Grants Pass Stormwater Management Manual

Grants Pass
LIVE ROGUE
Oregon

KELLER ASSOCIATES

March 2018

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The purpose of this document is to provide detailed implementation guidance to stakeholders in Grants Pass, Oregon (City). Although this is a technical document, every effort has been made to write in non-technical and clear language so that planners, designers, engineers, landscape architects, architects, developers, contractors, maintenance staff, field crews, and other watershed stewards in both the public and private sectors can develop, redevelop and retrofit more environmentally sound and cost-effective sites.

Implementing a Low Impact Development (LID) site is similar to conventional development in many ways; however, the main difference is that the site's natural and built conditions drive decisions. Site design should lead with stormwater considerations as a primary programmatic element. Interdisciplinary collaboration can provide perspectives and knowledge that can streamline the development process and result in less costly sites than conventional development. This document has been adapted by the City to account for the natural variations in rainfall, soils, and other considerations specific to the City. The LID Implementation Forms (described in more detail below) are a critical tool in this guidance that steps users through the chapters and appendices that provide the essential information needed to avoid costly mistakes and poorly functioning sites. The general structure of the document is described below:

Chapter 1 introduces the concept of low impact development as one solution to improve water quality in the City by defining it, offering a brief history of stormwater management, documenting benefits, summarizing the Best Management Practices (BMPs), offering critical information on the intersection of LID with Department of Environmental Quality (DEQ) regulations such as the Underground Injection Control, and discussing costs of LID.

Chapter 2 covers the applicability of a project to this document and the requirements to meet landscaped area, water quality, and flow control management requirements.

Chapter 3 details the LID site development process through planning, design, construction, and maintenance. Early interdisciplinary collaboration and communication are the foundation of implementing cost-effective and environmentally effective BMPs. Planners, designers, contractors, and maintenance staff each play unique but interwoven roles in impacting or protecting water quality.

Chapter 4 provides detailed guidance for each BMP through the planning, design, construction and maintenance project phases, as well as BMP-specific cost considerations. A quick reference table (Table 4-1) helps guide the user to determine what each BMP can manage, what sizing approaches can be used, and if infiltration testing is required. BMPs are grouped into categories: those that limit disturbance, those that minimize impervious area, those that manage the rainfall that lands on them, those that manage runoff directed to them, and those that improve water quality of runoff without significantly reducing its quantity (See Appendix G for BMP Suitability Matrix).

Chapter 5 provides instructions on completing the LID Implementation Forms, which defines a hierarchy of BMPs and steps the planner or designer can use to size BMPs. The LID Implementation Forms, provided in Excel format are a companion document to this Chapter.

Chapter 6 provides instructions to complete and file the Operations and Maintenance Agreement Form, which documents who will be responsible for BMP maintenance, what specific maintenance activities are needed, where the BMPs are located on a site map, and legal language.

Chapter 7 presents on-site source controls for managing site specific sources of pollutants. The implementation of this chapter is in addition to the water quality and flow control measures required.
Appendix A is a checklist of site planning reports and specific information for what should be included in each report, so that the proper scope of work to implement LID sites is known.

Appendix B describes design criteria and construction and maintenance techniques common to multiple BMPs to ensure proper function. Permit submittal requirements detail minimum information to be included on plans. This section also describes approved hydrologic modeling approaches.

Appendix C provides detailed information on infiltration testing, which is required to cost-effectively select and implement many of the BMPs. Included is a Simplified Sizing Approach Infiltration Testing Form and a data entry form for meeting submittal requirements.

Appendix D clarifies the materials specifications for a variety of components specified in the BMPs such as gravel, compost, impermeable liners. It also includes detailed specifications (i.e. both materials and installation) for constructing porous asphalt pavements and using structural tree soil underneath pavement.

Appendix E describes important considerations when choosing plants and lists approved plants.

Appendix F includes standard details for most BMPs included in this guidance, as well as supporting infrastructure.

Appendix G is the BMP Suitability Matrix. BMPs are grouped into categories: those that limit disturbance, those that minimize impervious area, those that manage the rainfall that lands on them, those that manage runoff directed to them, and those that improve water quality of runoff without significantly reducing its quantity

HOW TO USE THIS GUIDANCE DOCUMENT

This guidance document provides detailed planning, design, construction, and maintenance information on best management practices (BMPs) that treat stormwater runoff on-site and reduce runoff volumes to protect water quality and reduce flooding downstream. This document is accompanied by the LID Implementation Forms in Excel format that can be used to size BMPs.

Your LID project will be most successful and cost-effective if you examine the site holistically, considering stormwater and natural resources from the beginning and incorporating a few BMPs, rather than simply adding one or two large stormwater facilities at the end of the site planning process (***Figure 1-1***).

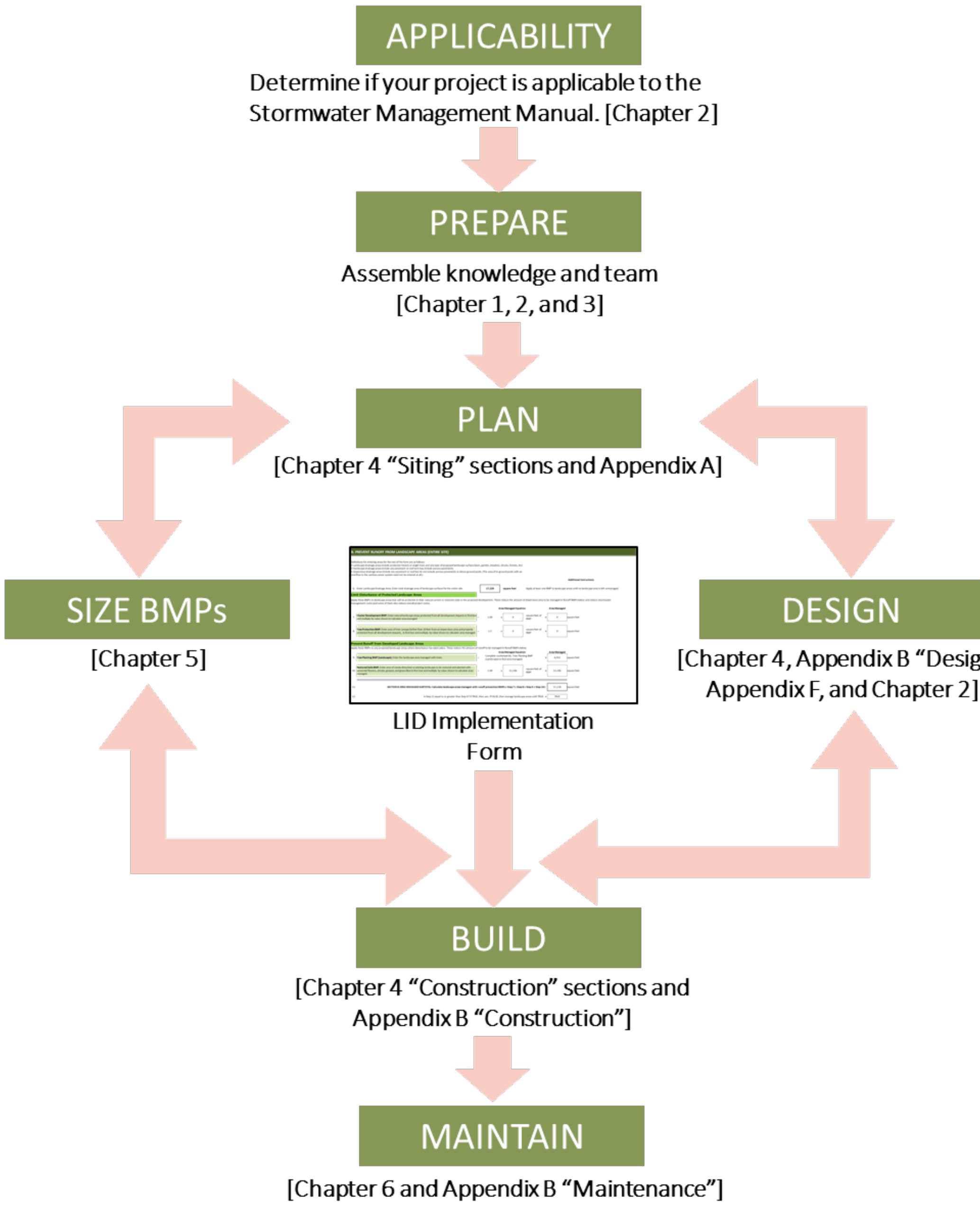


Figure 1-1. General approach to using this guide

APPLICABILITY: Determine if your project is applicable to the Stormwater Management Manual

Review Chapter 2: Applicability & Requirements

- Review section "*Applicability*" to determine if your project must follow the Stormwater Management manual requirements.

