrush	X		X	X	X		Y		SUN PART SHADE	24"	A
<i>Symphyotrichum subspicatum</i> , Douglas' Aster	X	X	X	X	X	X	Y		SUN	36"	B
<i>Thymus serpyllum</i> , Creeping Thyme							X	N	SUN	3"	C
<i>Veronica liwanensis</i> , Speedwell							X	N	SUN PART SHADE	2"	C
Large Shrubs and Small Trees*											
<i>Acer circinatum</i> , Vine Maple	X		X	X	X		Y		SUN PART SHADE	15'	B
<i>Amelanchier alnifolia</i> , Western Serviceberry	X		X	X	X		Y		SUN	20'	B

Private Facility Plant List (continued)

Plant Name	Proposed Facility Type							Characteristics		
	Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	Green Roof	Preferred Light	Potential Height	Planting Zone
Botanic name, Common name							NW Native			
<i>Ceanothus sanguineus</i> , Oregon Redstem Ceanothus	X			X	X	X		Y	SUN	PART SHADE
<i>Cornus sericea</i> , Red-twig Dogwood	X			X	X	X		Y	SUN	PART SHADE
<i>Physocarpus capitatus</i> , Pacific Ninebark	X			X	X	X		Y	SUN	PART SHADE
<i>Ribes sanguineum</i> , Red-Flowering Current	X			X	X	X	X	Y	SUN	
<i>Rosa pisocarpa</i> , Cluster Rose	X			X	X			Y	SUN	PART SHADE
<i>Rubus parviflorus</i> , Thimbleberry	X			X	X	X		Y	SUN	PART SHADE
<i>Rubus spectabilis</i> , Salmonberry	X			X	X	X		Y	SUN	PART SHADE
<i>Sambucus cerulea</i> , Blue Elderberry	X			X	X	X		Y	SUN	PART SHADE
<i>Sambucus racemosa</i> , Red Elderberry	X			X	X	X		Y	SUN	PART SHADE
Small Shrubs										
<i>Amalanchier alnifolia</i> , Saskatoon Serviceberry							X	Y	SUN	20"
<i>Berberis thunbergii</i> , Japanese Barberry							X	N	SUN	4'
<i>Spirea douglasii</i> , Douglas Spirea	X	X	X	X	X	X		Y	SUN	PART SHADE
<i>Holodiscus discolor</i> , Oceanspray	X	X		X	X	X		Y	SUN	
<i>Lavandula angustifolia</i> 'Hidcote', Dwarf English Lavander							X	N	SUN	30"
<i>Lonicera involucrata</i> , Black Twinberry	X	X		X	X	X		Y	SUN	PART SHADE
<i>Viburnum edule</i> , Highbush Cranberry	X	X	X	X	X	X		Y	PART SHADE	SHADE
<i>Oemleria cerasiformis</i> , Indian Plum	X	X		X	X	X		Y	PART SHADE	SHADE
<i>Philadelphus lewisii</i> , Wild Mock Orange	X	X		X	X	X		Y	SUN	
<i>Ceanothus velutinus</i> , Snowbrush	X	X		X		X		Y	SUN	
<i>Cornus sericea</i> 'Kelseyi', Kelsey Dogwood	X	X		X	X	X		N	SUN	PART SHADE
<i>Gaultheria shallon</i> , Salal	X	X		X		X	X	Y	PART SHADE	SHADE
<i>Mahonia aquifolium</i> , Oregon Grape	X	X		X	X	X	X	Y	SUN	PART SHADE
<i>Mahonia nervosa</i> , Dull Oregon Grape	X	X		X	X	X	X	Y	PART SHADE	SHADE
<i>Mahonia repens</i> , Creeping Oregon Grape							X	Y	SUN	PART SHADE
<i>Paxistima myrsinifolia</i> , Oregon Box Leaf	X	X		X		X		Y	PART SHADE	SHADE
<i>Symphoricarpos alba</i> , Common Snowberry	X	X		X	X	X		Y	SUN	PART SHADE
<i>Symphoricarpos mollis</i> , Creeping Snowberry							X	Y	SUN	PART SHADE
<i>Thymus vulgaris</i> , Common Thyme							X	N	SUN	PART SHADE

Private Facility Plant List (continued)

