Green Development Practices for Stormwater Management

An Implementation Guide for Development Projects in the Pleasant Valley and Springwater Plan Districts

Contents

1.0 Introduction

The purpose of this document is to provide the development community and City of Gresham staff with clear direction on how to meet stormwater management requirements specific to the Pleasant Valley and Springwater Plan Districts. Stormwater Master Plans and Development Codes (Sections 4.1468, 4.1481, and 4.1564) were prepared for these districts, which refer to specific stormwater management standards. This document provides more detailed guidance on how to meet these standards, as well as additional requirements related to stormwater management.

The Pleasant Valley and Springwater Plan District Stormwater Master Plans require that "Green Development Practices" be used to manage 100% of the stormwater runoff from private property, prior to discharge off-site into the stormwater conveyance infrastructure in streets or open spaces that will eventually flow to regional management facilities such as ponds or constructed wetlands. Green Development Practices reduce the volume of stormwater flowing off-site by retaining it near the source, and include rain gardens (aka swales, bioswales, or biofiltration), stormwater planters, porous pavements, or tree planting.

The Master Plans also require that all new streets incorporate "Green Street" elements to manage stormwater prior to discharge off-site. Green Street elements are Green Development Practices located within the street right-of-way, designed and constructed to address unique challenges present in streetscapes. The City of Gresham has developed Green Street Standards for use in design of these elements. Green Street rain gardens and stormwater planters form an interconnected network of shallow, heavily planted landscapes with the purpose of conveying, treating, retaining, and infiltrating stormwater as part of the overall stormwater management system to mimic the natural hydrologic cycle.

In most cases, stormwater piping will be needed to convey excess stormwater from streets and private property to regional management facilities (ponds and constructed wetlands) prior to discharge into the areas' natural streams.

This overall system of private property Green Development Practices, public right-of-way Green Street elements, and regional stormwater management facilities will work as a whole to help ensure that stream systems within and downstream of the Pleasant Valley and Springwater Plan Districts remain healthy, do not flood more frequently than before development, and continue to provide sustainable habitat for fish and wildlife.

This document explains what Green Development Practices are, how to select appropriate practices for different development scenarios, how to design them, and how they should be maintained to operate effectively. Design requirements are specified regarding triggers for Green Development Practices, sizing criteria, setbacks, minimum and maximum dimensions, and materials. These requirements must be followed by applicants submitting for building and public works permits for construction in the Pleasant Valley or Springwater Plan District areas.

2.0 What Are Green Development Practices?

Green Development Practices for stormwater management in the Pleasant Valley and Springwater Plan Districts include rain gardens, stormwater planters, porous pavements, and tree planting. All of these techniques retain stormwater close to its source, helping to mimic natural pre-development hydrology.

Rain Gardens

Infiltration Rain Garden

Filtration Rain Garden

Stormwater Planters

Infiltration Stormwater Planter
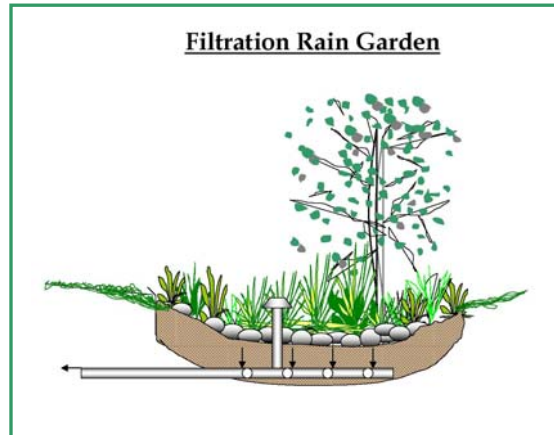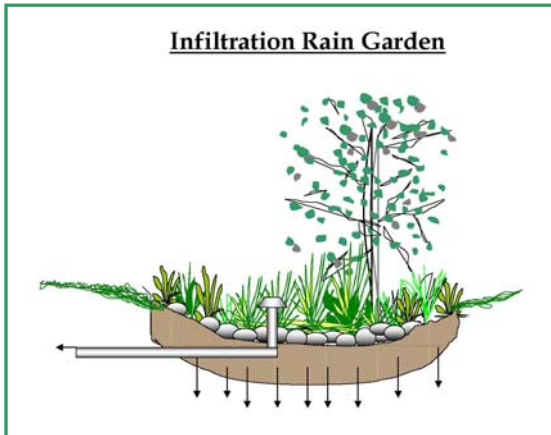
Filtration Stormwater Planter
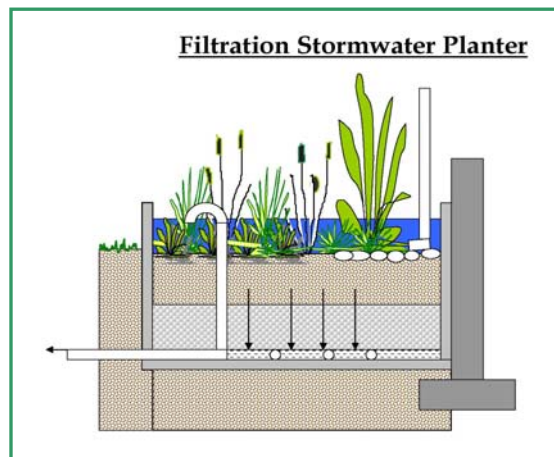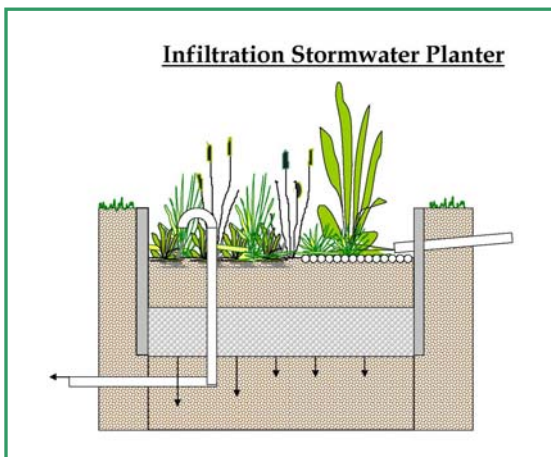
Porous Pavements

Porous Asphalt Mixes　　　**Porous Concrete Mixes**　　　**Porous Paver Systems**

3.0 Why Use Green Development Practices?

As new homes, buildings, parking lots, and streets are constructed in undeveloped areas, stormwater is typically collected and piped to nearby streams. This change in natural hydrology (increase in stormwater runoff volumes and flow rates) can result in degradation to stream systems in the form of erosion and eventual down-cutting and instability. During periods of dry weather, water levels in streams are lower than normal as impervious surfaces such as roads, rooftops, and parking lots prevent rainwater from infiltrating into the ground and replenishing groundwater. Moreover, pollutants in the runoff washed from roads, parking lots, and rooftops can contaminate habitat for fish and other wildlife.

For many years now, regional facilities such as large ponds and underground stormwater detention structures have been utilized to slow the flow of stormwater from developed areas before discharge to streams. While these practices have demonstrated improvements in control of flow rates from individual developments, stream systems have endured increased durations of high flows due to the increased volume of stormwater runoff still being released. To address this increase in runoff volume, other techniques to collect, infiltrate, and/or evaporate stormwater close to its source are needed. Green Development Practices (aka Low Impact Development "LID" Practices) can be used to accomplish this, helping the overall stormwater management system mimic pre-developed hydrology.

With Green Development Practices, runoff from small rainfall events is infiltrated into the ground as it does in forested or undeveloped areas, replenishing the groundwater aquifer. Pollutants are filtered out by the top layers of soil where they are biodegraded by resident organisms. Much of the runoff from larger rainfall events is captured and infiltrated, while the excess is directed to the stormwater conveyance system which flows to regional management facilities.

This overall system of Green Development Practices on private property, Green Street elements in public right-of-ways, and regional stormwater management facilities will ensure that natural stream systems in the Pleasant Valley and Springwater Plan Districts stay healthy and continue to provide habitat for fish and wildlife.

4.0 How the Stormwater Management System Works in Pleasant Valley & Springwater

As rain falls over the Pleasant Valley and Springwater plan districts, it either lands on pervious (forested or landscaped areas) or impervious (streets, rooftops, sidewalks, parking lots, or driveways) surfaces. Most of the water falling on pervious areas soaks into the ground, while most of the water falling on impervious areas quickly runs off, carrying pollutants and sediments with it.

See Figure 1 on the following page for a diagram of how stormwater is to be managed in Pleasant Valley and Springwater.

Rather than being discharged directly to piped collection systems in the streets, stormwater runoff from private property shall be directed to on-site Green development Practices, such as rain gardens or stormwater planters, or reduced with the use of porous pavements or tree planting. Stormwater runoff from public streets and sidewalks shall be directed to Green Street elements, such as rain gardens or stormwater planters within the public right-of-way, or reduced with the use of porous pavements or tree planting.

After filtering through Green Development Practices, excess stormwater shall be directed to regional management facilities prior to release into natural streams and wetlands.

5.0 Hydrologic Modeling Credit for Use of Green Development Practices & Green Streets

For the purpose of sizing the identified Regional Management Facilities within the Pleasant Valley and Springwater Plan Districts, the use of Green Development Practices and Green Streets will be given hydrologic credit per the following:

> For stormwater detention modeling purposes, where Green Development Practices and Green Streets are used to manage 100% of the stormwater from impervious surfaces per this manual, those impervious surfaces may be considered 50% pervious in the hydrologic calculations.

> For stormwater quality modeling purposes, where Green Development Practices and Green Streets are used to manage 100% of the stormwater from imperious surfaces per this manual, those impervious surfaces may be considered 100% pervious in the hydrologic calculations, and therefore do not need further treatment.

In the event of extremely high-intensity or prolonged rainfall, Green Development Practices and Green Streets will not be given hydrologic credit for the purpose of sizing conveyance piping within or downstream of each development.