PREPARE: Educate yourself and assemble your team

Review Chapter 1: Overview of Stormwater and Low Impact Development

Learn:

- How runoff volumes impact water quality.
- Which BMPs may need authorization from DEQ as Underground Injection Controls.
- Early interdisciplinary collaboration and communication are the foundation of implementing cost-effective and environmentally-effective BMPs. Planners, designers, contractors, and maintenance staff each play unique roles in impacting or protecting water quality.

Review Chapter 2: Applicability & Requirements

Familiarize yourself with the requirements of the two BMP sizing approaches, the Simplified Sizing Approach and the Engineered Design Approach. Reviewing this section is critical in determining what will be required to size and design BMPs. This section will also allow the user to determine if a licensed engineer is required and if a qualified professional will be required for infiltration testing. The user can also determine how to meet requirements for landscaped area, water quality, and flow control management.

Learn:

- What BMP sizing methods are required and what they involve.
- "*Stormwater Management: Water Quality*": Determine what water quality is and how to manage it.
- "*Stormwater Management: Flow control*": Determine what flow control is and how to manage it.

Review Chapter 3: Understanding the LID Process

Thinking about stormwater earlier allows more effective strategies to be used throughout a site and adds efficiency to development. Because stormwater regulations are newer and less familiar than plumbing and building codes, a strategy for stormwater management is often not thought about until the end of planning or construction. This chapter provides some tools and insight on processes and describes the important roles members of the development team play in creating an LID site (described below):

- The LID Planning Process: Checklists, site planning steps
- The LID Design Process: Plans submittal requirements
- The LID Construction Process: The importance of protecting soil permeability and using erosion prevention and sediment control measures
- The LID Operations and Maintenance Process: Maintenance responsibility, tasks for maintaining impervious and landscape surfaces, writing a plan

Review Chapter 4: Specifics on the Recommended Best Management Practices (BMPs)

Review detailed siting, design, construction, and maintenance on BMPs. Choosing the "best" BMPs maximizes efficiency, cost-savings and effectiveness of the stormwater management component of development and redevelopment. This chapter offers specifics on each BMP that will be important to consider as the LID Implementation Forms provide a process of how best to reduce runoff and clean stormwater.

- Limit Disturbance BMPs (Conserve Fast(er) Draining Soils, Cluster Development, Tree Protection, Minimal Excavation Foundations, Construction Sequencing)
- Minimize Impervious Area BMPs (Share parking spaces, Minimize Front Setbacks, Share a Driveway)
- Restored Soil BMP
- Tree Planting BMP
- Depave Existing Pavement BMP
- Contained Planter BMP
- Vegetated Roof BMP
- Porous Pavement BMP
- Rain Garden, Stormwater Planter, and LID Swale BMPs
- Soakage Trench BMP
- Drywell BMP
- Water Quality Conveyance Swale
- Dispersion BMPs (Vegetated Filter Strip, Downspout Dispersion)
- Wet, Extended Wet, and Dry Detention Pond BMP

PLAN YOUR SITE

- ✓ Use **Chapter 3** and **Appendix A**. Consider your site holistically and consider where you might best place stormwater management facilities and which natural resources could be preserved.
- ✓ Review the Site Suitability Matrix **Table G-1, Appendix G**. This table indicates which BMPs are suitable for a variety of conditions (e.g. relative stormwater management effectiveness, site conditions, land uses).
- ✓ Use the "Siting" sections under each BMP in **Chapter 4**. Locate facilities carefully, according to the guidance provided.
- ✓ **Appendix C**. Test your site's infiltration rate to find fast(er) draining soils. Later, test your soil's infiltration rate in any locations where infiltration facilities will be installed.

SIZE YOUR BMPs

Work through **Chapter 5** using the Step-by-Step LID Implementation Form. This is where the information in the rest of the manual all comes together. Test drive the form and refer back to the other chapters and appendices as resources to locate and design the stormwater BMPs:

1. Open the Excel file "*LID Implementation Form*".
2. **IMPORTANT!** Refer to **Chapter 5** for instructions and criteria to complete the LID Implementation Form and worksheets.
3. Have a licensed engineer design BMPs if simplified sizing factors can't be used and when criteria in **Chapter 2** "*Stormwater Management: Water Quality*" and "*Stormwater Management: Flow Control*" require it.
4. Complete a first draft of the LID Implementation Form, preferably in the early planning phase.
5. Revisit and modify the LID Implementation Form:
    a. If all surfaces have not been managed by BMPs. Redesign the site and strategies, as feasible.
    b. If the site layout has changed.
6. Finalize the construction plans and the LID Implementation Form and submit for permits as described in **Chapter 3** "*The LID Design Process*".

DESIGN YOUR BMPs

- ✓ Use **Chapter 4** and the standard details in **Appendix F** to design your BMPs. Paying attention to these details can help ensure your facilities will be easy to maintain and effective over the long term.

- ✓ Use **Appendices B and D** to specify materials and methods of placement. Clearly describing the best materials and how they should be installed is an important step in creating construction documents.

BUILD YOUR BMPs

- ✓ Refer to **Chapter 3** "The LID Construction Process", **Chapter 4** See "*Construction*" sections, and **Appendix B** "*Construction*". This will help ensure your stormwater facilities are properly built and/or planted. Clear and frequent communication between the designer and the construction team is essential for success.

MAINTAIN YOUR BMPs

Use **Chapter 6**: Operations and Maintenance Agreement. Once the LID Implementation Form has documented the BMPs for the site, the operations and maintenance information specific to each can be compiled into a legal form suitable for filing with the appropriate jurisdiction. Information includes:

- Identification of who is responsible for paying and performing maintenance
- BMP-specific maintenance activities to perform

GLOSSARY

AASHTO H-20 — The design load needed to design pavement sections that will support tractor-semi-trailer combinations, which are assumed to weigh 40,000 pounds.

approved discharge point — A location where overflow from a BMP may be directed, which includes a surface infiltration facility; storm drain or other conveyance system; a waterway (as approved by the Oregon Department of State Lands), or an underground injection control facility (as approved by the Oregon Department of Environmental Quality).

bedrock — A hard, solid rock surface that may underlie fragmented/decomposed rock and soil. Considered an impervious surface.

Best Management Practice (BMP) — "A device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters."[1]

Cation Exchange Capacity (CEC) — "The amount of exchangeable cations that a soil can adsorb at pH 7.0 expressed in terms of milliequivalents per 100 grams of soil."[2] An adequate CEC in soil contributes to pollutant treatment.

contained planter BMP — A container with plants placed over an impervious surface intentionally implemented to reduce runoff and prevent or reduce pollution.

contaminated soils — Soils at sites where contaminants have accumulated because of historic activities, not necessarily limited to industrial sites. Contaminated sites have a highly regulated development path with additional permitting. Coordination with the local DEQ cleanup program is advised.

conveyance swale: — Long, open channel that conveys stormwater runoff, but may not provide substantial water quality treatment due to a lack of tall, structured plants to slow flows. These are not considered LID BMPs. An example of a conveyance swale is a rock lined roadside ditch.

detention basin: — A large depression in the ground where runoff is stored and released slowly. Detention basins are used to reduce flooding but have been found to be less effective at protecting downstream

[1] *U.S. Environmental Protection Agency. Preliminary Data Summary of Urban Stormwater Best Management Practices. Retrieved from: https://www3.epa.gov/npdes/pubs/usw_a.pdf*

[2] *Puget Sound Partnership. (2012). Low Impact Development Technical Guidance Manual for Puget Sound. Retrieved from: http://www.psp.wa.gov/downloads/LID/20121221_LIDmanual_FINAL_secure.pdf*

water quality. The Environmental Protection Agency now prefers low impact development BMPs, which reduce flooding and improve downstream water quality[3]. Because detention basins do not reduce runoff and have been found to pollute water with temperature, scouring, and changing flows that impact streams, detention basins are not considered an LID BMP.

dispersion — Spreading stormwater over a landscape area designed to treat runoff.

downspout disconnection — A form of dispersion that directs a building's roof drains to a lawn or garden instead of into stormwater pipes.

drywell — A well, assemblage of perforated pipes, or drain tiles that receive runoff and infiltrate that runoff underground.

evaporation — The process of water changing from a liquid to a gas. Evaporation is a significant portion of the annual water cycle that reduces runoff in undeveloped and/or forested areas of Western Oregon.

evapotranspiration — The collective term for the process of water returning to the atmosphere via interception and evaporation from plant surfaces and transpiration through plant leaves[2].

green street — Any BMP or collection of BMPs receiving runoff from and located in a public right-of-way. This term may refer to trees, vegetated filter strips, rain gardens, stormwater planters, vegetated roofs (e.g. bus stop shelters), and porous pavement.

invasive plants — Aggressive plants that outcompete native plants for water, sunlight and nutrients and therefore harm the environment, economy and human health.

impervious surface — A surface that prohibits water from soaking into the ground. Examples include roofs, concrete, asphalt, pavers, compacted gravel, compacted clay, plastic liners, and clogged landscape fabric.

landslide or landslide area — "The downslope movement of rock, soil, or related debris."[4] This term includes areas that already experienced a landslide and landscapes that have the potential to slide in the future.

level spreader — A strategy to spread flows evenly over a surface to reduce erosion and improve treatment as runoff enters a BMP.