Plant Name	Proposed Facility Type							Characteristics		
	Vegetated Swale	LIDA Swale/Rain Garden	Infiltration/Flow Through Planter	Extended Dry Basin	Constructed Water Quality Wetland	Vegetated Filter Strip	Green Roof	Preferred Light	Potential Height	Planting Zone
Botanic name, Common name										
Groundcovers										
<i>Arctostaphylos uva-ursi</i> , Kinnickinnick	X		X				Y	 SUN	6"	B
<i>Fragaria chiloensis</i> , Coastal Strawberry	X		X	X	X	X	Y	 SUN  PART SHADE	6"	B
<i>Fragaria vesca</i> , Woodland Strawberry	X		X	X	X		Y	 SUN  PART SHADE	10"	B
<i>Fragaria virginiana</i> , Wild Strawberry	X		X	X	X	X	Y	 SUN  PART SHADE	10"	B/C
<i>Helictotrichon sempervirens</i> , Blue Oat Grass			X		X		N	 SUN	24"	B
<i>Mahonia repens</i> Creeping Oregon Grape		X	X		X		Y	 SHADE	12"	B
Trees **										
<i>Abies grandis</i> , Grand Fir	X		X	X			Y	 SUN  PART SHADE	150'	B
<i>Acer macrophyllum</i> , Big Leaf Maple	X		X	X			Y	 SUN  PART SHADE	60'	B
<i>Alnus rubra</i> , Red Alder	X		X	X			Y	 SUN	80'	A/B
<i>Crataegus douglasii</i> , Black Hawthorn	X		X	X	X		Y	 SUN	40'	A/B
<i>Malus fusca</i> , Pacific Crabapple	X		X	X	X		Y	 SUN  PART SHADE	30'	A/B
<i>Populus tremuloides</i> , Quaking Aspen	X		X	X	X		Y	 SUN	40'	A/B
<i>Prunus emarginata</i> var. <i>mollis</i> , Bitter Cherry	X		X	X	X		Y	 SUN	50'	A/B
<i>Pseudotsuga menziesii</i> , Douglas Fir	X		X	X			Y	 SUN  PART SHADE	200'	B
<i>Quercus garryana</i> , Oregon White Oak	X		X	X			Y	 SUN	100'	B
<i>Rhamnus purshiana</i> , Cascara	X		X	X	X		Y	 SUN	30'	A/B
<i>Thuja plicata</i> , Western Red Cedar	X		X	X			Y	 SUN  PART SHADE  SHADE	150'	A/B
<i>Tsuga heterophylla</i> , Western Hemlock	X		X	X			Y	 SUN  PART SHADE	125'	A/B
<i>Salix scouleriana</i> , Scouler's willow	X		X	X			Y	 SUN	30'	B
<i>Tsuga mertensiana</i> , Mountain Hemlock	X		X	X			Y	 SUN  PART SHADE	125'	B



Private Stormwater Facilities Agreement

After Recording Return to:
Clean Water Services
2550 SW Hillsboro Hwy.
Hillsboro, OR 97123

PRIVATE STORMWATER FACILITIES AGREEMENT

This Agreement is made and entered into this _____ day of _____ 20____, by and between Clean Water Services (District) and _____ (Owner) whose address is _____.

RECITALS

A. Owner has developed or will develop the Facilities listed below. (List the type of private stormwater facilities on site and the quantity of each type).

Facility type (list each) _____ Quantity _____

B. The Facilities enable development of property while mitigating the impacts of additional surface water and pollutants associated with stormwater runoff prior to discharge from the property to the public stormwater system. The consideration for this Agreement is connection to the public stormwater system.

C. The property benefited by the Facilities and subject to the obligation of this Agreement is described below or in Exhibit A (Property) attached hereto and incorporated by reference.

D. The Facilities are designed by a registered professional engineer to accommodate the anticipated volume of runoff and to detain and treat runoff in accordance with District's Design and Construction Standards.

E. Failure to inspect and maintain the Facilities can result in an unacceptable impact to the public stormwater system.

NOW, THEREFORE, it is agreed by and between the parties as follows:

1. **OWNER INSPECTIONS** District shall provide Owner an Operations and Maintenance Plan (O&M Plan) for each Facility. Owner agrees to operate, inspect and maintain each Facility in accordance with the current O&M Plan and any subsequent modifications to the Plan. Owner shall maintain a log of inspection activities. The log shall be available to District upon request or during District inspections.
2. **DEFICIENCIES** All aspects in which the Facilities fail to satisfy the O&M Plan shall be noted as "Deficiencies".
3. **OWNER CORRECTIONS** All Deficiencies shall be corrected at Owner's expense within thirty (30) days after completion of the inspection. If more than 30 days is reasonably needed to correct a Deficiency, Owner shall have a reasonable period to correct the Deficiency so long as the correction is commenced within the 30-day period and is diligently prosecuted to completion.
4. **DISTRICT INSPECTIONS** Owner grants District the right to inspect the Facilities. District will endeavor to give ten (10) days prior written notice to Owner, except that no notice shall be required in case of an emergency. District shall determine whether Deficiencies need to be corrected. Owner (at the address provided in this Agreement, or such other address as Owner may designate in writing to District) will be notified in writing through the US Mail of the Deficiencies and shall make corrections within 30 days of the date of the notice.
5. **DISTRICT CORRECTIONS** If correction of all Owner or District identified Deficiencies is not completed within thirty (30) days after Owner's inspection or District notice, District shall have the right to have any Deficiencies corrected. District (i) shall have access to the Facilities for the purpose of correcting such Deficiencies and (ii) shall bill Owner for all costs reasonably incurred by District for work performed to correct the Deficiencies (District Correction Costs) following Owner's failure to correct any Deficiencies in the Facilities. Owner shall pay District the District Correction Costs within thirty (30) days of the date of the invoice. Owner understands and agrees that upon non-payment, District Correction Costs shall be secured by a lien on the Property for the District Correction Cost amount plus interest and penalties.
6. **EMERGENCY MEASURES** If at any time District reasonably determines that the Facilities create any imminent threat to public health, safety or welfare, District may immediately and without prior notice to Owner take measures reasonably designed to remedy the threat. District shall provide notice of the threat and the measures taken to Owner as soon as reasonably practicable, and charge Owner for the cost of these corrective measures.
7. **FORCE AND EFFECT** This Agreement has the same force and effect as any deed covenant running with the land and shall benefit and bind all owners of the Property present and future, and their heirs, successors and assigns.
8. **AMENDMENTS** The terms of this Agreement may be amended only by mutual agreement of the parties. Any amendments shall be in writing, shall refer specifically to this Agreement, and shall be valid only when executed by the owners of the Property, District and recorded in the Official Records of the county where the Property is located.
9. **PREVAILING PARTY** In any action brought by either party to enforce the terms of this Agreement, the prevailing party shall be entitled to recover all costs, including reasonable attorney's fees as may be determined by the court having jurisdiction, including any appeal.
10. **SEVERABILITY** The invalidity of any section, clause, sentence, or provision of this Agreement shall not affect the validity of any other part of this Agreement, which can be given effect without such invalid part or parts.