Figure 1: Diagram of Stormwater Management System in Pleasant Valley and Springwater

Stormwater runoff from private property impervious surfaces

Stormwater runoff from public street right-of-way impervious surfaces

Green Development Practices

Green Streets

Regional Stormwater Management Facilities

Natural Streams
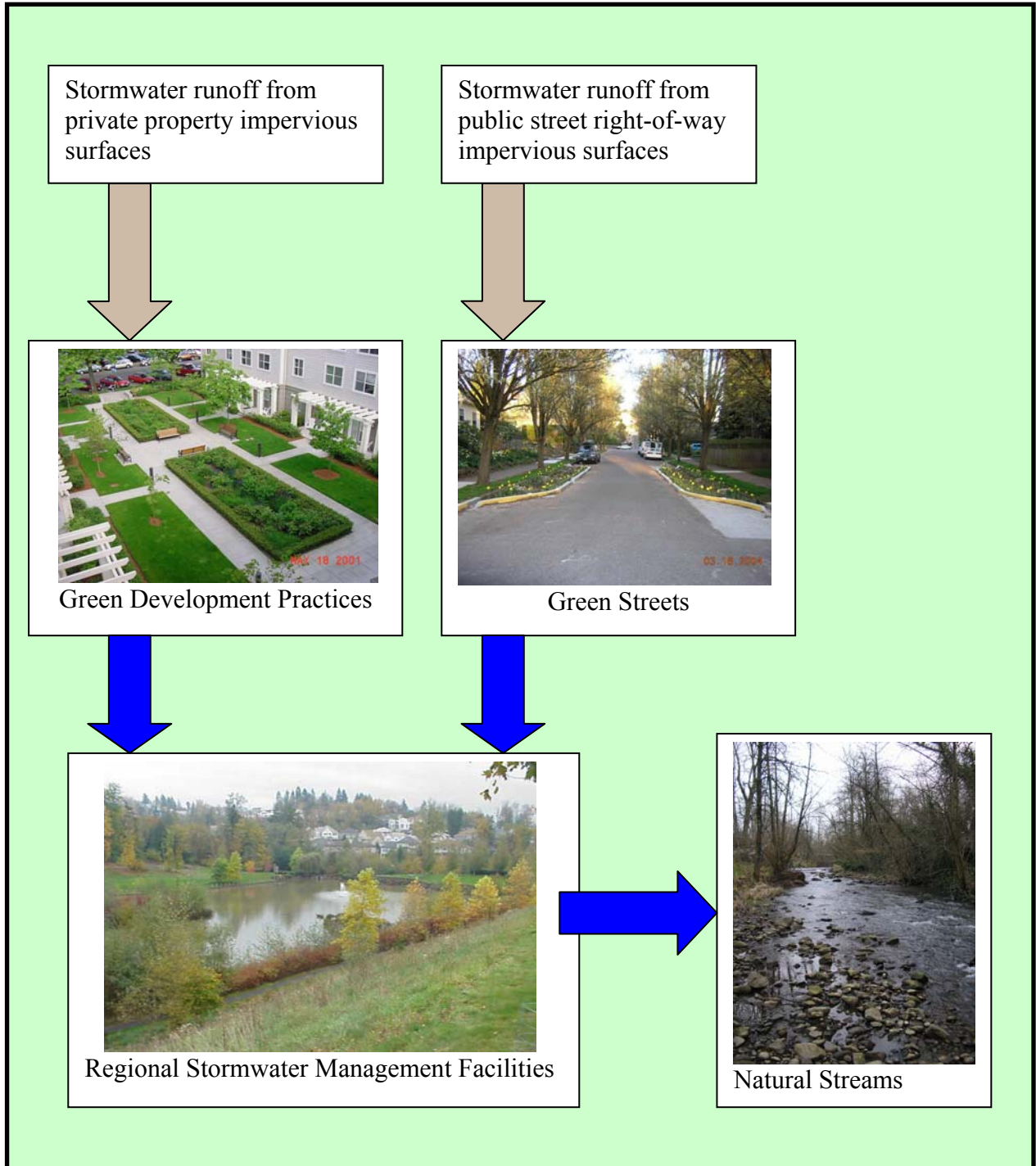
6.0 How to Design Green Development Practices

Applicability
The following Table 1 illustrates which sources of stormwater runoff each Green Development Practice can manage:

Table 1: Green Development Practice Applicability				
	Rain Gardens	Stormwater Planters	Porous Pavements	Tree Credits
Rooftops	X	X		
Driveways	X	X	X	X
Parking Lots	X	X	X	X
Streets	X	X	X	X

Each Green Development Practice has additional applicability criteria related to slopes, soils, setbacks, and geometry included in following design sections.

Sizing
Form SIM: Simplified Sizing Approach for Green Development Practices shall be used to size rain gardens and stormwater planters, and to collect impervious surface reduction credits for tree planting.   Rain garden and stormwater planter square-footage sizes calculated from Form SIM are minimum square footages. Form SIM must be submitted with the building or public works permit application.

The simple sizing factors included in Form SIM for the square-footage of rain gardens (0.06 x the square footage of impervious area) and stormwater planters (0.05 x the square footage of impervious area) are designed to provide management for a 1-inch rainfall event over 24 hours (NRCS Type 1A rainfall distribution), assuming the native soils infiltrate at 0.5 inches per hour. See Appendix A for the spreadsheets used to develop these factors.

Design
Detailed design requirements for rain gardens and stormwater planters are provided in following sections. Facility geometry, slope, plumbing, soil amendment/mulch, and planting requirements and specifications are provided. Criteria for the application of stormwater management credit for use of porous pavements and tree planting is also provided.

Permit Drawing Requirements
At a minimum, building or public works permit drawings must include the following items when Green Development Practices are used:

- □ Location of the rain gardens, stormwater planters, porous pavement surfaces, or new or existing trees to receive stormwater management credit in relation to the proposed home or buildings, parking lots, driveways, and street frontage. Label all setbacks.
- □ Size of the rain gardens, stormwater planters, or porous pavement with dimensions labeled on the drawings. Size and species of new or existing trees to receive stormwater management credit. Include Form SIM with the building permit submittal.

- □ Typical cross-section of the rain gardens, stormwater planters, or porous pavement surfaces. Depths, materials, and all dimensions shall be labeled. AutoCAD files of typical cross-sections can be obtained from the City of Gresham by calling 503-618-2621.
- □ For rain gardens or stormwater planters, the soil amendment specifications to be used. See Appendix B for soil amendment specifications.
- □ For rain gardens or stormwater planters, a detailed planting plan with species, size of plantings, and spacings noted. See Appendix C for example planting plans.
- □ For porous pavement applications, the material and placement specifications must be included for pavement mixes or pavers, open-graded base rock layer, and geotextile fabrics. Porous pavement designs must be designed and stamped by a registered professional engineer in the State of Oregon.

Other Requirements for Permit Application

Form O&M: Operations & Maintenance Agreement for Green Development Practices must be completed, notarized, and submitted to the City per Section 7.0 for all Green Development Practices prior to building permit issuance.

Additional Requirements for Green Development Practices in the Public ROW (Green Streets)

When used in the public right-of-way, Green Development Practices must be designed in accordance with the City of Gresham Green Street Standards, which includes Green Street right-of-way widths, cross-sections, and typical plan views for each street use designation.

Porous pavement applications for public street or sidewalk applications must be pre-approved by the City of Gresham.

For rain gardens and stormwater planters in the public right-of-way (Green Streets), developers may take advantage of the City of Gresham's *We'll Plant It Program*. See Appendix C for a description of this program.

Form SIM: Simplified Sizing Approach for Green Development Practices

This form shall be used to size Green Development Practices and demonstrate compliance with Pleasant Valley and Springwater Plan District stormwater management requirements. Stormwater conveyance and disposal requirements must still be met.

INSTRUCTIONS

Impervious Area = [   ] **Box 1**

1. Enter the square footage of impervious site area in Box 1 at the top of this form. Porous pavement areas do not need to be included.

2. Select rain gardens or stormwater planters from Rows 1 or 2. In Column 1, enter the square footage of impervious area that will drain into each facility type.

3. For Rows 1 and 2, multiply each impervious area from Column 1 by the corresponding sizing factor in Column 2, and enter the result in Column 3. This is the rain garden or planter ponding surface area needed to manage runoff from the contributing impervious area.

Green Development Practice	Column 1 Impervious Area Managed	Column 2 Sizing Factor	Column 3 Facility Surface Area	Unit
1) Rain Garden	_____ sf	x 0.06	[ ]	sf
2) Stormwater Planter	_____ sf	x 0.05	[ ]	sf
3) Tree Credit	_____ sf	(= # of new trees meeting criteria below x 100)		

Total Impervious Area Managed [   ] **Box 2**

Box 1 - Box 2 [   ] **Box 3**

4. Complete the tree credit calculation on Row 3. Each tree that meets the criteria at right will receive 100 square feet of impervious surface reduction credit. Enter this credit in Column 1, Row 3 as a positive number.

5. Total Column 1 (Rows 1-3) and enter the resulting "Total Impervious Area Managed" in Box 2.

6. Subtract Box 2 from Box 1 and enter the result in Box 3. When this number reaches 0 or less, Green Development Practice requirements have been met. Submit this form with the application for building or public works permit.

7. If Box 3 is greater than 0 square feet, add square footage or facilities to Column 1 and recalculate, or use additional facilities from the City of Gresham's Water Quality Manual to manage stormwater from these remaining impervious surfaces.

<u>Tree Credit Criteria:</u>

To receive impervious surface reduction credit, new trees must be planted within 25 feet of ground-level impervious surfaces. Trees cannot be credited against rooftop surfaces. New evergreen trees must be at least 6 feet tall at the time of planting to receive credit. New deciduous trees must be at least 2 inch caliper (diameter) at the time of planting to receive credit. For sites with over 2,400 square-feet of impervious surface to manage, no more than 20% can be reduced through the planting of trees. For sites with over 40,000 square-feet of impervious surface to manage, no more than 10% can be reduced through the planting of trees.

Rain Gardens

Sizing

Multiply the square-footage of the impervious surface (rooftops, driveways, parking lots, etc.) by 6% to calculate the square-footage of rain garden needed. The square-footage is determined at the peak water surface prior to overflow. For example, a single-family home site with a 1,000 square-foot rooftop and 200 square-foot driveway (1,200 square-feet of total impervious area) would require a rain garden 1,200 * 0.06 = 72 square feet in size. This could be accomplished with one 7.2-foot by 10-foot (6-inch minimum ponding depth) rain garden, two 6-foot by 6-foot rain gardens, or one rain garden roughly 10-feet in diameter.

Geometry/Slopes

See the typical cross-sectional drawings below for infiltration and filtration rain gardens.
• There is no shape requirement for rain gardens. They can be designed as square, rectangular, circular, oblong, or irregular.
• The minimum width for any rain garden shall be 5 feet.
• The maximum side slopes within rain gardens shall be 3 horizontal to 1 vertical.
• The minimum ponding depth shall be 6 inches. Maximum ponding depth shall be 12 inches.
• The minimum depth of soil amendment for rain gardens shall be 18 inches. See Appendix B for the required soil amendment specifications to be included with the permit plans.