LID swale — Long, planted, open channel that conveys stormwater runoff and is designed and constructed to promote infiltration.

limit disturbance BMP — Any BMP that protects a site or portion of a site in its current, natural vegetated state and/or protects soil permeability.

Low Impact Development (LID) — A pattern of land development that preserves natural resources and promotes opportunities to manage stormwater where it falls. LID relies on a collection of carefully selected techniques to reduce, receive, and clean stormwater runoff to protect and improve water availability and quality.

minimal excavation foundation BMP — A foundation type that allows groundwater to move freely through soil (not pipes) underneath the building (e.g. pier foundations and buildings with crawl spaces).

minimize impervious area BMP — Any BMP that reduces land area not able to infiltrate or evaporate rainfall or runoff as a result of being covered by buildings, roofs, and roads, parking lots and sidewalks.

mulch — Material such as compost, bark or wood chips spread on soil to retain moisture, discourage weeds and protect against wind and rain erosion.

mycorrhizae — The mycelium (roots) of a fungus.

mycorrhizal — "The symbiotic association of the mycelium (roots) of a fungus with the roots of a seed plant."[2]

native plants — Plants that occur historically in an area. If planted in conditions they naturally occur, these

---

[3] *U.S. Environmental Protection Agency. (2009). Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. Retrieved from: http://www.epa.gov/sites/production/files/2015-09/documents/eisa-438.pdf*

[4] *Oregon Department of Geology and Mineral Industries. Landslide Hazards in Oregon. Retrieved from: http://www.oregongeology.org/sub/Landslide/Landslidehome.htm*

plants need little or no fertilizer or care once established and provide wildlife habitat.

non-native (ornamental) plant — Plants that do not occur historically in an area, which may not be invasive, but also may not provide wildlife habitat.

new development — Any project where the land cover is changed from a natural, pre-developed state into another land cover.

pervious — See: porous

permeable — See: porous

predevelopment or predeveloped condition — The naturally vegetated land cover and contour (i.e. shape and slope) that would historically have been on a site prior to any construction.

porous — A material that allows water to pass through it.

porous pavement — Surface to walk, drive or park on that reduces stormwater runoff by allowing water to soak into the ground (i.e. permeable pavers, pervious concrete, porous asphalt, flexible paving systems and porous gravel).

post-development or post-developed condition — The land cover on a site as a result of development activities, which may include but is not limited to buildings, roads, sidewalks, ornamental, and working and protected landscapes.

qualified professional (infiltration testing)- A qualified professional for performing infiltration includes a Professional Engineer, Registered Geologist, Soil Scientist or other professional testing service with equivalent training and experience in determining the permeability of soils.

rainfall management — Use of BMPs to treat and reduce the volumes of stormwater leaving a site by infiltrating or evaporating rain that falls directly on the surface of the BMP. Examples of rainfall management facilities include restored soils, vegetated roofs, and contained planters. When rainfall management BMPs are used, they are referred to as "Runoff Prevention BMPs".

rain garden — A "sunken garden bed" with gentle side slopes that collects and treats stormwater runoff by ponding runoff and passing it through soils and plants. A rain garden does not function like a wetland nor is it considered a wetland for regulatory purposes.

redevelopment — Any project where existing land cover, which was previously developed, is changed to another land cover.

restored soil — The practice of amending disturbed soils (i.e. any soil in an urbanized area) to restore permeability and support plant establishment.

retrofit — Any project that improves water quality from an existing developed area.

runoff — Rainfall and snowmelt that flows off of a land surface instead of seeping into the ground or evaporating in the air. Runoff can carry pollutants to waterways.

runoff management — Using BMPs to treat and reduce the volumes of stormwater leaving a site by infiltrating or evaporating runoff collected and/or channeled from other areas to the BMP. Examples of runoff management facilities include rain gardens, stormwater planters, and LID swales. When runoff management BMPs are used, they are referred to as "Runoff Reduction BMPs".

runoff prevention BMP — Any BMP that reduces the volume of runoff leaving a site by evaporating and/or infiltrating rainfall that falls directly on it.

runoff reduction BMP — Any BMP that decreases the volume of runoff leaving a site by evaporating and/or infiltrating runoff directed to the BMP from another area.

runoff treatment — Use of BMP(s) to treat runoff. More desirable treatment BMPs also reduce runoff. Less desirable treatment BMPs allow treated runoff to leave the site. Examples include lined rain gardens, lined stormwater planters and lined LID swales.

run on – runoff from beyond the project boundary.

soakage trench — an excavated trench filled with coarse stone that receives runoff and stores it until it infiltrates underground into surrounding soils.

stormwater planter — A structural container (either above or sunken into the ground) with vertical side slopes and a flat bottom that collects and treats stormwater runoff, primarily from rooftops, driveways, sidewalks, parking lots, and streets by ponding runoff and passing it through soils and plants.

Total Maximum Daily Load (TMDL) — An analysis and written quantitative plan for attaining and maintaining water quality standards in a stream. It includes a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet state water quality standards, allocations of portions of that amount to the pollutant sources or sectors, and a Water Quality Management Plan to achieve water quality standards.

treatment soil — A naturally occurring or engineered mix which may include clay, silt, sand, gravel, compost, microorganisms, and mycorrhizae that has the desired physical and chemical properties needed to clean stormwater as it passes through it.

tree planting — to install a new tree in a permanent location that provides adequate soil volume and other site conditions to meet its long-term health needs.

tree protection — to preserve trees by fencing, limiting soil compaction, guarding from animal damage and other practices.

watershed — An area of land delineated by a ridge that causes water to drain to different rivers, ponds, lakes, seas, or oceans.

water quality conveyance swale — Long, planted, open channel that conveys stormwater runoff. These facilities are generally not designed to promote infiltration. Instead, they are designed for conveyance and sometimes detention, providing some water quality treatment.

wetland — An area that has surface water or saturated soils often enough to create unique soil characteristics that support vegetation that is adapted to inundation and saturation and lacks vegetation that is intolerant of inundation or saturation. Directing stormwater to wetlands is not considered a low impact development BMP.

urbanized — Any watershed where publicly or privately-owned land surfaces in a city, town, or rural area have been developed and cause that watershed to be 5% or more impervious. (This is definition differs from that used by the United States Census Bureau.)

Underground Injection Control (UIC) — "A manmade structure that places fluid underground"[5].

vegetated filter strips — A dispersion BMP that manages runoff flowing onto it from pavement and roof surfaces.

vegetated roof — A roof system with plants that reduces runoff, improves air quality, provides wildlife habitat, and saves energy. Vegetated roofs **can** last longer than conventional roofs.

vegetated stormwater facilities — This is a general term that applies to rain gardens, stormwater planters, and LID swales, which are configured differently, but achieve a similar, high level of treatment and runoff reduction through intentional temporary ponding of water.

[5] *Oregon Department of Environmental Quality. Frequently Asked Questions on UICs. Retrieved from:* *http://www.deq.state.or.us/wq/uic/faqs.htm#What_is_a_UIC_System*

CHAPTER 1: INTRODUCTION TO LOW IMPACT DEVELOPMENT

The purpose of this guidance is to provide an informed and methodical approach to manage stormwater using Low Impact Development (LID) to preserve or mimic the natural hydrologic cycle and achieve water quality goals.

WHAT IS LOW IMPACT DEVELOPMENT?

Low impact development is a pattern of land development that preserves natural resources and promotes opportunities to manage stormwater where it falls. LID relies on a collection of carefully selected techniques to reduce, receive, and clean stormwater runoff to protect and improve water availability and quality. The Puget Sound Partnership defines LID as "a stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project design.[6]" LID may also be referred to as Green Infrastructure, Green Development Practices, or Alternative Storm Water Management Systems.

Figure 1-2. Traditional development versus low impact development patterns on a residential subdivision, where each site has 110 lots. Parcels are clustered to preserve valuable existing trees and reduce impervious areas, cut and fill are significantly reduced, and relatively small-scale, BMPs are distributed throughout the site to manage rainfall and runoff where it is generated.

[6] *University of Washington, College of Environment. Urban Forestry/Urban Greening Research. Green Cities: Good Health. Retrieved from : http://depts.washington.edu/hhwb/Thm_Livable.html*

WHAT IS A BMP?

The EPA defines a best management practice (BMP) as "a device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters." Despite widespread use of "best" to describe these practices, these practices can be ineffective if improperly applied. LID, by definition, uses several BMPs together (i.e. not a single BMP). BMPs must be selected appropriately based on site opportunities and constraints and project objectives. They must also be applied during the appropriate phase(s) of the project. Some BMPs may play an important role during multiple project phases.