IN WITNESS WHEREOF, Owner and District have signed this Agreement.

NOTARIZE DOCUMENT BELOW

INDIVIDUAL OWNERS SIGN BELOW

Owner (Individual)

Owner (Individual)

CLEAN WATER SERVICES

By: _____
General Manager or Designee

CORPORATE, LLC, PARTNERSHIP, TRUST OR OTHER
LEGAL ENTITY SIGN BELOW

(Entity name)

By: _____
(Sign here for entity)

Title: _____

APPROVED AS TO FORM

District Counsel

[Use this notary block if OWNER is an individual.]

STATE OF _____)
)
County of _____)

This instrument was acknowledged before me this _____ day of _____, 20____,
by _____.

Notary Public

[Use this notary block if OWNER is an entity.]

STATE OF _____)
)
County of _____)

This instrument was acknowledged before me on _____ (date)
by _____ (name of person) as

(title) of _____ (name of entity).

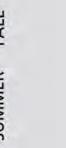
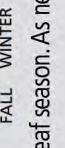
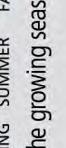
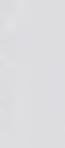
Notary Public

Operation and Maintenance Plans

- 77 Porous Pavement
- 78 Green Roof
- 79 Infiltration Planter/Rain Garden
- 82 Flow-Through Planter
- 85 LIDA Swale
- 88 Vegetated Swale
- 92 Vegetated Filter Strip
- 94 Extended Dry Basin
- 98 Constructed Water Quality Wetland

Porous Pavement Operation and Maintenance Plan

Annual Inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Surface is Clogged	Water infiltrates unevenly across surface or ponds in low areas	Recommend vacuum sweep at least twice per year; if pavement surface has become significantly clogged use low pressure washer to restore permeability; do not use surfactants	 SUMMER  FALL	
Cracked or moving edge constraints; cracked or settled pavement	Cracked or moving edge constraints; cracked or settled pavement that affects overall performance of stormwater structural components	Repair all cracks, settlement or other defects that affect performance of structural components. Refer to manufacturers' specifications	As Needed	
Leaf, soil deposition on surface	Leaf litter that could affect stormwater infiltration through pavement. Look for soil washout from adjacent planted areas	Sweep leaf litter and sediment to prevent surface clogging and ponding. Planted areas adjacent to porous pavement should be well maintained to prevent soil washout onto the pavement.	 WINTER  FALL During leaf season. As needed	
Excessive Weeds	Weeds cover 10% of the surface area	Remove weeds by hand, or use an herbicide approved for use around sensitive areas; refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment	 SPRING  SUMMER  FALL During the growing season	
Settling of pavers or lack of aggregate around pavers	Filter medium between pavers reduced. Aggregate loss in pavers from settling and power washing	Reset pavers and replace pore space with aggregate from original design	As Needed	
Visual evidence of trash, debris or dumping	Any debris or trash that could clog the surface	Remove trash or debris and vacuum sweep area if necessary	As Needed	

Green Roof Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Standing Water	Standing water; super saturated soil observed. Check for clogged drain or compacted soil	Clear drains; remove organics and other debris from drain; loosen compacted soil and amend soil	 WINTER SPRING	
Leaks in Green Roof	Leaks in roof observed. Check for tears or perforation of membrane	Contact manufacturer or installer for repair or replacement		
Dead or stressed vegetation; exposed soil	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Remove dead or stressed vegetation and replant per original planting plan; irrigate as needed. Remove excessive weeds and all invasive plants	 FALL SPRING	
Excessive Vegetation	Vegetation has become overgrown	Prune grass and plantings; remove clippings	 SUMMER FALL	
Excessive Weeds	Weeds on more than 20% of the surface area	Remove weeds by hand; avoid using pesticides	 SPRING SUMMER FALL	
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilized using proper erosion control measures. Establish appropriate vegetation as needed		
If replanting in the Summer, irrigation will be necessary.				