Infiltration Rain Garden

Riser piping and debris shield set to allow minimum ponding depth of 6", maximum ponding depth of 12"

Rain Garden planting plan per specification

Incoming stormwater source from roof downspout or paving

Overflow piping directs excess stormwater to an approved disposal point

Infiltration of water into native soils

Soil amendment per specification, minimum depth of 18"

5' min. rain garden width at peak water surface elevation
Width x length = square footage from Form SIM

Infiltration Rain Gardens- Applicability
Infiltration rain gardens are used to manage stormwater flowing from all types of impervious surfaces, on private property and within the public right-of-way. Because they are generally more effective than filtration rain gardens at retaining large volumes of stormwater on-site, they shall be used instead of filtration rain gardens in circumstances when native soils infiltrate at least 0.5 inches per hour and they can be located at least 10 feet from building foundations and not immediately upslope of building structures.

Piping for Infiltration Rain Gardens
Piping per Plumbing Code requirements shall be used to direct stormwater from impervious surfaces to infiltration rain gardens, or if used within the public street right-of-way or within or adjacent to parking lot areas, stormwater may flow directly into them via curb openings. An overflow drain shall be constructed to allow at least 6 inches but not more than 12 inches of water to pond in the rain garden prior to overflow. On private property, this overflow drain and piping must meet Plumbing Code requirements and shall direct excess stormwater to an approved disposal point as identified on the subdivision's Public Works Permit drawings.

Within the public street right-of-way, this overflow drain and piping must meet City of Gresham Public Works Standards and shall direct excess stormwater to an approved disposal point.

Filtration Rain Garden

Riser piping and debris shield set to allow minimum ponding depth of 6", maximum ponding depth of 12"

Rain Garden planting plan per specification

Incoming stormwater source from roof downspout or paving

Overflow and underdrain piping directs excess stormwater to an approved disposal point

Filtration of water through topsoil into perforated underdrain system (4" ABS typ.) wrapped in 12" thick gravel layer

Soil amendment per specification, minimum depth to underdrain pipe = 18"

5' min. rain garden width at peak water surface elevation Width x length = square footage from Form SIM

Impermeable 60 mil. PVC liner where rain garden is located within 10' of building foundation or immediately upslope of structures

Filtration Rain Gardens- Applicability
Filtration rain gardens are used to manage stormwater flowing from all types of impervious surfaces on private property, where native soils infiltrate at less than 0.5 inches per hour. Filtration rain gardens may be located within 10 feet of building foundations if lined with an impermeable membrane.

Piping for Filtration Rain Gardens
Piping per Plumbing Code requirements shall be used to direct stormwater from impervious surfaces to filtration rain gardens, or if used within or adjacent to parking lot areas, stormwater may flow directly into them via curb openings. An overflow drain shall be constructed to allow

at least 6 inches but not more than 12 inches of water to pond in the rain garden prior to overflow. A perforated system of pipes shall be constructed 18" under the filtration rain garden to drain water that has filtered through the topsoil and prevent long-term ponding. On private property, this overflow drain and piping must meet Plumbing Code requirements and shall direct excess and filtered stormwater to an approved disposal point as identified on the subdivision's Public Works Permit drawings.

Setbacks
• For infiltration rain gardens and filtration rain gardens without an impermeable liner, the minimum setback from building structures shall be 10 feet.
• Infiltration rain gardens or filtration rain gardens without an impermeable liner shall not be located immediately upslope of building structures.
• There is not a required setback for filtration rain gardens as long as an impermeable 60 mil. PVC liner is used.
• Infiltration rain gardens shall be set back a minimum of 5 feet from property lines.

Soil Amendment/Mulch
The native soil in the top 18 inches of all rain gardens shall be amended with a mix of one part imported organic compost and one part gravelly sand, such that there are equal parts compost, sand, and native soil. This will require the rain garden area to be over excavated by approximately 12 inches prior to adding sand and compost. The specification included in Appendix B shall be used for this purpose and included on the permit plans. The mix shall be thoroughly tilled together on-site, and shall be capable of infiltrating water without immediate ponding on the surface. If such ponding occurs, add organic compost and sand and re-till until infiltration performance is enhanced. A 2-inch layer of shredded bark mulch (not bark dust or bark chips) shall be used between the plantings to completely cover the soil and prevent erosion or weed intrusion.

Plantings
A dense mix of plantings in rain gardens is critical to successful hydrologic function, prevents erosion, prevents weed invasion, and enhances aesthetic value. For all rain gardens, 1-gallon plants shall be planted at a maximum spacing of 18 inches on-center throughout the rain garden surface area.

See Appendix C for additional rain garden planting requirements, including a list of plants that have demonstrated good survival rates and low maintenance needs in the seasonal wet and dry conditions present. Also see Appendix C for a description of the *We'll Plant it Program*.

Stormwater Planters

Sizing
Multiply the square-footage of the impervious surface (rooftops, driveways, parking lots, etc.) by 5% to calculate the square-footage of stormwater planter needed. The square-footage is determined at the peak water surface prior to overflow. For example, a single-family home site with a 1,000 square-foot rooftop and 200 square-foot driveway (1,200 square-feet of total impervious area) would require a stormwater planter 1,200 * 0.05 = 60 square feet in size. This could be accomplished with one 6-foot by 10-foot (9-inch ponding depth minimum, 12-inch maximum) stormwater planter, or two 6-foot by 5-foot stormwater planters.

Geometry/Slopes
See the typical cross-sectional drawings below for infiltration and filtration stormwater planters.
• There is no shape requirement for stormwater planters. They can be designed as square, rectangular, circular, oblong, or irregular.
• The minimum width for any stormwater planter shall be 30 inches.
• The minimum ponding depth for stormwater planters shall be 9 inches. The maximum ponding depth shall be 12 inches.

• The minimum depth of amended soil mix for stormwater planters shall be 18 inches. See Appendix B for the required soil amendment specification to be included with the permit plans.
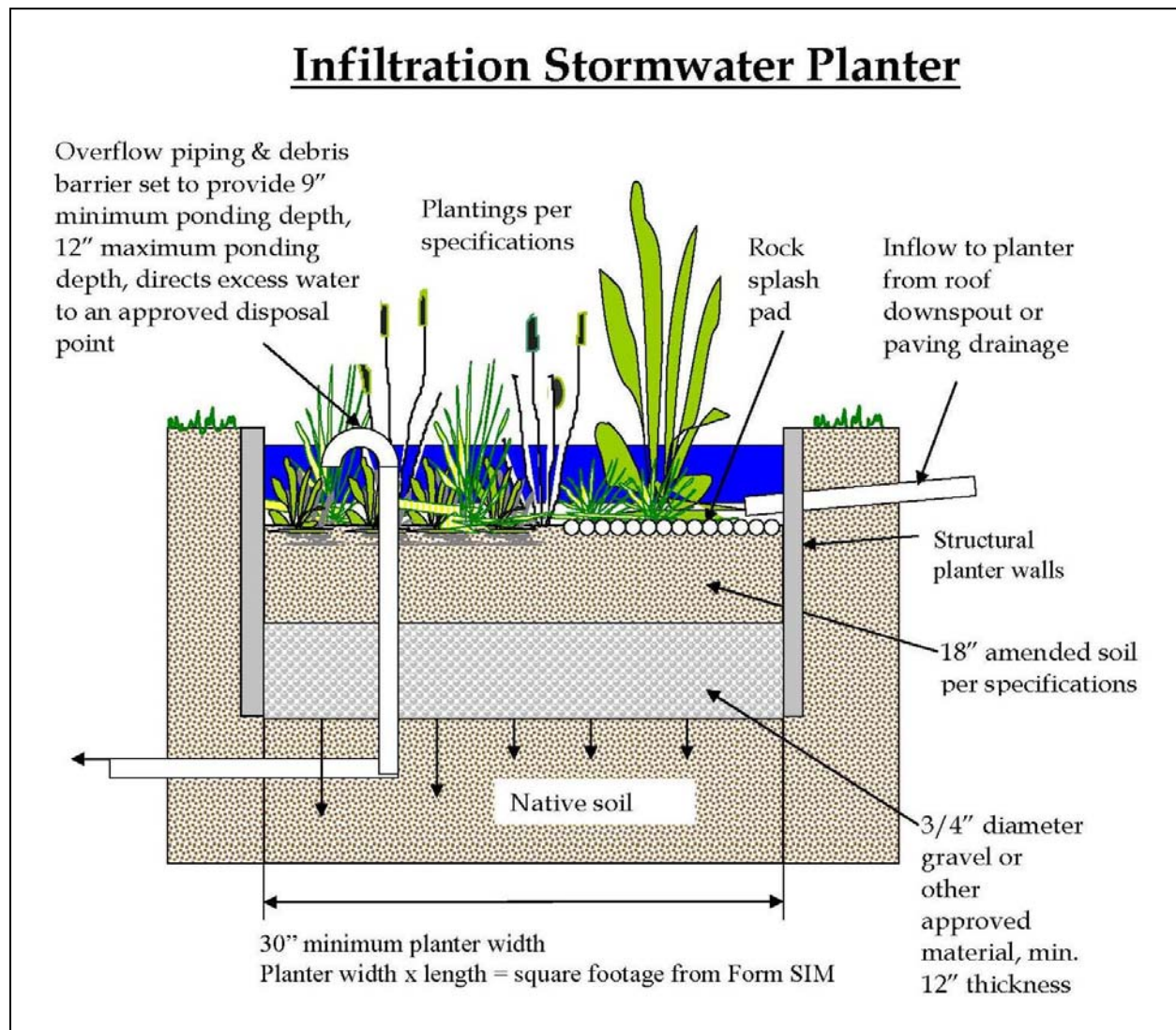
Infiltration Stormwater Planer- Applicability

Infiltration stormwater planters are used to manage stormwater flowing from all types of impervious surfaces, on private property and within the public right-of-way. Because they are generally more effective than filtration stormwater planters at retaining large volumes of stormwater on-site, they shall be used instead of filtration stormwater planters in circumstances when native soils infiltrate at more than 0.5 inches per hour, and they can be located at least 10 feet from building foundations and not immediately upslope of building structures.

Piping for Infiltration Stormwater Planters

Piping per Plumbing Code requirements shall be used to direct stormwater from impervious surfaces to infiltration stormwater planters, or if used within the public street right-of-way or

within or adjacent to parking lot areas, stormwater may flow directly into them via curb openings. An overflow drain shall be constructed to allow at least 9 but not more than 12 inches of water to pond in the planter prior to overflow. On private property, this overflow drain and piping must meet Plumbing Code requirements and shall direct excess stormwater to an approved disposal point as identified on the subdivision's Public Works Permit drawings. Within the public street right-of-way, this overflow drain and piping must meet City of Gresham Public Works Standards and shall direct excess stormwater to an approved disposal point

Filtration Stormwater Planter

Overflow piping & debris barrier set to provide 9" minimum ponding depth, 12" maximum ponding depth, directs excess water to an approved disposal point

Plantings per specifications

Inflow to planter from roof downspout or paving drainage

Rock splash pad

Structural planter walls

18" amended soil per specifications

Underdrain piping directs excess stormwater to an approved disposal point

Native soil

3/4" diameter gravel or other approved material, min. 12" thickness

30" minimum planter width
Planter width x length = square footage from Form SIM

Perforated pipe (4" ABS typ.) underdrain system

Filtration Stormwater Planters- Applicability
Filtration stormwater planters are used to manage stormwater flowing from all types of impervious surfaces on private property, where native soils infiltrate at less than 0.5 inches per hour. Filtration stormwater planters may be located within 10 feet of building foundations if lined with an impermeable membrane.