For example, tree protection requires careful consideration at key points (see **Chapter 4** for more information on how to protect trees throughout the process):

- Planning: Layout the site to avoid impacts to valuable trees.
- Design: Minimize grading around trees, route utilities around trees, and include fenced protection zones on the plans.
- Construction: Maintain tree protection zones and call an arborist when cutting roots.
- Maintenance: Limit compaction, prune appropriately and apply integrated pest management techniques to support the health of the tree.

BMPs may be incorporated into existing as well as newly built developments and redevelopments. Since LID includes an array of BMPs like site planning to minimize loss of vegetation, impervious area, and runoff generation, LID is generally applicable on all sites and for all land use classification (e.g. residential, commercial, industrial, institutional, etc., see ***Table G-1***).

TYPES OF BMPS

One aspect of LID is the distribution of BMPs applied through the site, which can be thought of in several different ways. Perhaps the most significant distinction is whether a BMP prevents runoff in the first place (i.e. runoff prevention BMP) or manages runoff from existing, new, or redeveloped surfaces (i.e. runoff reduction BMP).

Runoff Prevention BMPs

Runoff prevention BMPs may be either good decisions that protect or restore a site (e.g. “narrow streets” and “open space” in ***Figure 1-2***) or reduce the volume of runoff leaving a site by evaporating and/or infiltrating rainfall that falls directly on it. These restoration and protection practices are often employed during the early planning phase and appear during subsequent project phases.

Relative Effectiveness: High
Relative Cost: Low to High

Runoff Reduction BMPs

Runoff reduction BMPs, on the other hand, decrease the volume of runoff leaving a site by evaporating and/or infiltrating runoff directed to the BMP from another area. They tend to be engineered or highly designed facilities that mitigate the damage created by changing the land cover from more porous to more impervious. Runoff reduction strategies can be used in retrofit, redevelopment and new construction projects and should be considered only after all potential runoff prevention BMPs have been considered and applied. Runoff reduction BMPs are considered low impact development because they promote infiltration and evapotranspiration, rather than just treatment and flood water storage and release.

Relative Effectiveness: Low to Moderate
Relative Cost: Higher than runoff prevention BMPs but typically less than or equivalent to conventional

stormwater BMPs

BMPs Detailed in this Guidance

Refer to the BMP Suitability Matrix (***Table G-1***) for information on which BMPs are runoff prevention and which are runoff reduction types. Some are both, depending on the design. **Chapter 4** provides detailed implementation guidance on BMPs.

Limit Disturbance: Conserve Fast(er) Draining Soils BMP. This practice helps planners locate hardscapes such as roofs and sidewalks to site areas that drain slower, leaving a higher functioning landscape area to manage rainfall and runoff.

Figure 1-3. Infiltration testing identifies faster draining soil areas at the site scale (see Appendix C), regardless of soil type.

Limit Disturbance: Cluster Development BMP. Cluster development is a BMP usually applied on a campus or subdivision scale that groups development on one place of the site and leaves undeveloped open space on another *(**Figure 1-2**).*

Limit Disturbance: Tree Protection BMP. This preserves trees by fencing, limiting soil compaction, guarding from animal damage and other practices. Trees capture rain, filter pollutants, provide shade and cool air, improve air quality and provide habitat.

Limit Disturbance: Minimal Excavation Foundation BMP. This is a foundation type that allows groundwater to move freely through soil (not pipes) underneath a building (e.g. pier foundations and buildings with crawl spaces). Groundwater flows are a natural and necessary element of predevelopment hydrology and keep streams running weeks or months after a rainfall event. The pores in the soil beneath a building with minimal excavation foundations provide temporary storage for rainfall and flowing groundwater. When this storage is reduced by basements and underground parking structures that exclude groundwater, runoff increases.

Figure 1-4. Foundations with little to no excavation can reduce runoff from large storms and from areas with high groundwater tables.

Limit Disturbance: Construction Sequencing BMP. During the design phase, consider where materials are stored, for how long, and how they are transported to that area, as well as how they are protected from the rain to make construction easier and reduce water pollution during construction.

Minimize Impervious Area BMPs:

- In public rights-of-way
- In other areas (*e.g.* share parking spaces, minimize front setbacks, share a driveway)
- In public right-of-ways & other areas (depave, reduce pavement through planning and design)

Restored Soils BMP. This is the practice of amending disturbed soils (i.e. any soil in an urbanized area) to restore permeability and support plant establishment. Soils are compacted during construction and maintenance operations, sometimes to a similar density (or hardness) as concrete. If soils are left in a compacted state, landscape areas become sources of runoff.

Contained Planter BMP. Contained planters placed over hard surfaces intercept rainfall and reduce runoff through evaporation.

Figure 1-5. Contained planters can be placed on the ground or over impervious surfaces to intercept rainfall and reduce runoff through evaporation.

Tree Planting BMP. New trees reduce runoff from both impervious and landscape areas and become more effective stormwater management facilities as they grow over time.

Vegetated Roof BMP. Vegetated roofs are an assembly of materials that intercept rainfall and reduce runoff through evaporation.

Figure 1-6. A vegetated roof at Sequential Biofuels in Eugene. Credit: Derek Godwin

Porous Pavement BMP. Porous pavement (also known as permeable or pervious pavement) is a pedestrian or vehicular pavement that allows rainfall to enter and be stored in the void spaces within the pavement and eventually infiltrate into underlying soils.

Figure 1-7. Permeable pavers are just one option for porous pavements to infiltrate rain as soon as it falls.

Rain Garden BMP. A rain garden may be any vegetated depression in the ground where runoff is directed for treatment. The geometry of rain gardens incorporates gently sloping sides and a relatively flat bottom.

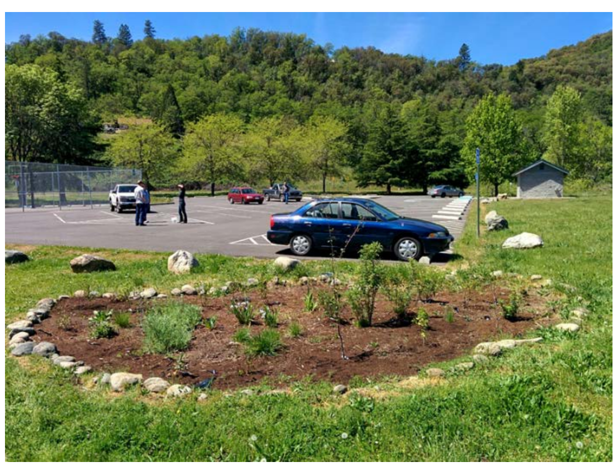


Figure 1-8. A rain garden manages runoff from this park's parking lot.

Stormwater Planter BMP. Stormwater planters are sometimes referred to as a rain garden in a box. The only significant difference between the two is that stormwater planters have vertical sides created by structural elements, such as walls or deep curbs.

Figure 1-9. A series of stormwater planters treat runoff from roofs and sidewalks at a university.

LID Swale BMP. An LID Swale is a vegetated long, linear facility that ponds and infiltrates runoff during small storms.

Figure 1-10. Where parking lots already have planting-island requirements, LID Swales can easily and cost-effectively be integrated into an existing or proposed landscape footprint.

Soakage Trench BMP. A soakage trench is a shallow, underground rock gallery where stormwater is stored until it infiltrates (primarily) out of the bottom.

Drywell BMP. A drywell is a deep, vertical underground structure with perforations that stores stormwater until it can infiltrate out the sides.

Water Quality Conveyance Swale BMP. A water quality conveyance swale is similar to an LID swale but has no structures that pond water. Instead, stormwater flows freely through the facility.

Dispersion BMP. A dispersion BMP spreads stormwater over a landscape area designed to treat runoff and may be either a vegetated filter strip or a downspout disconnection. A vegetated filter strip is an area covered in vegetation that receives sheet flow runoff from impervious surfaces located at ground level. Disconnecting a downspout directs runoff from a roof to a landscape area instead of allowing your water to flow quickly off-site via the storm drain. In many rural areas, where pipe infrastructure is limited, downspout disconnection is a common dispersion practice.

Figure 1-11. This street beautification project also manages runoff as it sheet flows from the roadway to the planted strip. This is a great example of how LID principles can be incorporated into a community without adding cost.

Wet ponds are constructed with a permanent pool of water (commonly referred to as pool storage or dead storage). Stormwater enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biological processes. When the sizing criteria is followed, pollution reduction requirements are presumed to be met. Additional facilities may be required to meet flow control requirements, as applicable.

Extended wet ponds are also constructed with a permanent pool of water but have additional storage above that fills during storm events and releases water slowly over several hours. The permanent pool is sized to provide pollution reduction, and the additional storage above (extended detention area) is sized to meet flow control requirements. Pollutants are removed from stormwater through gravitational settling and biological processes. When the sizing criteria are followed, pollution reduction requirements are presumed to be met. The extended detention must be designed using acceptable hydrologic modeling techniques (see **Appendix B** and **Chapter 2**) to meet applicable flow control requirements.