Infiltration Planter / Rain Garden Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Invasive Vegetation as outlined in Appendix A	Invasive vegetation found in facility. Examples include: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment.	 SPRING SUMMER FALL	
Obstructed Inlet/Outlet	Material such as vegetation, trash, sediment is blocking more than 10% of the inlet pipe or basin opening	Remove blockages from facility	 WINTER SPRING Inspect after major storm (1-inch in 24 hours)	
Excessive Vegetation	Vegetation grows so tall it competes with or shades approved emergent wetland grass/shrubs; interferes with access or becomes a fire danger	Cut tall grass 4" to 6" and remove clippings. Prune emergent wetland grass/shrubs that have become overgrown.	 SPRING Ideal time to prune emergent wetland grass is spring. Cut grass during dry months	
Tree/Shrub Growth	Tree/shrub growth shades out wetland/emergent grass in treatment area. Interferes with access for maintenance/inspection	Prune trees and shrubs that block sun from reaching treatment area. Remove trees that block access points. Do not remove trees that are not interfering with access or maintenance without first contacting Clean Water Services or local City.	 WINTER Ideal timing for pruning trees is winter	

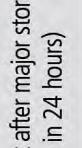
Infiltration Planter / Rain Garden Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Hazard Trees	Observe dead, dying or diseased trees	Remove hazard trees. A certified arborist may need to determine health of tree or removal requirements	As Needed	
Poor Vegetation Coverage	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Determine cause of poor growth and correct the condition. Replant per the approved planting plan and applicable standards at the time of construction. Remove excessive weeds and all invasive plants.	 SPRING FALL  SPRING	Ideal time to plant is spring and fall seasons
Trash and Debris	Visual evidence of trash, debris or dumping	Remove trash and debris from facility. Dispose of properly	 SPRING FALL  SPRING	 SPRING SUMMER FALL WINTER
Contaminants and Pollution	Evidence of oil, gasoline, contaminants or other pollutants. Look for sheens, odor or signs of contamination.	If contaminants or pollutants are present, coordinate removal/cleanup with local jurisdiction	 SPRING FALL  SPRING	 SPRING SUMMER FALL WINTER
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilize using proper erosion control measures. Establish appropriate vegetation as needed.	 FALL  SPRING	
Flow Not Distributed Evenly	Flows unevenly distributed through planter width due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire planter width	 SPRING  SPRING	

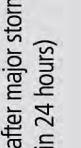
Infiltration Planter / Rain Garden Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Vector Control	Evidence of rodents or water piping through facility via rodent holes. Insects such as wasps and hornets interfere with maintenance/inspection activities	Repair facility if damaged. Remove harmful insects, use professional if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options	As Needed	
Sediment Accumulation in Treatment Area	Sediment depth in treatment area exceeds 3 inches	Remove sediment from treatment area. Ensure planter is level from side to side and drains freely toward outlet; no standing water within 24 hours after any major storm (1-inch in 24 hours)	 SUMMER  FALL	Ideally in the dry season
Standing Water	Standing water in the planter between storms that does not drain freely. Water should drain after 24 hours of dry weather	Remove sediment or trash blockages; improve end to end grade so there is no standing water 24 hours after any major storm (1-inch in 24 hours)	 WINTER  SPRING	Inspect after major storm (1-inch in 24 hours)
Grate Damaged, Missing or Not in Place	Grate is missing or only partially in place may have missing or broken grate members	Grate must be in place and meets design standards. Replace or repair any open structure	As Needed	

Flow-Through Planter Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Sediment Accumulation in Treatment Area	Sediment depth exceeds 3 inches	Remove sediment from treatment area. Ensure planter is level from side to side and drains freely toward outlet; no standing water within 24 hours after any major storm (1-inch in 24 hours)	 SUMMER  FALL	Ideally in dry season
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilized using proper erosion control measures Establish appropriate vegetation as needed	 FALL  WINTER  SPRING	Inspect after major storm (1-inch in 24 hours)
Standing Water	Standing water in the planter between storms that does not drain freely. Water should drain after 24 hours of dry weather.	Remove sediment or trash blockages. Grade out areas of mounding and improve end to end grade so there is no standing water.	 WINTER  SPRING	
Flow Not Distributed Evenly	Flow unevenly distributed through planter width due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire planter width	 WINTER  SPRING	
Obstructed Inlet/Outlet	Material such as vegetation, sediment, trash is blocking more than 10% of the inlet/outlet pipe	Remove blockages from facility	 WINTER  SPRING	Inspect after major storm (1-inch in 24 hours)

Flow-Through Planter Operation and Maintenance Plan (continued)

Annual Inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Poor Vegetation Coverage	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants per approved plans and applicable standards at time of construction. Remove excessive weeds and all invasive plants.	 SPRING FALL	Ideal time to plant is spring and fall seasons
Invasive Vegetation as outlined in Appendix A	Invasive vegetation found in facility. Examples include: Himalayan Blackberry, Reed Canary Grass, Teasel, English Ivy, Nightshade, Clematis, Cattail, Thistle	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment.	 SPRING SUMMER FALL	
Excessive Vegetation	Vegetation grows so tall it competes with or shades approved emergent wetland grass/shrubs; interferes with access or becomes a fire danger	Prune over-hanging limbs, if possible; remove brushy vegetation as needed. Prune emergent wetland grass/shrubs that have become overgrown.	 SPRING	Ideal time to prune emergent wetland grass is spring
Vector Control	Evidence of rodents or water flowing through facility via rodent holes. Harmful insects such as wasps or hornets present	Repair damage to facility. Remove harmful insects, call professional if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options.	As Needed	

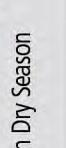
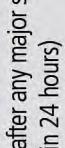
Flow-Through Planter Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Trash and Debris	Visual evidence of trash, debris or dumping.	Remove and dispose of trash and debris from facility. Dispose of properly.	 SPRING  SUMMER  FALL  WINTER	
Contamination and Pollution	Evidence of oil, gasoline, contaminants, or other pollutants. Look for sheens, odor or signs of contamination.	If contaminants or pollutants present, coordinate removal/cleanup with local jurisdiction.	 SPRING  SUMMER  FALL  WINTER	
Outlet Structure Damaged	Grate or overflow structure is missing or only partially in place and may have missing or broken grate members.	Repair or replace outlet structure.	As Needed	