Piping for Filtration Stormwater Planters
Piping per Plumbing Code requirements shall be used to direct stormwater from impervious surfaces to filtration stormwater planters, or if used within the public street right-of-way or within or adjacent to parking lot areas, stormwater may flow directly into them via curb openings. An overflow drain shall be constructed to allow at least 9 but not more than 12 inches of water to pond in the planter prior to overflow. A perforated system of pipes shall be constructed under the filtration stormwater planter to drain water that has filtered through the topsoil and prevent long-term ponding. On private property, this overflow drain and piping must meet Plumbing Code requirements and shall direct excess and filtered stormwater to an approved disposal point as identified on the subdivision's Public Works Permit drawings.

Setbacks
• For infiltration stormwater planters or filtration stormwater planters without an impermeable liner, the minimum setback from building structures shall be 10 feet.
• Infiltration stormwater planters shall not be located immediately upslope of building structures.
• There is not a required setback for filtration stormwater planters as long as they are lined with waterproofed concrete or 60 mil. PVC liner to prevent infiltration.
• Infiltration stormwater planters shall be set back a minimum of 5 feet from property lines.

Soil Amendment/Mulch
The native soil in the top 18 inches of all stormwater planters shall be amended with a mix of one part imported organic compost and one part gravelly sand, such that there are equal parts compost, sand, and native soil. This will require the stormwater planter area to be over excavated by approximately 12 inches prior to adding sand and compost. The specification included in Appendix B shall be used for this purpose and included on the permit plans. The mix shall be thoroughly tilled together on-site, and shall be capable of infiltrating water without immediate ponding on the surface. If such ponding occurs, add organic compost and sand and re-till until infiltration performance is enhanced. A 2-inch layer of shredded bark mulch (not bark dust or bark chips) shall be used over the amended soil and between the plantings to completely cover the soil and prevent erosion or weed intrusion.

Plantings
A dense mix of plantings in stormwater planters is critical to successful hydrologic function, prevents erosion, prevents weed invasion, and enhances aesthetic value. For all stormwater planters, the following plant quantities and sizes shall be installed per 100 square feet of surface area, as calculated from Form SIM:

   Option A
   • **50** 1-gallon container at initial planting minimum- Shrubs, large clump-grasses, sedges, or rushes, 12"-24" diameter at maturity.

   Option B
   • **40** 1-gallon container at initial planting minimum- Shrubs, large clump-grasses, sedges, or rushes, 12"-24" diameter at maturity, and;
   • **20** 4-inch container at initial planting minimum– Shrubs, large clump-grasses, sedges, or rushes, 12"-24" diameter at maturity.

• Plants shall be spaced evenly throughout the stormwater planter area.
• Perennial accent plants and bulbs may be planted sporadically throughout rain gardens to add seasonal color and variability.

See Appendix C for example planting plans for 100 square-foot stormwater planters, using plant species that have demonstrated good survival rates and low maintenance needs in the seasonal wet and dry conditions present, as well as a description of the *We'll Plant it Program*.
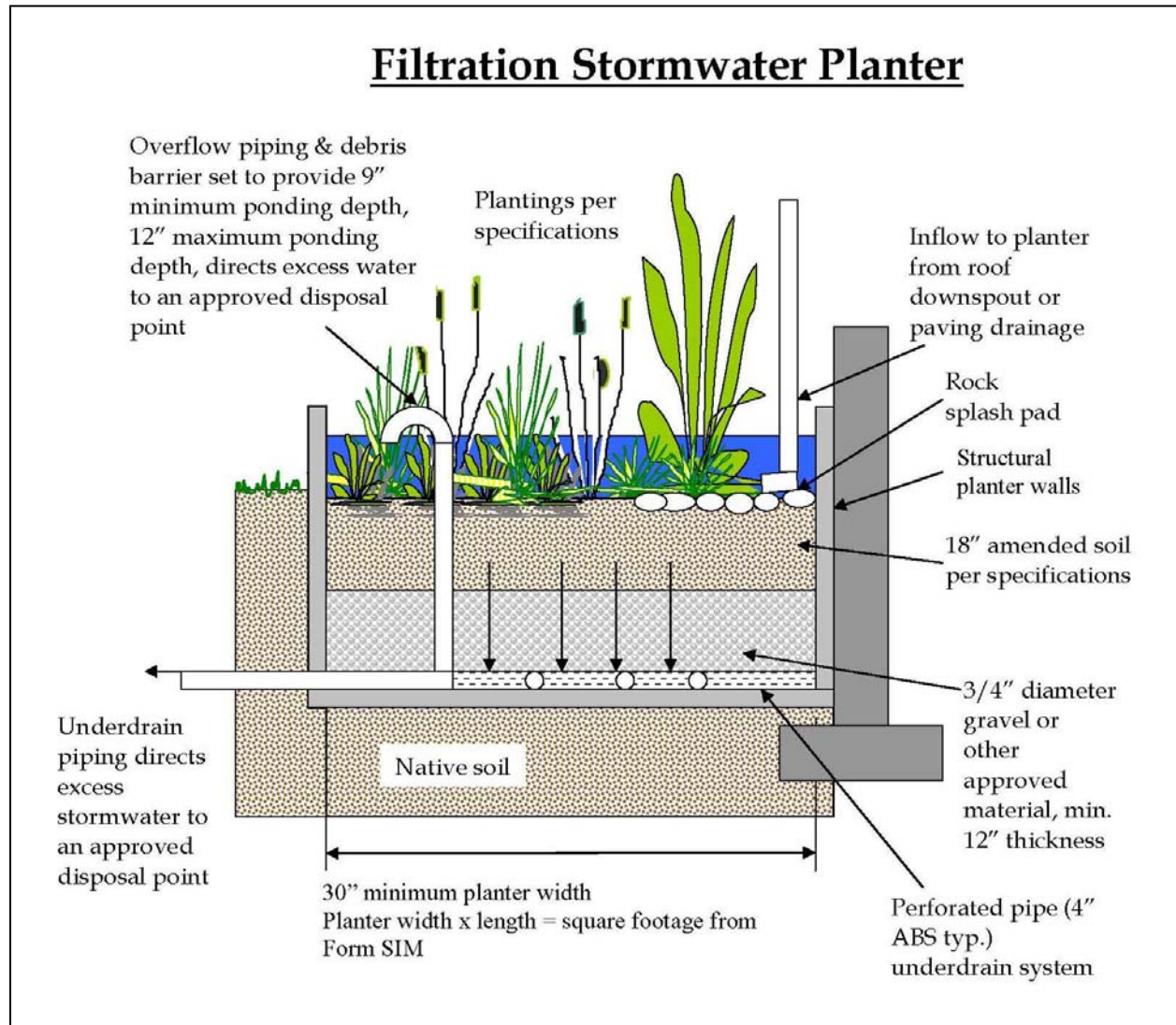
Porous Pavements
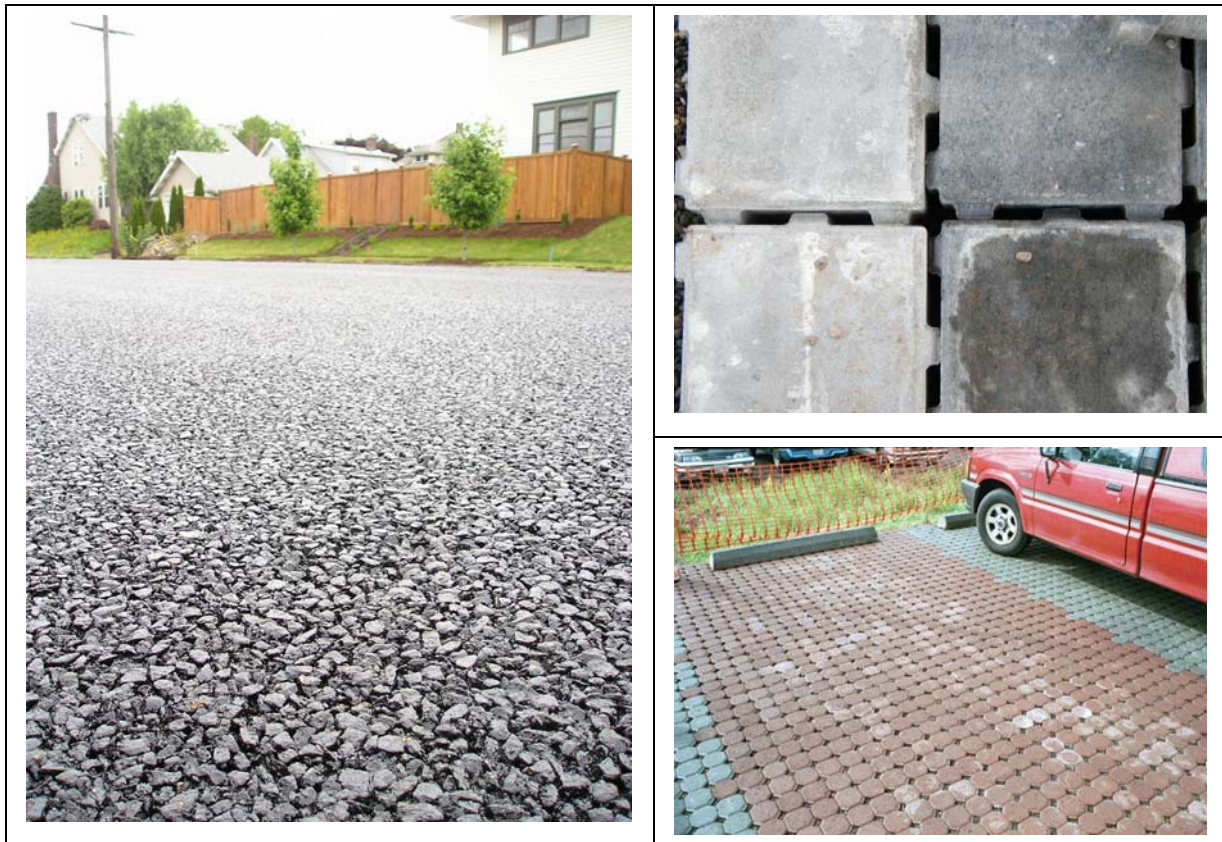
Photos
Left- porous asphalt mix, top right- SF RIMA^{TM} pavers, bottom right- Uni Eco-Stone® pavers

Description
Porous pavements allow rainwater to pass directly through the paving surface into gravel layers below, where it slowly infiltrates into the native soils. There are many types of porous pavements available on the market today, including but not limited to porous asphalt mixes, porous concrete mixes, and concrete paver systems designed with gaps or holes to allow water to pass through. The following list includes the types of paving systems that are considered by the City to be porous. Other paving systems may be reviewed on a case-by-case basis for porous designation, and must show the ability to pass water quickly through the pavement layer:

• Porous asphalt mix, standard ODOT "F" mix placed over an open-graded base rock layer
• Porous concrete mix, open-graded mix placed over an open-graded base rock layer
• Uni Eco-Stone® pavers placed over an open-graded base rock layer
• Uni Ecoloc® pavers placed over an open-graded base rock layer
• SF RIMA^{TM} pavers placed over an open-graded base rock layer
• TurfStone paver system, planted with grass or filled with clean gravel

The long-term effectiveness of a porous pavement system to retain and/or infiltrate water depends on the ability and practice of keeping its surface and pavement layer clear of debris and sediment that can cause clogging.