Dry detention ponds are designed to fill during storm events and slowly release the water over several hours. Dry detention ponds must be designed using acceptable hydrologic modeling techniques (see Appendix B) to meet applicable flow control requirements. Additional facilities are required to meet water quality requirements, unless the bottom flow path of the pond is designed as a swale according to the swale sizing and design criteria.

A VERY BRIEF HISTORY OF STORMWATER MANAGEMENT

Water Quality

For a long period after the industrial revolution, communities didn't manage stormwater at all. In the 1970s, several events, such as the Cuyahoga River catching fire, attracted attention to the very low water quality in some of our nation's waterways. Regulations to reduce pollutant discharges from industrial activities and wastewater treatment plants greatly improved water quality; however, even after significantly addressing these pollution sources, waterways were still polluted. Scientists and regulators discovered that every land surface exposed to rain can contribute pollutants to our waterways.
LID evolved as a way to manage runoff from these widely distributed land surfaces.

Water Quantity

Flooding was recognized as an issue and in the 1970s the Soil Conservation Service developed a methodology that they believed would reduce flooding. They encouraged the construction of detention basins that were designed to delay peak flows from large or intense storm events. As the science of watershed hydrology evolved, scientists found that detention basins are not as beneficial for water quality. More information is provided on this in subsequent sections.

In addition to flooding, over time, communities noticed that their wells were running dry; the historical patterns of development (paving vast areas for cars, building roofs, and reducing the permeability of soils) kept rainfall from entering the soil to recharge the aquifer. LID also evolved as a way to reduce flooding and recharge the aquifer.

WHY USE LOW IMPACT DEVELOPMENT?

There are several reasons to use LID:

- It can be more cost-effective to build and maintain than conventional stormwater facilities such as detention basins and pipes.
- Reduces water pollution, which supports the health and welfare of our communities with improved drinking water quality[7], reduced water treatment costs[8], and cleaner waterways that provide recreational and economic opportunities.
- Will reduce localized flooding during storms (where flooding did not historically already take place) by mimicking predevelopment hydrology patterns
- This is the most accepted path to meeting your community's water quality goals, which may be defined by a National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit or the Total Maximum Daily Load (TMDL) program. In 2009 the EPA wrote, "Until recently, stormwater programs established to address water quality objectives have been designed to control traditional pollutants that are commonly associated with municipal and industrial discharges, *e.g.*, nutrients, sediment, and metals. Increases in runoff volume and peak discharge rates have been regulated through state and local flood control programs. Although these programs have merit, knowledge accumulated during the past 20 years has led stormwater experts to the conclusion that conventional approaches to control runoff are not fully adequate to protect the nation's water resources."

---

[7] *U.S. Environmental Protection Agency. Water: Green Infrastructure. Retrieved from:* *http://water.epa.gov/infrastructure/greeninfrastructure/gi_why.cfm*
[8] *Ernst, C. (2004). Protecting the Source. Retrieved from:* *http://syracusecoe.org/EFC/images/allmedia/LIBRARYProtectingtheSource_TPLAWWA2004.pdf*

Protecting Water Quality by Addressing Water Quantity

In undeveloped areas, rainwater or snowmelt does not run off the land as much as it does in urbanized towns and cities. Trees, plants and soil capture much of the precipitation, and about half of it evaporates back into the air (Puget Sound Partnership 2012). Most of the precipitation that doesn't evaporate or get captured by vegetation soaks into the ground where soil and microbes remove pollutants naturally. The water slowly recharges streams, wetlands and groundwater. In Western Oregon, studies have shown that as low as 0.5% of our average annual rainfall becomes runoff in a predeveloped condition. Similarly, the EPA has found that, in an average year, only 5% of the nation's storms (the largest ones) generate runoff from land in a predeveloped condition[9].

The natural hydrologic cycle described above is radically changed when land is developed in the way it has been for decades. Typical development clears the land of vegetation and covers it with hard surfaces such as roads, parking lots and rooftops and impacts the porosity of vegetated areas, too. Construction and foot traffic compact soils, so that even landscaped areas can generate unnaturally high runoff volumes. Lawns are only 10-50% as permeable as forest soils, meaning 50 to 90% of rain that falls on lawns runs off. Storm drains are installed to get water out of the way by sending it into local streams, oceans, or lakes without treatment. Development dramatically increases runoff volumes, which even when controlled by detention basins, can cause flooding, damage to fish and wildlife habitat, scour stream channels, and deliver pollutants such as oils and pesticides to local waterways. The decreased infiltration results in less cool, clean groundwater to recharge streams in the dry summer months and a reduction in water availability throughout the watershed.

Reducing runoff has two significant water quality benefits. It reduces the amount of pollution delivered to downstream waterways, and reduces stream bank erosion, so more soil along stream banks stays where it is, instead of polluting the waterway.


Figure 1-12 (left). Typical example of urbanized creek down-cutting, with associated bank destabilization, loss of riparian vegetation, and sedimentation resulting from high peak flow rates and volumes of stormwater runoff.

Figure 1-13 (right). Historical, non-LID development patterns generate higher runoff volume. LID reduces localized and regional flooding.

[9] *U.S. Environmental Protection Agency. (2009). Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. Retrieved from:* http://www.epa.gov/sites/production/files/2015-09/documents/eisa-438.pdf

Water Quality & Pollutant Sources

Preventing pollution is a primary objective of LID. While the term “stormwater infrastructure” is often thought of as the conveyance system of inlets, conveyance pipes and ditches, culverts, and outlets, all areas that drain to that system also convey rainfall across their surfaces, with the potential to pollute groundwater and surface waterways. Roofs are considered relatively clean. Sidewalks are generally considered moderately clean, but not as clean as roofs. Vehicular surfaces (e.g. roads, driveways, parking lots) and landscapes are considered high sources of pollution.

In natural areas, water quality impacts come mostly from air deposition of pollutants such as mercury and particulates, derived from activities such as dust from farming and construction operations, burning coal, and pesticide use.

Developed areas have many of these same depositional pollutants, as well as a much wider range of pollutants:

- Particulates/sediment (Total suspended solids, turbidity)
- Heavy metals (e.g. zinc, copper, mercury)
- Bacteria
- Polyaromatic hydrocarbons (PAHs)
- Temperature
- pH
- Mossicides
- Runoff volume
- Pentachlorophenol (utility poles)
- Fertilizers (phosphorus, nitrogen, nitrites, nitrates) (landscapes only)
- Pesticides and herbicides (landscapes only)

There are many opportunities to reduce these pollutants by changing how we design, construct, and maintain these surfaces. LID can be used effectively to treat a variety of stormwater pollutants. BMPs in this guidance may help reduce flow volumes leaving the site and may reduce the concentration of one or more of the following pollutants: sediment, trash, heavy metals, nutrients, pesticides and toxic chemicals, and bacteria through on-site treatment in the systems themselves and by reducing runoff volume flowing from the site.

Sometimes, it is desirable to reduce a particular pollutant. If a BMP is not particularly good at removing a pollutant, information is provided in the introduction of that BMP’s detailed description in **Chapter 4** to prevent this BMP from being used inappropriately. In this case, use a BMP with a demonstrated ability to remove that particular pollutant. Sometimes, a BMP in this guidance may simply be modified to provide the desired removal. For instance, nitrogen is effectively removed when water is passed through a layer of soil with no oxygen (i.e. anaerobic conditions), so a modification to the rain garden designs here could be performed by a licensed engineer with experience in designing rain gardens.

Figure 1-14. Water quality is important to the life that lives in streams, but humans also rely on clean water for drinking, recreation, and economic security.

UNDERGROUND INJECTION CONTROLS OVERVIEW

Underground Injection Control (UIC) facilities are regulated by the Oregon Department of Environmental Quality and may include any stormwater facility that infiltrates directly into the soil subsurface. UICs must be authorized by DEQ before they are constructed. UICs include drywells and soakage trenches where runoff is "injected" into the subsurface via perforated manholes or pipes. These techniques may be incorporated into LID designs with authorization by DEQ. Aside from single family residence roof drain infiltration, there are several things about a detail of these infiltration facility types that could require authorization by the Oregon DEQ.

The following figures are reprinted from a DEQ 2014 publication[10]:

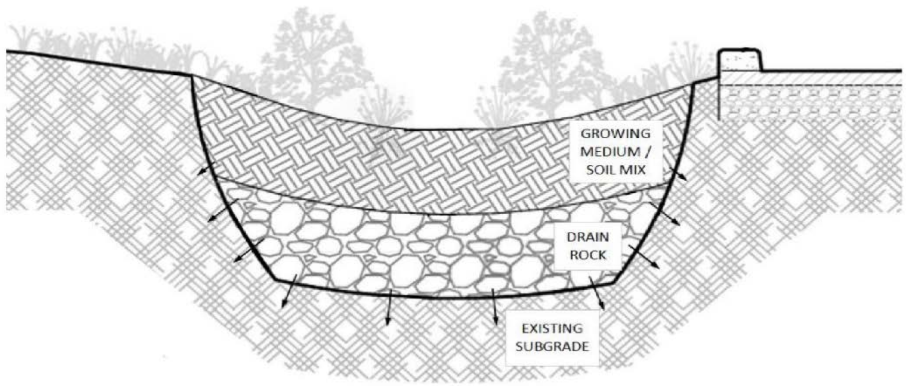


Figure 1-15. Use of drain rock storage area is not a UIC. Image courtesy of DEQ.