LIDA Swale Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Sediment Accumulation in Treatment Area	Sediment depth exceeds 3 inches	Remove sediment deposits in treatment area. Swale should be level from side to side and drain freely toward outlet	 SUMMER  FALL Ideally in Dry Season	
Standing Water	Standing water in the swale between storms that does not drain freely	Remove sediment or trash blockages; improve grade from end to end of swale; no standing water 24 hours after any major storm (1 inch in 24 hours)	 WINTER  SPRING Inspect after any major storm (1-inch in 24 hours)	
Flow Not Distributed Evenly	Flows unevenly distributed through swale due to uneven or clogged flow spreader	Level the spreader and clean so that flows spread evenly over entire swale width	As Needed	
Poor Vegetation Coverage	80% survival of approved vegetation and no bare areas large enough to affect function of facility	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants per approved plans and applicable standards at time of construction. Remove excessive weeds and all invasive plants.	 FALL  SPRING Ideal time to plant is Spring and Fall seasons	
Excessive Vegetation	Vegetation grows so tall it competes with or shades approved emergent wetland grass/shrubs; interferes with access or becomes a fire danger	Prune overhanging limbs if possible. Prune emergent wetland grass/shrubs that have become overgrown	 SPRING Ideal time to prune emergent wetland grass is Spring	

LIDA Swale Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Invasive Vegetation as outlined in Appendix A	Invasive vegetation found in facility. Reed Canary Grass; Teasel, English Ivy; Nightshade; Clematis; Cattail, Thistle; Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment	 SPRING SUMMER FALL	
Hazard Trees	Observed dead, dying or diseased trees	Remove hazard trees. A certified arborist may need to determine health of tree or removal requirements	As Needed	
Obstructed Inlet/Outlet	Material such as vegetation, sediment or debris is blocking more than 10% of the inlet/outlet pipe	Remove blockages from facility	 WINTER SPRING Inspect after any major storm (1-inch in 24 hours)	
Damage to Outlet Structure	Outlet structure damage may include a grate that is missing or not in place. Grate may have broken members or have a damaged frame	Grate must be in place and meet design standards. Replace or repair grate and ensure grate is firmly attached	As Needed	
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern Evidence of trash, debris or dumping	Repair eroded areas and stabilized using proper erosion control measures. Establish appropriate vegetation as needed	 FALL WINTER SPRING	

LIDA Swale Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Trash and Debris		Remove trash and debris from facility. Dispose of properly	 SPRING  SUMMER  FALL  WINTER	
Contamination and Pollution	Evidence of oil, gasoline, contaminants, or other pollutants. Look for sheens, odor or other signs of contamination	Locate source of contamination and correct. Remove oil using oil-absorbent pads or vac-truck. If low levels of oil persist plant wetland plants that can uptake small concentrations of oil such as <i>Juncus effusus</i> . (soft rush) If high levels of contaminants or pollutants are present, coordinate removal/ cleanup with local jurisdiction	 SPRING  SUMMER  FALL  WINTER	
Vector Control	General evidence of rodents or water piping through facility via rodent holes. Insects such as wasps and hornets interfere with maintenance/ inspection activities	Repair facility if damaged. Remove harmful insects, use professional if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options	As Needed	
Damage to Outlet Structure	Damage to Frame or Top Slab. Frame not sitting flush on top slab (more than $\frac{3}{4}$ inch between frame and top slab); frame not securely attached	Ensure frame is firmly attached and sits flush on the riser rings or top slab	As Needed	
Damage to Outlet Structure	Fractures or Cracks in Walls or Bottom. Maintenance person determines the structure is unsound. Soil entering structure through cracks	Structure replaced or repaired to design standards	As Needed	

Vegetated Swale Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Obstructed Inlet/Outlet	Material such as vegetation, sediment is blocking more than 10% of inlet/outlet pipe or basin opening	Remove blockages from facility	 WINTER SPRING	
Flow not distributed evenly	Flows unevenly distributed through swale due to uneven or clogged flow spreader	Level and clean the spreader so that flows spread evenly over entire swale width	 WINTER SPRING	
Sediment Accumulation in Treatment Area	Sediment depth in treatment area exceeds 3 inches	Remove sediment from treatment area. Ensure facility is level from side to side and drains freely toward outlet; no standing water once inflow has ceased	 SUMMER FALL	Ideally in the dry season
Tree/Shrub Growth	Tree/shrub growth shades out wetland/emergent grass in treatment area. Interferes with access for maintenance/inspection	Prune trees and shrubs that block sun from reaching treatment area. Remove trees that block access points. Do not remove trees that are not interfering with access or maintenance without first contacting Clean Water Services or local City	 WINTER	Ideal timing for pruning is winter
Hazard Trees	Observed dead, dying or diseased trees	Remove hazard trees. A certified arborist may be needed to determine health of tree or removal requirements		As Needed

Vegetated Swale Operation and Maintenance Plan (continued)