Applicability
Porous pavements that meet all applicable State and City building codes may be used on private property to receive stormwater management credit as a Green Development Practice. Porous pavement areas do not need to be entered into Form SIM for further management by rain gardens, stormwater planters, or tree credits.

Porous pavement surfaces must be designed and stamped by a registered professional engineer in the State of Oregon. Proprietary porous pavement systems must be installed per manufacturer specifications.

Porous pavement proposals in the public right-of-way must be pre-approved by the City of Gresham.

Porous pavements shall not be used in areas covered by the 100-year floodplain, or at slopes that exceed 3%.

Underdrain System
Where the native soil is not capable of infiltrating at a rate adequate to keep water from the 25-year, 24-hour storm from filling the gravel layer and backing up into the pavement layer, an underdrain system shall be employed to direct excess water to an approved disposal point. For purposes of receiving stormwater management credit as a Green Development Practice, underdrain systems will be required where the native soils infiltrate at 0.5"/hr or less, or where the slope of the paving surface and gravel base layer may cause water to accumulate and fill the gravel layer quickly in the lower area.

Safety Overflow
Porous pavement systems shall be designed with a safety overflow mechanism to prevent ponding in the event that the surface is clogged with sediment or debris. The overflow mechanism may consist of an inlet drain, catch basin, curb opening, or other method to convey water to an approved disposal point.

Tree Credits

Large, mature trees provide several stormwater management benefits, including interception and evaporation of rainfall, uptake and evapotranspiration of groundwater, and cooling of surfaces that contribute to thermal loading of runoff.

New trees planted in the Pleasant Valley and Springwater Plan Districts within 25 feet of ground-level impervious surfaces may be eligible for stormwater management credit. Credit will not be given to mitigate for rooftop impervious surfaces. New evergreen trees must be at least 6 feet tall at the time of planting, and new deciduous trees must be at least 2 caliper inches at the time of planting. For sites with over 2,400 square-feet of impervious surface to manage, no more than 20% can be reduced through the use of tree credits. For sites with over 40,000 square-feet of impervious surface to manage, no more than 10% can be reduced through the use of tree credits.

Trees used for stormwater management credit must be clearly labeled on the building permit drawings as such, with size and species labeled. Form SIM must be filled out and submitted with the building permit submittal. Trees shall be maintained and protected on the site after construction and for the life of the development. During the life of the development, trees approved for stormwater credit shall not be removed without approval from the City of Gresham. Trees that are removed or die shall be replaced within 6 months with like species, or species from the list below.

The following tree and arborescent shrub species are approved for stormwater management credit. Other species may be given credit on a case-by-case basis.

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

7.0 Operation & Maintenance of Green Development Practices

In order to function for their intended purpose over the long term, Green Development Practices must be periodically maintained. Privately owned facilities such as rain gardens, stormwater planters, and porous pavements on private property are the sole responsibility of the property owner to maintain. Prior to issuance of a building permit, the owner must sign an O&M agreement with the City (Form O&M, included below), committing the owner and future owners to certain operation and maintenance activities. This agreement must be recorded with Multnomah County prior to building permit issuance.

Maintenance responsibility of Green Development Practices located within public street right-of-ways or easements dedicated to the City will be shared between the City and adjacent private property owner. The City's maintenance responsibility will include periodic removal of accumulated trash, debris, and sediment, and repair or replacement of curbing, inlet drains, or rock check-dams. Weeding and trimming or replacement of shrubs, grasses, or other plantings will be the responsibility of the adjacent private property owner. In order to comply with adjacent private property owners' aesthetic values, adjacent private property owners may perform trash and sediment removal on a more frequent basis than the City is capable of achieving. Under no circumstance shall a private property owner place fill, trash, lawn trimmings, or leaves into public or private Green Development Practice facilities.

Form O&M Instructions:

1) Read the form thoroughly prior to filling it out. If you have any questions about how to fill it out, or the responsibilities the form commits the owner to, please call the City of Gresham at 503-618-2621.
2) Fill out Box 1, including owner's name, telephone number, mailing address, site address, and site legal description.
3) For Box 2, depending on which types of Green Development Practices are being installed on the site, attach the Rain Garden O&M Form, Stormwater Planter O&M Form, or Porous Pavement O&M Form (included below) to Form O&M, and check the applicable box (or boxes).
4) Fill out Box 3, including party responsible for O&M, contact information if other than owner, anticipated installation date of the facility, and name of the person preparing the form.
5) In Box 4, either sketch the property or include a separate site plan sheet including street frontage (label street name), home or buildings, parking lots, and driveways. Indicate with *'s where each Green Development Practice is to be located, and label each one as a rain garden, stormwater planter, or porous pavement.
6) Read the legal requirements in Box 5.
7) Under witness of a certified notary, sign the form in Box 6 and have it notarized.
8) Submit the completed Form O&M with the building permit application for review by the City of Gresham. The form will need to be recorded with Multnomah County and proof submitted to the City of Gresham prior to building permit issuance.

County Recorder's Office Contact Information:

Multnomah County Recorder
Room 158
501 SE Hawthorne St.
Portland, OR 97214
Http://www.co.multnomah.or.us/at/services.html
Phone: 503-988-3326

This Box for Multnomah County Recording Use Only

FORM O&M: Operations & Maintenance Agreement for Green Development Practices	
Permit Application #:	Project #:

BOX 1

Owner's Name: Phone Number: (_____) _____ - _____

Mailing Address:

Site Address:

Site Legal Description:

BOX 2

Type of Green Development Practices. *Check all that apply:* ❑ Rain Garden ❑ Stormwater Planter ❑ Porous Pavement

BOX 3

Party responsible for maintenance of Green Development Practice. *Check One:*

❑ Property Owner	❑ Homeowner's Association	❑ Other (d*escribe):*_____

Contact Information (only if other than owner)

Maintenance Contact Name: Phone Number: (_____) _____ - _____

Maintenance Contact Address:

Estimated Date of Installation (month/year):

Prepared By:

BOX 4   Insert site plan here or attach separate sheet.

The Green Development Practices located on this site plan are a required condition of permit approval for the identified property. The owner of the identified property is required to operate and maintain these facilities in accordance with the attached O&M plans. The requirement to operate and maintain these facilities in accordance with the O&M plans is binding on all current and future owners of the property. The O&M plan may be modified under written consent of new owners with written approval by and re-filing with the City of Gresham. Call (503) 618-2621 for information or assistance.

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BOX 5: LEGAL REQUIREMENTS

I.   OWNER INSPECTIONS

OWNER shall provide inspections of the Facilities as needed to ensure proper function on a continual basis. Proper function for each facility type is described in the Operations and Maintenance Plan (O&M Plan).

II.   DEFICIENCIES

All aspects in which the Facilities fail to satisfy the O&M Plan shall be noted as "Deficiencies".

III.   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.

IV.   CITY INSPECTIONS

OWNER grants to the CITY the right to inspect the private stormwater Facilities. The CITY will endeavor to give ten (10) days prior written notice (as courtesy to OWNER), except that no notice shall be required in case of an emergency. The CITY 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 City) 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.

V.   CITY CORRECTIONS

If correction of all OWNER or CITY identified Deficiencies is not completed within thirty (30) days after OWNER'S inspection or CITY notice, CITY shall have the right to have any Deficiencies corrected. The CITY (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 CITY for work performed to correct such Deficiencies ("City Correction Costs") following OWNER'S failure to correct any Deficiencies in the Facilities. OWNER shall pay to CITY the City Correction Costs within thirty (30) days of the date of the invoice. If payment is not made within 30 days, the CITY shall collect pursuant to Gresham Revised Code Article 7.50 regarding enforcement of cost assessment. OWNER understands and agrees that upon non-payment, City Correction Costs shall be secured by a lien on OWNER'S property for the City Correction Cost amount plus interest and penalties.

VI.   EMERGENCY MEASURES

If at any time the CITY reasonably determines that the Facilities create any imminent threat to public health, safety or welfare, the CITY may immediately and without prior notice to the Owner take measures reasonably designed to remedy the threat. The CITY shall provide notice to OWNER of the threat and the measures taken as soon as reasonably practicable, and charge OWNER for the cost of corrective measures.

VII.   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 site, present and future, and their heirs, successors and assigns.

VIII.   ASSIGNMENT TO HOMEOWNERS ASSOCIATION; PROPERTY OWNERS LIABLE

The OWNER may assign this Agreement to a homeowners association comprised of the owners of the benefiting properties. However, the respective owners of each property shall be jointly and severally liable for City Correction Costs if not otherwise paid. All notices to OWNER shall be sent to the address designated in writing by the homeowners association.

IX.   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 both parties to this Agreement and recorded in the Official Records of Multnomah County.

X.   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.

XI.   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.

BOX 6

BY SIGNING BELOW, filer accepts and agrees to the terms and conditions contained in this operations & maintenance plan and in any document executed by filer and recorded with it.

_____

Filer:

NOTARIZATION: GIVEN under my hand and official seal

this _____ day of _____ , _____.