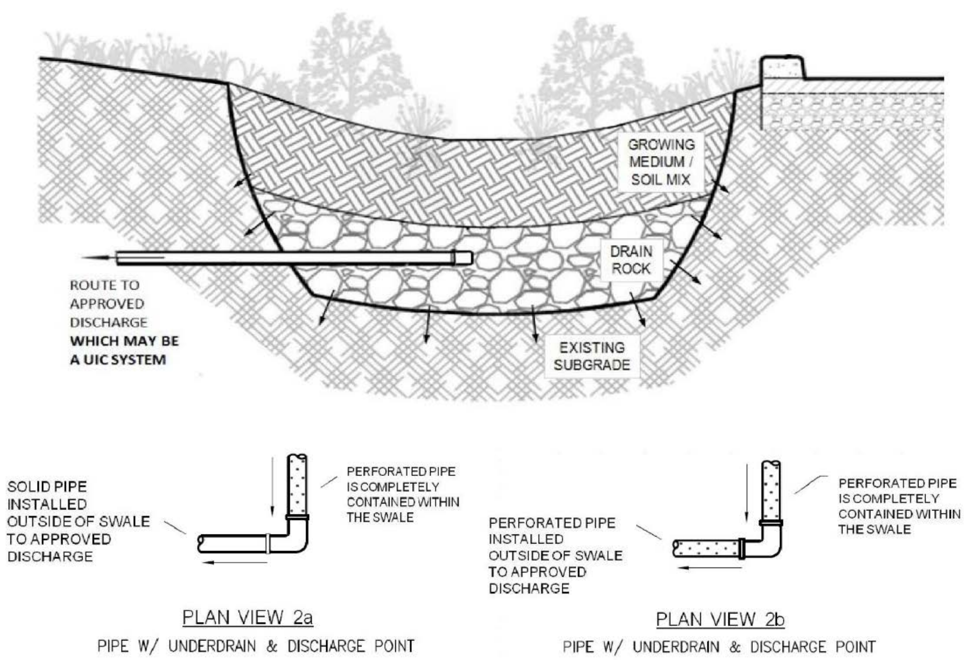


Figure 1-16. A swale with a perforated pipe (located in the drain rock where only the very edge/bend of it is illustrated) is not a UIC if a solid pipe (plan view 2a) discharges to a waterway, sewer system, or other above ground approved discharge point. If a perforated pipe (plan view 2b) is used for conveyance to the approved discharge point, it will discharge stormwater into the subsurface; therefore, the perforated pipe itself is a UIC.

[10] *"Identifying an Underground Injection Control". (2014). Retrieved from: http://www.deq.state.or.us/wq/pubs/factsheets/uic/IDswInjSysFS.pdf*

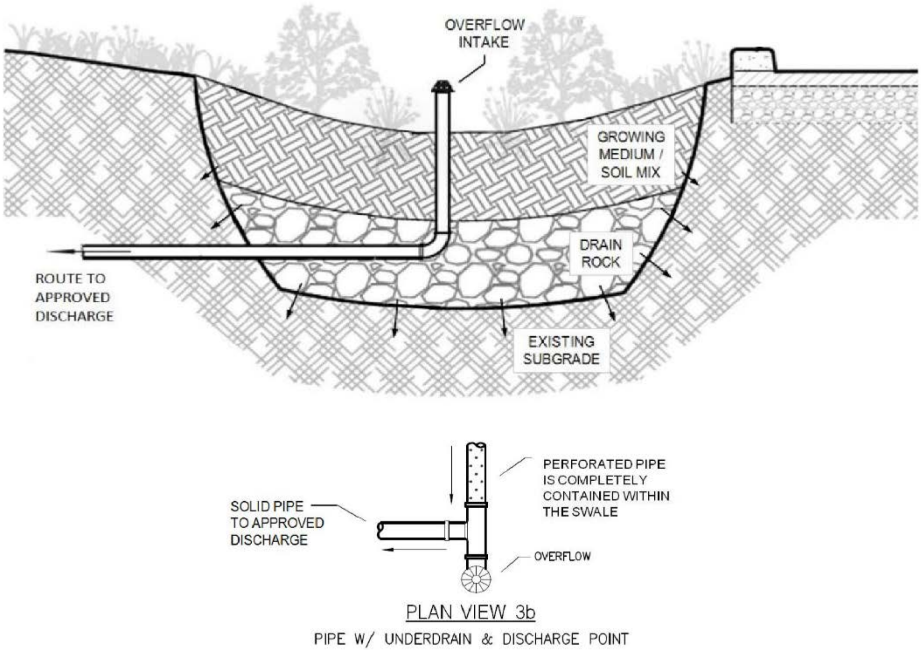


Figure 1-17. If perforated pipes only collect and convey stormwater, and the perforated pipes are located within the swale, then the swale is not considered to be a UIC. (Plan View 3b) The perforated pipe runs the length of the swale, collects stormwater, and conveys the stormwater to an approved discharge. This is not a UIC.

The rule authorization process should be followed, including requirements for pretreatment prior to discharge to a UIC. For example, in *Figure 1-18*, the lined rain garden (with 18" of soil) does not infiltrate but provides pretreatment prior to discharge through a non-perforated pipe that drains to a drywell, also underground.

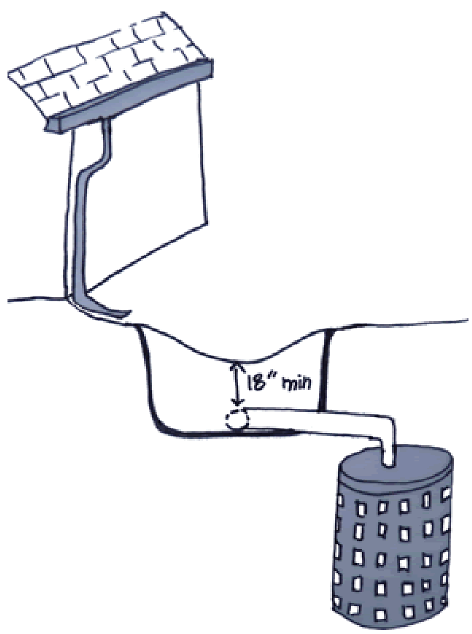


Figure 1-18. A lined rain garden provides the required pretreatment for a regulated UIC such as a drywell.

More information on permitting UICs can be obtained from the DEQ website on the Underground Injection Control Permit program[11] and in relevant sections in **Chapter 4.**

[11] *DEQ website on the Underground Injection Control Permit program: http://www.deq.state.or.us/wq/uic/uic.htm*

COMMUNICATION DURING THE LID PROCESS

The LID site development process builds on the traditional approach to site design, which must examine the regulatory framework and the client's programmatic needs but expands that process to capitalize on existing natural and built resources from the site planning phase, through the design, construction, and maintenance phases. This section provides useful information on the overall LID process, providing an overview of the project management that might be performed by the planner, designer, contractor, maintenance staff, scientist, and anyone else who might work on a new development, redevelopment, or retrofit project. (See **Chapter 4** for specific guidance on implementing BMPs.)

Planning

The LID implementation process begins with analysis of the site and incorporates steps to involve local decision makers early in the process. A Site Assessment Checklist *(Appendix A)* and the BMP Suitability Matrix *(**Table G-1**)* are two decision-making tools that might be visited and revisited through the site planning process.

Forming an integrated project team is a crucial step in creating low impact development sites. The integrated project team should include consultants and contractors to be used throughout the project, chosen and engaged at the planning stage.

By engaging the entire team early in the process to identify practices that can be synergistically used to do more than one thing on the project, the final project costs can often match or be lower than those of a conventionally built project. A common mistake that can make LID more costly than necessary is not assessing the maintenance capability (budget, available equipment) of the future staff or landowner during the planning phase. **An operations and maintenance agreement must be made with the City in the initial planning stage** (See "*Maintenance*" section of this chapter for more information).

Many of the disciplines represented on a typical site development team have overlapping opportunities to address water quality and quantity during the design phase. Specialists on your project may include an architect, geotechnical engineer, contractor, mechanical, electrical, and plumbing engineer, wetland scientist, arborist, landscape architect, licensed engineer, biologist, landscape contractor and facility manager. For examples of how these disciplines might impact runoff volume (see ***Table 2-1)***.

Design

Modeling and permit drawings will detail the long-term blend of runoff prevention and runoff reduction BMPs during the planning phase. Hydrologic modeling, which for most BMPs has been simplified by the LID Implementation Form described in **Chapter 5**, will test the assumptions about feasibility made during the planning phase.