Annual Inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilized using proper erosion control measures. Establish appropriate vegetation as needed.	  WINTER  SPRING  FALL	
Poor Vegetation Coverage	80% survival of approved vegetation and no bare areas large enough to affect function of facility	Determine cause of poor growth and correct the condition. Replant per the approved planting plan and applicable standards at time of construction. Remove excessive weeds and all invasive plants.	  SPRING  FALL  SPRING Ideal time to plant is spring and fall seasons	
Invasive Vegetation as outlined in Appendix A	Invasive vegetation is found in facility. Examples include: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment	  SPRING  SUMMER  FALL	
Excessive Vegetation	Vegetation grows so tall it competes with or shades approved emergent wetland grass/shrubs; interferes with access or becomes fire danger	Cut tall grass to 4" to 6" and remove clippings. Prune emergent wetland grass/shrubs that have become overgrown.	 SPRING Ideal time to prune emergent wetland grass is spring. Cut grass in dry months	
Trash and Debris	Visual evidence of trash, debris or dumping	Trash and debris removed from facility. Dispose of properly	 SPRING  SUMMER  FALL  WINTER	

Vegetated Swale Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Standing Water	Standing water in the swale between storms that does not drain freely	Remove sediment or trash blockages; improve grade from end to end of swale; no standing water 24 hours after any major storm (1-inch in 24 hours)	 WINTER SPRING Inspect after any major storm (1-inch in 24 hours)	
Vector Control	Evidence of rodents or water piping through facility via rodent holes. Harmful insects such as wasps and hornets interfere with maintenance/ inspection activities	Repair facility if damaged. Remove harmful insects, use professional if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options	As Needed	
Contamination and Pollution	Evidence of oil, gasoline, contaminants, or other pollutants. Look for sheens, odor or signs of contamination	If contaminants or pollutants present, coordinate removal/ cleanup with local jurisdiction	 SPRING SUMMER FALL WINTER	
Grate Damaged, missing or not in place	Grate is missing or only partially in place, may have missing or broken grate members	Grate must be in place and meet design standards. Replace or repair any open structure, replace grate if missing.	As Needed	
Damage to Outlet Structure	Frame not sitting flush on top slab (more than $\frac{3}{4}$ inch between frame and top slab); frame not securely attached	Ensure frame is firmly attached and sits flush on riser rings or on top of slab. Structure replaced or repaired to design standards	As Needed	

Vegetated Swale Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Damage to Outlet Structure	Fractures or Cracks in Walls or Bottom. Maintenance person determines the structure is unsound. Soil entering structure through cracks	Structure replaced or repaired to design standards	As Needed	
Damage to Outlet Structure	Settlement or Misalignment. Failure of basin has created a safety, function, or design problem	Structure replaced or repaired to design standards	As Needed	

Vegetated Filter Strip Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Flow not distributed evenly	Flows unevenly distributed through filter strip due to uneven or clogged flow spreader	Level and clean the spreader so that flows spread evenly over entire filter strip width	 WINTER SPRING	
Invasive Vegetation as outlined in Appendix A	Invasive vegetation is found in facility. Examples include: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail Thistle; Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment.	 SPRING SUMMER FALL	
Poor Vegetation Coverage	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Determine cause of poor growth and correct the condition; replant with plugs or containerized plants per approved plans and applicable standards at time of construction. Remove excessive weeds and all invasive plants	 FALL SPRING	Ideal time to plant is Spring and Fall seasons
Excessive Vegetation	Vegetation grows so tall it competes with or shades approved emergent wetland grass/shrubs; interferes with access or becomes a fire danger	Cut grass tall grass 4" to 6" and remove clippings. Prune emergent wetland grass/shrubs that have become overgrown.	 SPRING	Ideal time to prune emergent wetland grass is Spring. Cut grass in dry months
Tree/Shrub Growth	Tree/shrub growth shades out wetland/emergent grass in treatment area. Interferes with access for maintenance/inspection	Prune trees and shrubs that block sun from reaching treatment area. Remove trees that block access points. Do not remove trees that are not interfering with access or maintenance without first contacting Clean Water Services or local City.	 WINTER	Ideal timing for pruning trees is winter

Vegetated Filter Strip Operation and Maintenance Plan (continued)

Annual Inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilize using proper erosion control measures. Establish appropriate vegetation as needed	   FALL WINTER SPRING	
Sediment Accumulation in Treatment Area	Sediment depth in treatment area exceeds 3 inches	Remove sediment from treatment area. Ensure facility is level from side to side and drains freely toward outlet; no standing water once inflow has ceased	   SUMMER FALL	Ideally in the dry season
Trash and Debris	Visual evidence of trash, debris or dumping	Remove trash and debris from facility. Dispose of properly	    SPRING SUMMER FALL WINTER	
Contaminants and Pollution	Evidence of oil, gasoline, contaminants or other pollutants. Look for sheens, odor or signs of contamination	If contaminants or pollutants present; coordinate removal/cleanup with local jurisdiction	    SPRING SUMMER FALL WINTER	
Vector Control	Evidence of rodents or water piping through facility via rodent holes. Harmful insects present such as wasps and hornets that interfere with maintenance/ inspection activities	Repair facility if damaged. Remove harmful insects, use professional service if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options	As Needed	