Notary Public in and for the State of Oregon:

My Appointment Expires on:

Rain Garden **Operations & Maintenance Requirements**
Rain gardens, also known as swales or bioswales, are planted open depressions in the landscape designed to accept stormwater runoff from adjacent impervious surfaces. Rain gardens trap pollutants in stormwater by filtering it through topsoil as the water infiltrates into native soils or underlying drain pipes. Rain gardens reduce the volume of stormwater that is discharged off-site and into natural streams. Rain gardens should drain within 24 hours of a storm event. All facility components should be inspected for proper operation quarterly at a minimum, and within 48 hours after each major storm event. The facility owner should keep a log, recording all inspection dates, observations, and maintenance activities. The following items must be inspected and maintained as stated:
Downspout pipes or curb cuts *shall maintain a calm flow of water entering the rain garden***.** • Source of erosion shall be identified and controlled when native soil is exposed or erosion channels are forming. Rock splash pads shall be placed around the point where water is discharged into the rain garden to slow the water and prevent erosion. • Sediment accumulation shall be removed with minimum damage to vegetation. Accumulated sediment shall be removed if it is more than 1" thick or if it is damaging vegetation. • Inlet shall be cleared when conveyance capacity is plugged. Sources of sediment and debris shall be identified and corrected.
Side Slopes *shall be maintained to prevent erosion in the rain garden.* • Slopes shall be stabilized and planted using appropriate erosion control measures when native soil is exposed or erosion channels are forming.
Topsoil *shall allow stormwater to percolate uniformly through the rain garden. If the rain garden does not drain within 48 hours, it shall be tilled and replanted.* • *Annual or semi-annual tilling shall be implemented if compaction or clogging continues.* • Debris in quantities that inhibit infiltration shall be removed routinely (e.g., no less than quarterly), or upon discovery.
Rain Garden Outlet*, such as an overflow drain or surface overflow channel shall be kept free of debris to prevent flooding.*
Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. Mulch shall be replenished as needed to ensure survival of vegetation and erosion prevention. • Fallen leaves and debris from deciduous plant foliage shall be removed. • Nuisance and invasive vegetation (such as weeds, blackberries and English Ivy) shall be removed when discovered. • Dead vegetation and woody material shall be removed to maintain less than 10% of the rain garden surface area. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining rain gardens, such as this O&M Plan, shall be provided to all property owners and tenants.
Pests such as rodents or mosquitos shall not be allowed to harbor in the rain garden. Pest control measures shall be taken when they are found to be present. • If sprays are considered, then a mosquito larvicide, such as Bacillus thuringiensis or Altosid formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. • Holes in the ground located in and around the garden shall be filled.

Stormwater Planter
Operations & Maintenance Requirements

Stormwater Planters are designed to accept stormwater runoff from adjacent impervious surfaces. They remove pollutants by filtering runoff through layers of topsoil and then either infiltrating it into native soils (infiltration stormwater planter) or perforated underdrain pipes to be discharged off-site (filtration stormwater planter). Water should drain through the planter within 24 hours after a storm event. All planter components should be inspected for proper operation quarterly, and within 48 hours of each major storm event. The facility owner should keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:

Downspouts from rooftops or pipes or curb openings from surface paving should allow unimpeded flow into the planter.

- Debris shall be removed routinely (e.g., no less than every 6 months) and upon discovery.
- Damaged pipe shall be repaired upon discovery.

Concrete Splash Blocks or Rock Splash Pads *shall be used to prevent erosion in the planter and splashing against adjacent structures.*

The Planter Reservoir receives and ponds stormwater prior to infiltration. It should be constructed with a durable material such as concrete or pressure-treated lumber. Water should drain from the reservoir within 3-4 hours of a storm event.

- Sources of clogging shall be identified and corrected.
- Damage to the concrete or wood structure shall be repaired upon discovery.

Planting Media consisting of topsoil, sand, native soil, and gravel shall allow stormwater to percolate uniformly through the planter.

- If the topsoil in the planter is not draining, amend it with sand, till it to alleviate compaction, or replace topsoil altogether.
- Sediment accumulation shall be removed with minimum damage to vegetation.
- Litter and debris shall be removed upon discovery.

Overflow and Underdrain Piping *conveys flow exceeding the reservoir and planter infiltration capacity to an approved stormwater receiving system*.

- Overflow pipe shall be cleared of sediment and debris when conveyance capacity is plugged.
- Damaged pipe shall be repaired or replaced upon discovery.

Vegetation shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion.

- Mulch shall be replenished at least annually.
- Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- Nuisance or invasive plants such as weeds or blackberries shall be removed when discovered.
- Dead vegetation shall be removed to ensure less than 10% planter area coverage, and replaced within one week of removal.

Spill Prevention measures shall be exercised when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.

Training and/or written guidance information for operating and maintaining stormwater planters, such as this O&M Plan, shall be provided to all property owners and tenants.

Insects & Rodents shall not be allowed to harbor in the stormwater planter. Pest control measures shall be taken when insects/rodents are found to be present. If sprays are considered, then a mosquito larvicide, such as Bacillus thuringiensis or Altosid formulations can be applied only if absolutely necessary, and only by a licensed individual or contractor. Holes in the ground located in and around the stormwater planter shall be filled and compacted.

Porous Pavement
Operations & Maintenance Requirements
Porous pavement is a permeable pavement surface with an underlying stone layer that temporarily stores water that percolates through the surface before infiltrating into the subsoil or being collected in underlying drain pipes and being discharged off-site. There are many types of porous pavements including plastic rings planted with grass, stone or concrete pavers with pore spaces backfilled with gravel or sand, porous asphalt mixes, and porous concrete mixes. Porous pavement should be designed to accept water from precipitation and potentially sheet flow from adjacent impervious surfaces, but not concentrated discharges of stormwater runoff. The pavement surface shall be inspected for proper infiltration performance and structural stability within 48 hours after each major storm event. The facility owner should keep a log, recording all inspection dates, observations, and maintenance activities. The following items shall be inspected and maintained as stated:
Surface Cleaning and Infiltration Performance: The surface of the porous pavement shall be kept clean and free of leaves, debris, and sediment. The surface shall not be overlaid with an impervious paving surface. Quarterly sweeping shall be implemented for porous asphalt, concrete, or paver systems. If infiltration performance is hindered by sediment clogging the pore spaces in the pavement, the pavement shall be swept with a vacuum sweeper to regenerate infiltration performance.
Overflows or Emergency Spillways are used in the event that the facility's infiltration capacity is exceeded. Overflow devices shall be inspected for obstructions or debris, which shall be removed upon discovery Overflow or emergency spillways shall be capable of transporting high flows of stormwater to an approved stormwater receiving system.
Vegetation (where applicable) shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion. • Fallen leaves and debris from deciduous plant foliage shall be raked and removed. • Grass shall be mowed to less than four inches and grass clippings shall be bagged and removed.
Spill Prevention measures shall be exercised when handling substances that can contaminate stormwater. A spill prevention plan shall be implemented at all non-residential sites and in areas where there is likelihood of spills from hazardous materials. All homes contain a wide variety of toxic materials including gasoline for lawn mowers, antifreeze for cars, solvents, pesticides, and cleaning aids that can adversely affect stormwater if spilled. It is important to exercise caution when handling substances that can contaminate stormwater. Releases of pollutants shall be corrected as soon as identified.
Training and/or written guidance information for operating and maintaining porous pavement shall be provided to all property owners and tenants. A copy of the O&M Plan shall be provided to all new property owners and tenants.
Access to the porous pavement shall be safe and efficient. Egress and ingress routes shall be maintained to design standards. Roadways shall be maintained to accommodate size and weight of vehicles, if applicable. Obstacles preventing maintenance personnel and/or equipment access to the porous pavement shall be removed. Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.
Signage may serve to educate people about the importance or function of the site's porous pavement surfaces. It may also discourage behaviors that adversely affect stormwater protection measures. If used at the site, broken or defaced signs shall be replaced or repaired.

8.0 References & Resources

City of Gresham Development Code, Sections 4.1468, 4.1481, and 4.1564

City of Gresham Public Works Standards

City of Gresham Water Quality Manual, Stormwater Division, Department of Environmental Services, Summer 2003

City of Portland Stormwater Management Manual, Revision 3, September 1, 2004

Pleasant Valley Stormwater Master Plan, Prepared for the City of Gresham and City of Portland by CH2MHill with HDR Engineering, Greenworks, P.C., Natural Resources Planning Services, Inc., and ECONorthwest, July 2004

Springwater Stormwater Master Plan, Prepared for the City of Gresham by HDR Engineering, December 2005

Low Impact Development, Technical Guidance Manual for Puget Sound, Puget Sound Action Team & Washington State University Pierce County Extension, January 2005

Harvesting Rain in the Pacific Northwest: Rain Gardens, by Gary Bock and Douglas M. Stienbarger, Watershed Stewards, sponsored in partnership by WSU Extension Clark County and the Clark County Clean Water Program, December 2005

Oregon Standard Specifications for Construction, 2002, Oregon Department of Transportation, APWA Oregon Chapter

Rain Garden Informational Web Sites
www.raingardens.org/Index.php
www.raingardennetwork.com/
www.dof.virginia.gov/rfb/rain-gardens.shtml
www.rainkc.com/home/index.asp
www.appliedeco.com/Projects/Rain%20Garden.pdf
www.uri.edu/ce/healthylandscapes/raingarden.htm
www.bbg.org/gar2/topics/design/2004sp_raingardens.html

Appendix A:

Spreadsheets for Development of
Form SIM Sizing Factors

Spreadsheet Illustrating Rain Garden Sizing
24 Hour Storms, NRCS Type 1A Rainfall Distribution

24 Hour Rainfall Depth =	1	in						
Peak Rainfall Intensity =	0.32	in/hr						
Impervious Surface Square-Footage =	1000							
Runoff Coefficient =	0.9							
Rain Garden Square-Footage =	55							
Ratio of Rain Garden to Impervious Surface =	0.055							
Soil Infiltration Rate =	0.5	in/hr						
Maximum Ponding Depth in Rain Garden =	6.00	in						

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
			Inflow	Inflow	Inflow	Maximum	Inflow -	Inflow -	Cumulative	Cumulative
Time	Rainfall	Rainfall	Rate	Volume	Volume	Infiltration	Infiltration	Infiltration	Inflow -	Ponding
	Depth	Intensity					Rate	Volume	Outflow	Depth
(min)	(in)	(in/hr)	(cfs)	(cf)	(in)	(cfs)	(cfs)	(cf)	(cf)	(in)
0	0.0000	0.00	0.00	0	0	0.00063657	-0.00064	-0.3819	0.00	0.00
10	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
20	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
30	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
40	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
50	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
60	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
70	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
80	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
90	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
100	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	0.00	0.00
110	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
120	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
130	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
140	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
150	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
160	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	0.00	0.00
170	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.07	0.02
180	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.14	0.03
190	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.20	0.05
200	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.27	0.07
210	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.34	0.08
220	0.0060	0.04	0.00	0.45	0.0054	0.00063657	0.00011	0.0681	0.41	0.10
230	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	0.55	0.13
240	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	0.69	0.17
250	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	0.84	0.20
260	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	0.98	0.24
270	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	1.12	0.27
280	0.0070	0.04	0.00	0.525	0.0063	0.00063657	0.00024	0.1431	1.27	0.31
290	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	1.50	0.37
300	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	1.73	0.42
310	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	1.97	0.48
320	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	2.20	0.54
330	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	2.43	0.59
340	0.0082	0.05	0.00	0.615	0.00738	0.00063657	0.00039	0.2331	2.67	0.65
350	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	3.00	0.73
360	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	3.33	0.81
370	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	3.66	0.89
380	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	3.99	0.97
390	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	4.32	1.06
400	0.0095	0.06	0.00	0.7125	0.00855	0.00063657	0.00055	0.3306	4.65	1.14