Figure 1-19. Permeable pavers are a beautiful amenity at the Red Hills Market in Dundee, OR.

Design is an iterative process that often includes a schematic design and a design development phase that results in a bid/permit drawing set. As various members of the team make changes to the site plan, multiple refinements of the drawing set, hydrologic model, cost estimate, and other deliverables will be needed. Interdisciplinary communication in the design phase occurs via regular meetings, calls, and emails; however, another important means of communication is via the plan set. Every discipline contributes some impact to the site that is likely to need to be addressed to meet water quality regulatory requirements, so careful review of every site plan during the various schematic and design development phases is critical.

Figure 1-20. Rain gardens (back left) were integrated with other infrastructure in the public right-of-way to create an attractive and welcoming streetscape on the Rogue River Highway (OR-99) in Grants Pass, OR.

Construction

The construction phase has many opportunities to implement runoff prevention BMPs. If a facility is properly designed but improperly constructed, the facility is more likely to pollute the stormwater further instead of protecting it.

The team should continue their collaboration by keeping each other informed and asking questions throughout the construction phase. Surveys are an imperfect representation of the real world. In disputes or disagreements, all parties should come to the table with an open mind and good intent, assuming others are doing the same.

Common difficulties faced by contractors include:

- **Meeting the specifications**: Finding material to meet the specification can be challenging. The material may be unfamiliar or difficult to source. Before substituting an alternative, contractors should ask for help in finding suppliers. The contractor should be wary of assuming that one product is equivalent to another and substituting it without prior approval.
- **Constructability**: Engage the general contractor in the planning and design phases to ensure that creative solutions are actually buildable.
- **Buy-in from sub-contractors**: While the general contractor may be on board with the water quality goals of a project, sub-contractors may not have had as much involvement on the project. Hold a pre-construction meeting with the planners, designers, general contractor and sub-contractors to clarify the water quality goals, their importance and how the contractor and sub-contractor can help meet the goals in their normal operations.

Maintenance

Proper operations & maintenance (O&M) of BMPs in the final project phase will dictate whether the intended long-term benefits are realized. The ability, preference, and available equipment of the maintenance staff and/or land owners should be considered when choosing BMPs. Low maintenance BMPs like restored soil should always be considered first, since the maintenance phase is the costliest and longest of all the development phases.

Figure 1-21. This catch basin has so much sediment a shrub is growing in it.

During the project's initial planning phase, the City maintenance staff and/or person(s) responsible for maintenance as agreed to in the O&M agreement contract in **Chapter 5** must be consulted to identify practices that they are most likely to use. BMPs and their components may need to be tailored to the available maintenance equipment, and maintenance staff input will be key in the design phase. When these steps are left out, facilities are often improperly maintained or modified to make maintenance easier, both of which are likely to impact the function of the facility in unexpected and possibly polluting ways.

CHAPTER 2: APPLICABILITY & REQUIREMENTS

TABLE OF CONTENTS

CHAPTER 2: APPLICABILITY & REQUIREMENTS

APPLICABILITY

All proposals related to development and redevelopment that create **more than or equal to 2,500 square feet of new or replaced impervious surface**, both public and private, within Grants Pass City limits must follow the standards of the Grants Pass Stormwater Management Manual (GPSWMM). This requirement applies to the total amount of impervious surface that will be developed or redeveloped at full build-out of the project. For every project, the impervious area includes the total proposed impervious area, including, but not limited to, buildings and structures, streets and frontages, and driveway aprons and sidewalks. Best Management Practices (BMPs) must manage runoff from all landscaped and hardscaped areas for the project site. Single family residential improvements that are not part of a new subdivision are exempt from these requirements.

BMP SIZING METHODS

This section summarizes two methods for sizing BMPs: The **Simplified Sizing Approach** and the **Engineered Design Approach**. BMPs sized with the Simplified Sizing Approach comply with the City's water quality and/or flow control standards when their respective sizing factors are used (**Chapter 5**) and when requirements are met for using the Simplified Sizing Approach. When the Engineered Design Approach is used, it is up to the project designer to demonstrate that the requirements in this document are met. Refer to sections, "*Stormwater Management: Water Quality*" and "*Stormwater Management: Flow Control*" for requirements on both sizing methods.

Project designers must select the Simplified Sizing Approach or Engineered Design Approach to design stormwater facilities. Each approach has a unique plan review and approval process that establishes a review and approval track for the project. The final selection of a project design approach is subject to City approval. The City may require use of a different approach upon review of site conditions and technical constraints. Some stormwater facility types require use of a specific design approach. A combination of approaches may be used for a single project, but the review and submittal requirements will be that of the more intensive approach.

Simplified Sizing Approach

The Simplified Sizing Approach is available for projects with less than 10,000 square feet (0.23 acre) of total new or redeveloped impervious area on private property, including but not limited to roofs, concrete, asphalt, pavers, compacted gravel, compacted clay, plastic liners, and clogged landscape fabric. Sizing may be performed by the landowner or any other qualified licensed professional or contractor. This approach is most appropriate for small-scale residential development, typically with limited professional design services available. It is not allowed for use on large, complex projects or on projects that have multiple catchments that, when combined, exceed 10,000 square feet of new or redeveloped impervious area. It is not allowed on projects that include the public right of way or are a Public Improvement (Municipal Code). BMPs sized with the Simplified Sizing Approach may require the Engineered Design Approach upon review by the City.

Projects that use the Simplified Sizing Approach use a simple calculation to size stormwater facilities (also called BMP). To size stormwater facilities, the project designer first quantifies the amount of new or redeveloped impervious area that is proposed. The portion of this area that would drain to a BMP is multiplied by a sizing factor that varies by BMP type. Sizing factors were developed for select BMPs (***Table***

2-1) as ratios of the BMP area to the impervious area draining to it as shown below.

$$Sizing\ Factor = \frac{BMP\ Footprint}{Impervious\ Area\ Draining\ to\ BMP}$$

BMPs are applied until all impervious area is managed for both water quality and flow control. The stormwater management facility sizing factors were developed with analysis shown in **Appendix B**. **Chapter 5** discusses how to use the Low Impact Development Forms and Worksheets to size BMPs using the Simplified Sizing Approach.

All BMPs designed with the Simplified Sizing Approach require an overflow to an approved discharge location. The Simplified Sizing Approach requires at least one infiltration test to be conducted before selecting and sizing stormwater management facilities (see **Appendix C** Infiltration Testing). Infiltration testing may be performed by the landowner or any other qualified licensed professional or contractor when using the Simplified Sizing Approach. All requirements for the simplified sizing approach must be met as defined in **Chapter 2**. An infiltration testing form must be submitted to the City before constructing BMPs (refer to **Appendix C**).

Engineered Design Approach

When any of the conditions for the Simplified Sizing Approach are not met, the Engineered Design Approach must be used to size BMPs for water quality and flow control management. The Engineered Design Approach may also be required as determined by the City Engineer. The Engineered Design Approach requires a licensed engineer to design BMPs based on the criteria in Sections "*Stormwater Management: Water quality*" and "*Stormwater Management: Flow Control*". Submission of the **Chapter 5** LID forms are not required with this design approach.

Selecting a Design Approach

Figure 2-1 below shows a logic tree for selecting the proper sizing methodology. The user will first determine if the manual applies to their project based on the footprint of new or replaced impervious surface area the project will create. If it is determined the manual is applicable to the designer's project, a sizing approach will need to be selected. If all the conditions in the "*Simplified Sizing Approach*" section and **Chapter 2** requirements are met, then the Simplified Sizing Approach may be used at the discretion of the City Engineer. Otherwise, the Engineered Design Approach must be used to size BMPs.