Extended Dry Basin Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Trash and Debris	Visual evidence of trash, debris or dumping	Remove trash and debris from facility. Dispose of properly	 SPRING  SUMMER  FALL  WINTER	
Contamination and Pollution	Evidence of oil, gasoline, contaminants, or other pollutants. Look for sheens, odor or signs of contamination	Locate source of contamination and correct. Remove oil using oil-absorbent pads or vactor truck. If low levels of oil persist plant wetland plants that can uptake small concentrations of oil such as <i>Juncus effusus</i> . (soft rush) If high levels of contaminants or pollutants are present, coordinate removal/ cleanup with local jurisdiction	 SPRING  SUMMER  FALL  WINTER	
Invasive vegetation as outlined in Appendix A.	Invasive vegetation found in facility. Examples include: Himalayan Blackberry, Reed Canary Grass, Teasel, English Ivy, Nightshade, Clematis, Cattail, Thistle, Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible; refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment	 SPRING  SUMMER  FALL	
Obstructed Inlet/Outlet	Material such as vegetation, trash, sediment is blocking more than 10% of inlet/outlet pipe or basin opening	Remove blockages from facility	 WINTER  SPRING Inspect after major storm (1-inch in 24 hours)	
Poor Vegetation Cover	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Determine cause of poor growth and correct the condition. Replant with plugs or containerized plants per the approved planting plan and applicable standards at time of construction. Remove excessive weeds and all invasive plants.	 SPRING  FALL Ideal time to plant is spring and fall seasons	

Extended Dry Basin Operation and Maintenance Plan (continued)

Annual Inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Vector Control	Evidence of rodents or water piping through facility via rodent holes. Harmful insects present such as wasps and hornets that interfere with maintenance/ inspection activities	Repair facility if damaged. Remove harmful insects, use professional if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options	As Needed	
Tree/Shrub Growth	Tree/shrub growth shades out wetland/ emergent grass in treatment area. Interferes with access for maintenance/ inspection	Prune trees and shrubs that block sun from reaching treatment area. Remove trees that block access points. Do not remove trees that are not interfering with access or maintenance without first contacting Clean Water Services or local City	 WINTER Ideal time for pruning is winter	
Hazard Trees	Observed dead, dying or diseased trees	Remove hazard trees. A certified Arborist may need to determine health of tree or removal requirements	As Needed	
Excessive Vegetation	Vegetation grows so tall that it competes with approved emergent wetland grass/shrubs, interferes with access or becomes a fire danger	Cut tall grass 4" to 6" and remove clippings. Prune emergent wetland grass/shrubs that have become overgrown.	 SPRING Ideal time to prune emergent wetland grass is spring. Cut grass in dry months	
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilize using proper erosion control measures. Establish appropriate vegetation as needed	 FALL WINTER SPRING	

Extended Dry Basin Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Settlement of Pond Dike/ Berm	Look for any part of dike/berm that has settled 4 inches or more lower than the design elevation	Repair dike/berm to approved design specifications. A licensed civil engineer should be consulted to determine the source of the settlement	As Needed	
Blockage of Emergency Overflow/ Spillway	Blockage of overflow/ spillway by trees, vegetation or other material. Blockages may cause the berm to fail due to uncontrolled overtopping	Remove blockage. Small root system (base less than 4 inches) may be left in place; otherwise, roots are removed. A licensed civil engineer should be consulted for proper berm/spillway restoration.	 WINTER SPRING Inspect after major storm (1-inch in 24 hours)	
Erosion of Emergency Overflow/Spillway	Native soil is exposed at the spillway, or there is only one layer of rock in an area of 5 square feet or larger	Restore rock and pad depth to appropriate depth. Refer to design specifications	 WINTER SPRING Inspect after major storm (1-inch in 24 hours)	
Blockage of Overflow Structure/ Orifice Plate	Excessive standing water or water is not detained for required time.	Inspect and if needed clear orifice plate for proper drainage or re-install to ensure required detention.	 WINTER SPRING Inspect after major storm (1-inch in 24 hours)	
Sediment Accumulation in Pond Bottom	Sediment accumulation in pond bottom exceeds 6 inches or affects facility inlet/ outlet or plant growth in treatment area	Remove sediment from pond bottom. Re-establish designed pond shape and depth. Establish appropriate vegetation in treatment area	 SUMMER FALL Ideally in the dry season	

Extended Dry Basin Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Grate Damaged, missing or not in place	Grate is missing or only partially in place, may have missing or broken grate members.	Grate must be in place and meet design standards. Replace or repair any open structure, replace grate if missing	As Needed	
Damage to Outlet Structure	Damage to Frame or Top Slab. Frame not sitting flush on top slab (more than $\frac{3}{4}$ inch between frame and top slab); frame not securely attached	Ensure frame is firmly attached and sits flush on the riser rings or top slab	As Needed	
Damage to Outlet Structure	Fractures or Cracks in Walls or Bottom. Maintenance person determines the structure is unsound. Soil entering structure through cracks.	Structure replaced or repaired to design standards.	As Needed	
Damage to Outlet Structure	Settlement or Misalignment of Basin. Failure of basin has created a safety, function, or design problem	Structure replaced or repaired to design standards	As Needed	