410	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	5.27	1.29
420	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	5.89	1.44
430	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	6.52	1.59
440	0.0180	0.11	0.00	1.35	0.0162	0.00063657	0.00161	0.9681	7.49	1.83
450	0.0180	0.11	0.00	1.35	0.0162	0.00063657	0.00161	0.9681	8.45	2.07
460	0.0340	0.20	0.00	2.55	0.0306	0.00063657	0.00361	2.1681	10.62	2.60
470	0.0540	0.32	0.01	4.05	0.0486	0.00063657	0.00611	3.6681	14.29	3.49
480	0.0270	0.16	0.00	2.025	0.0243	0.00063657	0.00274	1.6431	15.93	3.89
490	0.0180	0.11	0.00	1.35	0.0162	0.00063657	0.00161	0.9681	16.90	4.13
500	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	17.52	4.28
510	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	18.15	4.43
520	0.0134	0.08	0.00	1.005	0.01206	0.00063657	0.00104	0.6231	18.77	4.59
530	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	19.05	4.65
540	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	19.33	4.72
550	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	19.60	4.79
560	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	19.88	4.86
570	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	20.16	4.93
580	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	20.44	4.99
590	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	20.72	5.06
600	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	20.99	5.13
610	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	21.27	5.20
620	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	21.55	5.27
630	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	21.83	5.33
640	0.0088	0.05	0.00	0.66	0.00792	0.00063657	0.00046	0.2781	22.11	5.40
650	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	22.26	5.44
660	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	22.42	5.48
670	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	22.58	5.52
680	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	22.74	5.56
690	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	22.90	5.60
700	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.06	5.63
710	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.21	5.67
720	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.37	5.71
730	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.53	5.75
740	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.69	5.79
750	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	23.85	5.83
760	0.0072	0.04	0.00	0.54	0.00648	0.00063657	0.00026	0.1581	24.00	5.87
770	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.05	5.88
780	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.09	5.89
790	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.14	5.90
800	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.19	5.91
810	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.23	5.92
820	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.28	5.93
830	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.32	5.94
840	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.37	5.95
850	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.41	5.97
860	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.46	5.98
870	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.50	5.99
880	0.0057	0.03	0.00	0.4275	0.00513	0.00063657	0.00008	0.0456	24.55	6.00
890	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.54	6.00
900	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.54	6.00
910	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.53	5.99
920	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.52	5.99
930	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.52	5.99
940	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.51	5.99
950	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.50	5.99
960	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.49	5.99
970	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.49	5.98
980	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.48	5.98
990	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.47	5.98

1000	0.0050	0.03	0.00	0.375	0.0045	0.00063657	-0.00001	-0.0069	24.47	5.98
1010	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	24.38	5.96
1020	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	24.30	5.94
1030	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	24.22	5.92
1040	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	24.14	5.90
1050	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	24.06	5.88
1060	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.98	5.86
1070	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.89	5.84
1080	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.81	5.82
1090	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.73	5.80
1100	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.65	5.78
1110	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.57	5.76
1120	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.48	5.74
1130	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.40	5.72
1140	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.32	5.70
1150	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.24	5.68
1160	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.16	5.66
1170	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	23.07	5.64
1180	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.99	5.62
1190	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.91	5.60
1200	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.83	5.58
1210	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.75	5.56
1220	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.66	5.54
1230	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.58	5.52
1240	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.50	5.50
1250	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.42	5.48
1260	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.34	5.46
1270	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.25	5.44
1280	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.17	5.42
1290	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.09	5.40
1300	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	22.01	5.38
1310	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.93	5.36
1320	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.84	5.34
1330	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.76	5.32
1340	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.68	5.30
1350	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.60	5.28
1360	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.52	5.26
1370	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.43	5.24
1380	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.35	5.22
1390	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.27	5.20
1400	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.19	5.18
1410	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.11	5.16
1420	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	21.03	5.14
1430	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	20.94	5.12
1440	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	20.86	5.10
1450	0.0040	0.02	0.00	0.3	0.0036	0.00063657	-0.00014	-0.0819	20.78	5.08
1460	0.0000	0.00	0.00	0	0	0.00063657	-0.00064	-0.3819	20.40	4.98
	1.00			**75**	**0.90**					

Spreadsheet Illustrating Stormwater Planter Sizing
24 Hour Storms, NRCS Type 1A Rainfall Distribution

24 Hour Rainfall Depth =	1	in	
Peak Rainfall Intensity =	0.32	in/hr	
Impervious Surface Square-Footage =	1000		
Runoff Coefficient =	0.9		
Stormwater Planter Square-Footage =	42.9		
Ratio of Stormwater Planter to Impervious Surface =	0.0429		
Soil Infiltration Rate =	0.5	in/hr	
Maximum Ponding Depth in Stormwater Planter =	8.98	in	

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Time	Rainfall Depth	Rainfall Intensity	Inflow Rate	Inflow Volume	Inflow Volume	Maximum Infiltration	Inflow - Infiltration Rate	Inflow - Infiltration Volume	Cumulative Inflow - Outflow	Cumulative Ponding Depth
(min)	(in)	(in/hr)	(cfs)	(cf)	(in)	(cfs)	(cfs)	(cf)	(cf)	(in)
0	0.0000	0.00	0.00	0	0	0.00049653	-0.00049653	-0.2979	0.00	0.00
10	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.00	0.00
20	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.00	0.00
30	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.01	0.00
40	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.01	0.00
50	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.01	0.00
60	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.01	0.00
70	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.01	0.00
80	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.02	0.00
90	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.02	0.01
100	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	0.02	0.01
110	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.10	0.03
120	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.18	0.05
130	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.25	0.07
140	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.33	0.09
150	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.41	0.11
160	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	0.48	0.14
170	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	0.64	0.18
180	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	0.79	0.22
190	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	0.94	0.26
200	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	1.09	0.31
210	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	1.24	0.35
220	0.0060	0.04	0.00	0.45	0.0054	0.00049653	0.000253472	0.1521	1.40	0.39
230	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	1.62	0.45
240	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	1.85	0.52
250	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	2.08	0.58
260	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	2.30	0.64
270	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	2.53	0.71
280	0.0070	0.04	0.00	0.525	0.0063	0.00049653	0.000378472	0.2271	2.76	0.77
290	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	3.08	0.86
300	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	3.39	0.95
310	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	3.71	1.04
320	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	4.03	1.13
330	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	4.34	1.22
340	0.0082	0.05	0.00	0.615	0.00738	0.00049653	0.000528472	0.3171	4.66	1.30
350	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	5.08	1.42
360	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	5.49	1.54
370	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	5.90	1.65
380	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	6.32	1.77
390	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	6.73	1.88
400	0.0095	0.06	0.00	0.7125	0.00855	0.00049653	0.000690972	0.4146	7.15	2.00

410	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	7.86	2.20
420	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	8.56	2.40
430	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	9.27	2.59
440	0.0180	0.11	0.00	1.35	0.0162	0.00049653	0.001753472	1.0521	10.32	2.89
450	0.0180	0.11	0.00	1.35	0.0162	0.00049653	0.001753472	1.0521	11.37	3.18
460	0.0340	0.20	0.00	2.55	0.0306	0.00049653	0.003753472	2.2521	13.63	3.81
470	0.0540	0.32	0.01	4.05	0.0486	0.00049653	0.006253472	3.7521	17.38	4.86
480	0.0270	0.16	0.00	2.025	0.0243	0.00049653	0.002878472	1.7271	19.11	5.34
490	0.0180	0.11	0.00	1.35	0.0162	0.00049653	0.001753472	1.0521	20.16	5.64
500	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	20.86	5.84
510	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	21.57	6.03
520	0.0134	0.08	0.00	1.005	0.01206	0.00049653	0.001178472	0.7071	22.28	6.23
530	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	22.64	6.33
540	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	23.00	6.43
550	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	23.36	6.54
560	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	23.73	6.64
570	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	24.09	6.74
580	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	24.45	6.84
590	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	24.81	6.94
600	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	25.18	7.04
610	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	25.54	7.14
620	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	25.90	7.24
630	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	26.26	7.35
640	0.0088	0.05	0.00	0.66	0.00792	0.00049653	0.000603472	0.3621	26.62	7.45
650	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	26.87	7.51
660	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	27.11	7.58
670	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	27.35	7.65
680	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	27.59	7.72
690	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	27.83	7.79
700	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	28.08	7.85
710	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	28.32	7.92
720	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	28.56	7.99
730	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	28.80	8.06
740	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	29.04	8.12
750	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	29.29	8.19
760	0.0072	0.04	0.00	0.54	0.00648	0.00049653	0.000403472	0.2421	29.53	8.26
770	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	29.66	8.30
780	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	29.79	8.33
790	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	29.92	8.37
800	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.05	8.40
810	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.18	8.44
820	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.31	8.48
830	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.44	8.51
840	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.57	8.55
850	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.69	8.59
860	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.82	8.62
870	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	30.95	8.66
880	0.0057	0.03	0.00	0.4275	0.00513	0.00049653	0.000215972	0.1296	31.08	8.69
890	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.16	8.72
900	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.24	8.74
910	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.31	8.76
920	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.39	8.78
930	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.47	8.80
940	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.55	8.82
950	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.62	8.85
960	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.70	8.87
970	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.78	8.89
980	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.85	8.91
990	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	31.93	8.93

1000	0.0050	0.03	0.00	0.375	0.0045	0.00049653	0.000128472	0.0771	32.01	8.95
1010	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.01	8.95
1020	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.01	8.95
1030	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.01	8.96
1040	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.02	8.96
1050	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.02	8.96
1060	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.02	8.96
1070	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.02	8.96
1080	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.03	8.96
1090	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.03	8.96
1100	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.03	8.96
1110	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.03	8.96
1120	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.03	8.96
1130	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.04	8.96
1140	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.04	8.96
1150	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.04	8.96
1160	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.04	8.96
1170	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.04	8.96
1180	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.05	8.96
1190	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.05	8.96
1200	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.05	8.97
1210	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.05	8.97
1220	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.05	8.97
1230	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.06	8.97
1240	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.06	8.97
1250	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.06	8.97
1260	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.06	8.97
1270	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.06	8.97
1280	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.07	8.97
1290	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.07	8.97
1300	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.07	8.97
1310	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.07	8.97
1320	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.08	8.97
1330	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.08	8.97
1340	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.08	8.97
1350	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.08	8.97
1360	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.08	8.97
1370	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.09	8.97
1380	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.09	8.98
1390	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.09	8.98
1400	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.09	8.98
1410	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.09	8.98
1420	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.10	8.98
1430	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.10	8.98
1440	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.10	8.98
1450	0.0040	0.02	0.00	0.3	0.0036	0.00049653	3.47222E-06	0.0021	32.10	8.98
1460	0.0000	0.00	0.00	0	0	0.00049653	-0.00049653	-0.2979	31.80	8.90
	1.00			**75**	**0.90**					

Appendix B:

Soil Amendment & Mulch Specifications

SOIL AMENDMENT & MULCH SPECIFICATIONS

The native soil in the top 18 inches of all stormwater planters shall be amended with a mix of one part imported organic compost and one part gravelly sand, such that there are equal parts compost, sand, and native soil. This will require the stormwater planter area to be over excavated by approximately 12 inches prior to adding sand and compost. The specifications included hereon shall be used for this purpose and included on the permit plans. The mix shall be thoroughly tilled together on-site, and shall be capable of infiltrating water without prolonged ponding on the surface. If such ponding occurs, organic compost and sand must be added and re-tilled until infiltration performance is enhanced. A 2-inch layer of shredded bark mulch (not bark dust or bark chips) shall be used over the amended soil and between the plantings to completely cover the soil and prevent erosion or weed intrusion.