Constructed Water Quality Wetland Operation and Maintenance Plan

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Trash and Debris	Visual evidence of trash, debris or dumping	Remove trash and debris from facility. Dispose of properly	 SPRING  SUMMER  FALL  WINTER	
Contaminants and Pollution	Evidence of oil, gasoline, or other contaminants. Look for signs such as sheens or odors.	Locate source of contamination and correct. Remove oil using oil-absorbent pads or vector truck. If low levels of oil persist plant wetland plants that can uptake small concentrations of oil such as Juncus effusus. (soft rush) If high levels of contaminants or pollutants are present, coordinate removal/ cleanup with local jurisdiction.	 SPRING  SUMMER  FALL  WINTER	
Erosion	Erosion or channelization that impacts or effects the function of the facility or creates a safety concern	Repair eroded areas and stabilize using proper erosion control measures. Establish appropriate vegetation as needed.	 SPRING  WINTER	
Obstructed Inlet/Outlet or basin opening	Material such as vegetation, sediment, trash is blocking more than 10% of inlet/outlet pipe or basin opening	Remove blockages from facility.	 SPRING  WINTER	Inspect after major storm (1-inch in 24 hours)
Invasive Vegetation as outlined in Appendix A	Invasive vegetation found in facility. Examples include: Himalayan Blackberry; Reed Canary Grass; Teasel; English Ivy; Nightshade; Clematis; Cattail; Thistle; Scotch Broom	Remove excessive weeds and all invasive plants. Attempt to control even if complete eradication is not feasible. Refer to Clean Water Services Integrated Pest Management Plan for appropriate control methods, including proper use of chemical treatment.	 SPRING  SUMMER  FALL	

Constructed Water Quality Wetland Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

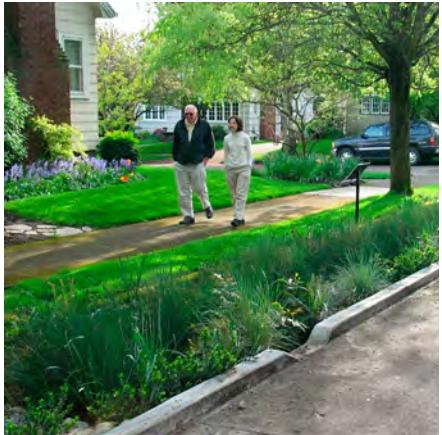
Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Tree/Shrub Growth	Tree/shrub growth shades out wetland/ emergent grass in treatment area. Interferes with access for maintenance/ inspection	Prune trees and shrubs that block sun from reaching treatment area. Remove trees that block access points. Do not remove trees that are not interfering with access or maintenance without first contacting Clean Water Services or local City.	 WINTER Ideal timing for pruning is winter	
Poor Vegetation Cover	80% survival of approved vegetation and no bare areas large enough to affect function of facility.	Determine cause of poor growth and correct the condition. Sediment accumulation or competition with invasive vegetation could be cause. Replant with plugs or containerized plants per the approved planting plan and applicable standards at time of construction. Remove excessive weeds and all invasive plants.	 SPRING  FALL Ideal time to plant is spring and fall seasons	
Hazard Trees	Observed dead, dying or diseased trees	Remove hazard trees. A Certified Arborist may need to determine health of tree or removal requirements.	As Needed	
Vector Control	Evidence of rodents, or water piping through facility via rodent holes. Harmful insects present such as wasps and hornets that interfere with maintenance/inspection activities	Repair facility if damaged. Remove harmful insects, use professional service if needed. Refer to Clean Water Services Integrated Pest Management Plan for management options.	As Needed	
Sediment Accumulation in Wetland Bottom	Sediment depth in wetland bottom exceeds 6 inches or affects inlet/outlet functions or plant growth in treatment area	Remove sediment from wetland bottom. Re-establish designed wetland shape and depth; re-seed if necessary to control erosion, or replant to achieve treatment.	 SUMMER  FALL Ideally in the dry season	

Constructed Water Quality Wetland Operation and Maintenance Plan (continued)

Annual inspections are required. It is recommended that the facility is inspected on a monthly basis to ensure proper function. The plan below describes inspection and maintenance activities, and may be used as an inspection log. Contact the design engineer, Clean Water Services or City representative for more information.

Identified Problem	Condition to Check for	Maintenance Activity	Maintenance Timing	✓ Task Complete Comments
Settlement of Pond Dike/ Berm	Look for any part of dike/berm that has settled 4 inches or more lower than the design elevation	Repair dike/berm to approved design specifications. A licensed civil engineer should be consulted to determine the source of settlement.	As Needed	
Excessive Vegetation	Vegetation grows so tall that it competes with approved emergent wetland grass/shrubs, interferes with access or becomes a fire danger	Cut tall grass to 4" to 6" and remove clippings. Prune emergent wetland grass/shrubs that have become overgrown	 Ideal time to prune emergent wetland grass is spring. Cut grass in dry months	
Grate Damaged, missing or not in place	Grate is missing or only partially in place, may have missing or broken grate members	Grate must be in place and meet design standards. Replace or repair any open structure, replace grate if missing.	As Needed	
Damage to Outlet Structure	Frame not sitting flush on top slab (more than 3/4 inch between frame and top slab), frame not securely attached	Frame is firmly attached and sits flush on the riser rings or top slab. Structure replaced or repaired to design standards.	As Needed	
Damage to Outlet Structure	Fractures or Cracks in walls or bottom. Maintenance person determines the structure is unsound. Soil entering structure through cracks	Structure replaced or repaired to design standards	As Needed	
Damage to Outlet Structure	Settlement or Misalignment of Outlet Basin. Failure of basin has created a safety, function, or design problem	Structure replaced or repaired to design standards	As Needed	

2021



Low Impact Development Approaches Handbook



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