Organic Compost
Organic compost shall have the following properties:
- 100% shall pass a ½-inch screen.
- pH between 5.5 and 7.0.
- Carbon nitrogen ratio between 20:1 and 35:1 (35:1 CN ratio recommended for native plants).
- Organic matter content between 40 and 50 percent.

Organic compost may consist of the following:

Mushroom Compost- The used bedding material from commercial mushroom production.

Composted Yard Debris- Commercially manufactured material, made from dead plant material such as grass clippings, weeds, green and dead dry leaves, garden and vegetable material, and ground branches of trees and shrubs. Furnish a product that is composted under controlled aerobic decomposition, with the internal temperature reaching $57°C$ ($135°F$) for 15 days, without exceeding $68°C$ ($155°F$). Ensure that it contains a maximum of 10% bacteria and 10% fungus.

Peat Moss- Horticultural grade, natural peat moss in air-dry condition, free from woody substances, in bales or bags labeled for content and volume. Only peat moss used in combination with one of the above composts is acceptable.

Gravelly Sand
Gravelly sand shall be free of organic material, contaminants, and hazardous materials, and shall conform to the following gradation:

U.S. Sieve Size	Percent Passing
2-inch	100
¾-inch	70-100
¼-inch	50-80
No. 40	15-40
No. 200	0-3

Mixing
Mix compost, sand, and native soil to a homogeneous consistency. Do not mix compost, sand, and native soil in the rain or wet conditions.

Storage
Store stockpiles of organic soil mix in a manner that prevents them from becoming wet from rain, stormwater runoff, or other sources of water, or contaminated by fine soil or other undesirable materials. All stockpiles of mixed soil material shall be protected and covered.

Placement
Place amended soil mix in rain gardens and stormwater planters in lifts not exceeding 6 inches in loose thickness. After all lifts have been placed, grade soil to finish grades as specified on the plans. Do not over compact soil mix with mechanical equipment after placement.

Mulch
Shredded bark mulch (not bark dust or bark chips) shall be used in a 2-inch layer minimum over the amended soil mix and between the plantings to completely cover the soil and prevent erosion or weed intrusion.

Infiltration Testing
Wet the surface of the rain garden or stormwater planter with a sprinkler or hose until saturated. Small rain gardens and planters (<100 square-feet in surface) area can be tested full-scale, while large rain gardens and planters can utilize isolated falling head tests (minimum 2 per 100 square-feet of area). Fill the testing area to a depth of 4-inches and track the time it takes to completely draw down. Repeat test 3 times. If the water in any of the tests fails to draw down in less than an hour, add compost and gravelly sand to the mix and re-till. Repeat this procedure until favorable test results are achieved.

Appendix C:
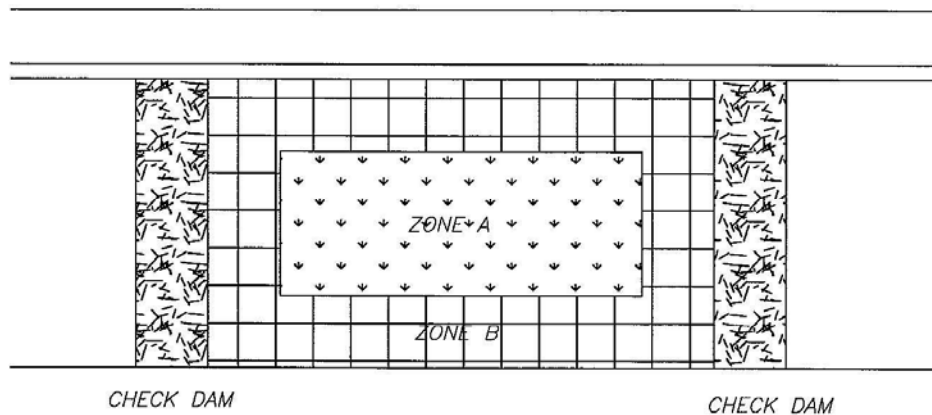
Example Planting Plans

EXAMPLE PLANTING PLANS

The following is an example planting plan for a rain garden, using plant species that have demonstrated good survival rates and low maintenance needs in the seasonal wet and dry conditions present.

Rain Garden Planting Plan

RAIN GARDEN PLANTS

ZONE	BOTANICAL NAME	COMMON NAME
A	CAREX APERTA	COLUMBIA SEDGE
A	CAREX DENSA	DENSE SEDGE
A	CAREX PANSA	
A	CAREX TESTACAE	NEW ZEALAND ORANGE SEDGE
A	CAREX TUMILICOLA	FOOTHILL SEDGE
A	DESCHAMPSIA CAESPITOSA "NORTHERN LIGHTS"	TUFTED HAIR GRASS
A	ELEOCHARIS PALUSTRIS	CREEPING SPIKE RUSH
A	JUNCUS BALTICUS	BALTIC RUSH
A	JUNCUS EFFUSUS "CARMEN'S JAPANESE"	COMMON RUSH
A	JUNCUS EFFUSUS "GOLD STRIKE"	COMMON RUSH
A	JUNCUS EFFUSUS "CARMAN'S GRAY"	COMMON RUSH
A	JUNCUS PATENS	SPREADING RUSH
B	ARCTOSTAPHYLLOS UVA-URSI	KINNICKINNIK
B	BLECHNUM SPICANT	DEER FERN
B	CORNUS SERICEA VAR. KELSEYII	DWARF REDTWIG DOGWOOD
B	LIRIOPE MUSCARI "BIG BLUE"	BIG BLUE LILY TURF
B	GAUTHERIA SHALLON	SALAL
B	MAHONIA NERVOSA	LOW OREGON GRAPE
B	MAHONIA REPENS	CREEPING OREGON GRAPE

PLANT 1 GALLON POTS 18" ON CENTER IN EACH ZONE. A MINIMUM OF 3 SPECIES SHALL BE USED IN EACH ZONE.

PERENNIAL ACCENT PLANTS AND BULBS MAY BE PLANTED SPORADICALLY THROUGHOUT RAIN GARDEN TO ADD SEASONAL COLOR AND VARIETY.

ZONE A

ZONE B

CHECK DAM   CHECK DAM

RAIN GARDEN TYPICAL PLAN VIEW

The following are example planting plans for stormwater planters, using plant species that have demonstrated good survival rates and low maintenance needs in the seasonal wet and dry conditions present.

Stormwater Planter Planting Plan Option A

Species	Pot Size	Diameter at Maturity	Coverage at Maturity (ft^2)	# of Plants*	Total Coverage (ft^2)
Grooved Rush	1 gallon	18"	1.8	10	18
Variegated Tufted Hair Grass	1 gallon	12"	0.8	10	8
Blue Oat Grass	1 gallon	24"	3.1	20	62
Orange New Zealand Sedge	1 gallon	18"	1.8	10	18
			Total:	**50**	**106**

* Number of plants per 100 square-feet of stormwater planter surface area

Stormwater Planter Planting Plan Option B

Species	Pot Size	Diameter at Maturity	Coverage at Maturity (ft^2)	# of Plants*	Total Coverage (ft^2)
Grooved Rush	1 gallon	18"	1.8	10	18
Grooved Rush	4 inch	18"	1.8	10	18
Variegated Tufted Hair Grass	1 gallon	12"	0.8	15	12
Variegated Tufted Hair Grass	4 inch	12"	0.8	5	4
Blue Oat Grass	1 gallon	24"	3.1	5	15.5
Blue Oat Grass	4 inch	24"	3.1	5	15.5
Orange New Zealand Sedge	1 gallon	18"	1.8	10	18
			Total:	**60**	**101**

* Number of plants per 100 square-feet of stormwater planter surface area

We'll Plant It Program

For rain gardens and stormwater planters in the public right-of-way (Green Streets), developers may take advantage of the City of Gresham's *We'll Plant It Program*. Under this program, the developer shall pay the City a planting fee (to be calculated by the City based on the square-footage of planting area) with the public works permit application. Rather than planting the Green Street facilities during street construction and maintaining them for the standard 2-year maintenance and warranty period, the developer shall install erosion control fabric over the graded facilities. The City will then plant the facilities after development on the private lots has occurred, and will take immediate responsibility for maintenance. If this option is selected, a planting plan is not required to be shown on the permit plans.

Rain Garden Planting Plan

Accent Perennials & Bulbs
(used sporadically throughout rain garden area)

Boxleaf Euonymus,
Euonymus japonica 'Microphylla'
Size: 18" tall and wide,
evergreen.

Sword Fern,
Polystichum munitum
Size: 2' tall, 4' wide, evergreen

Creeping Oregon Grape,
Mahonia repens
Size: 18" tall, 3' wide, evergreen

Daffodil,
Narcissus spp.
Size: 18" tall, medium
spring bloom.

Iris spp.
Iris
Size: 24" tall, med/late
spring bloom.

Sedges, Rushes, & Grasses
(designed to cover rain garden area at maturity)

Grooved Rush,
Juncus patens
Size: 18" tall and wide, evergreen

Blue Oat Grass,
Helictotrichens sempervirens
Size: 24" tall and wide,
evergreen.

Carex testacea,
Orange New Zealand Sedge
Size: 18" tall and wide, semi-
evergreen.

Variegated Tufted Hair Grass,
Deschampsia caespitosa 'Northern Lights'
Size: 12" tall and wide, evergreen