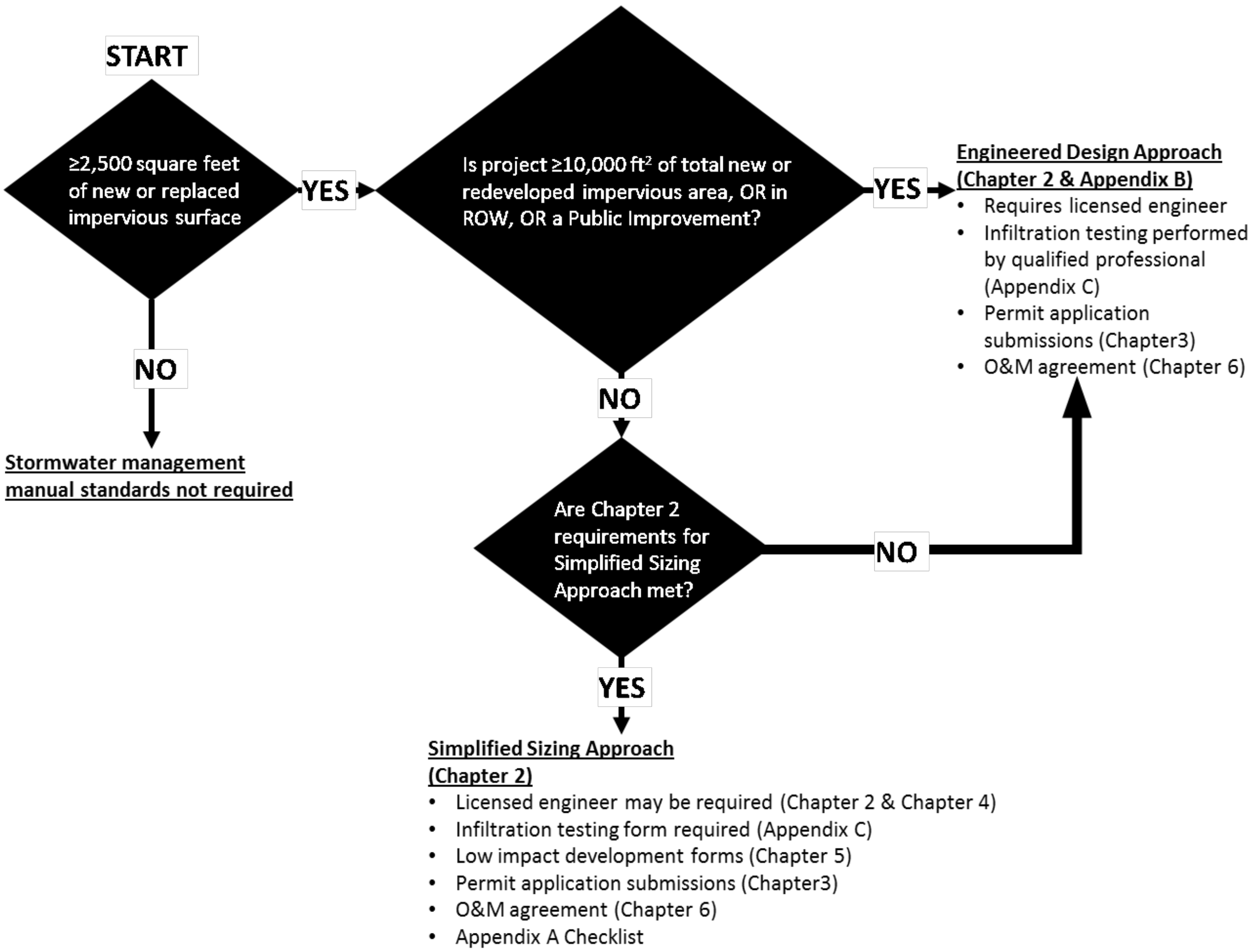


Figure 2-1. Logic tree for selecting sizing methods.

STORMWATER MANAGEMENT

Three factors need to be managed for each project:

- **Landscaped area management**
- **Water quality management**
- **Flow control management**

Landscaped areas include protected forests or single trees and any type of proposed landscape surface (lawn, meadow, shrubs, forests, and similar). Managing landscaped drainage areas can reduce the amount of impervious area to be managed and reduce the amount of runoff to manage. Water quality management is designed to reduce runoff pollution and mitigate the volume, duration, time of concentration and rate of stormwater runoff from development. Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increases in stormwater runoff peak flow rates and volumes resulting from development. For further details on how to manage these three factors, refer to the rest of **Chapter 2** and **Chapter 5**.

Best Management Practices: Quick Reference Table

The quick reference table (***Table 2-1***) lists what each BMP can manage, what sizing approaches can be used, and if infiltration testing is required. The three factors that need to be managed for applicable sites are landscaped area, water quality, and flow control. Boxes that are gray filled represent which factors can be managed for each BMP when requirements in **Chapter 2** are met. Sizing approaches that can be used to design each BMP are gray filled; white boxes mean the respective sizing approach can either not be used or is not applicable. BMPs that are not applicable for both sizing approaches will have the siting, design, construction, and maintenance requirements in their respective sections within **Chapter 4**.

Table 2-1. Quick reference table for applicable BMP management factors, sizing approaches, and infiltration testing requirements. Refer to respective BMP sections within this chapter for more details.

Best Management Practice (BMP)	Landscaped Area Management	Water Quality Management †	Flow Control Management †	Simplified Sizing Approach	Engineered Design Approach	Is Infiltration Testing Required
Conserve fast(er) draining soils BMP						■
Cluster Development BMP	■					
Tree Protection BMP	■					
Minimal Excavation Foundation BMP		■	■		■	■
Construction Sequencing BMP						
Depave existing pavement BMP		■	■			
Restored Soil BMP	■					
Contained Planter BMP		■	■			
Tree Planting BMP	■	■	■			
Vegetated Roof (Green Roofs) BMP		■	■			
Porous Pavement BMP		■	■		■	■
Rain Garden		■	■	■	■	■
Stormwater Planter		■	■	■	■	■
LID Swale BMP		■	■	■	■	■
Soakage Trench BMP		■	■	■	■	■
Drywell BMP		■	■		■	■
Water Quality Conveyance Swale BMP		■	■		■	■
Dispersion BMP		■		■	■	■
Wet Pond		■	■		■	■
Extended Wet Pond		■	■		■	■
Dry Detention Ponds		■	■		■	■

† Applies when meeting requirements in Chapter 2

■ =YES □ =NO or N/A

SOURCE CONTROLS

Site uses and characteristics such as fuel dispensing, above ground storage of liquids and bulk storage, material transfer areas, loading docks, solid waste storage, and vehicle and equipment washing areas may trigger additional water quality measures. Typical source control measures include covering potential pollutant areas, paving the areas to protect the underlying soils, hydraulically isolating drainage patterns, and containing potential pollutants.

Chapter 7 of this manual will provide details on which measures to implement. The requirements and implementation of this chapter is in addition to the applicable water quality, and flow control requirements.

STORMWATER MANAGEMENT: WATER QUALITY

The purpose of stormwater quality is to reduce runoff pollution and mitigate the volume, duration, time of concentration and rate of stormwater runoff from development by implementing low impact development practices while targeting the capture and treatment of up to the 95th percentile of the annual average rainfall. The 95th percentile rainfall event is the event whose precipitation total is greater than or equal to 95 percent of all storm events over a given period of record. The 95th percentile rainfall event is the measured precipitation depth accumulated over a 24-hour period that ranks as the 95th percentile rainfall depth based on the range of daily event occurrences during a 30-year period[1]. Precipitation records were retrieved from NOAA using data from station "*GHCND:USC00353445*" located in Grants Pass over the dates 01/01/1981 to 12/31/2010. The 95th percentile rainfall event is **1.2-inches in 24-hours for Grants Pass**.

To manage water quality for the project, the following is required:

- All proposed landscaped areas must be managed by landscaped area management BMPs.
- All proposed hardscaped areas must be managed by BMPs sized for at least the water quality storm of 1.2-inches in 24-hours.

Methods of managing landscaped areas

The following BMPs are assigned to manage landscaped areas:

- Cluster Development BMP
- Tree protection BMP
- Restored Soils BMP
- Tree Planting (Evergreen & Deciduous) BMP

Landscaped areas are fully managed when all area is managed by BMPs and relevant **Chapter 5** Forms and Worksheets are completed.

Methods of managing water quality

After addressing landscaped areas, hardscaped areas are managed with runoff prevention, runoff reduction, and other BMPs described in **Chapters 4** and **5**.
(Refer to Table 2-1 for BMPs applicable to landscaped area and water quality management)

Requirements for water quality management methods

1. **Simplified Sizing Approach**: Water quality sizing factors for BMPs may be used when the following requirements are met:
    a. **Chapter 4** conditions for "*Siting*", "*Design*", "*Construction*", and "*Maintenance*" are followed for BMPs being implemented.
        i. Any changes are approved by City Engineer.
    b. Design each BMP with required overflow.
        i. All BMPs must have overflow for the 25-year, 24-hour storm.
    c. Facilities are designed to receive and manage stormwater runoff from contributing impervious surfaces only.
    d. Project site is <10,000 square feet.
    e. Project is on private property only.
    f. Project is not in public right of way.
    g. Project is not a Public Improvement.

[1] *Silva, Peter. Technical Guidance on implementing the stormwater runoff requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. United States Environmental Protection Agency. EPA, 2009.*

   h. All submission requirements are met.
   i. Designs are approved by the City Engineer.

2. **Engineered Design Approach**: BMPs are sized according to the hydrologic conditions in **Appendix B** and meets the following requirements:
   a. Designed by a licensed engineer.
   b. **Chapter 4** conditions for "*Siting*", "*Design*", "*Construction*", and "*Maintenance*" are followed for each BMP being implemented.
      i. Any changes are approved by City Engineer.
   c. Post-development peak flow must be ≤ Pre-development peak flows.
      i. for the water quality storm of 1.2-inches in 24-hours.
   d. Design each BMP with required overflow.
      i. All BMPs must have overflow for the 25-year, 24-hour storm.
   e. Design must follow BMP Implementation criteria in **Appendix B**.
   f. All submission requirements are met.
   g. Designs are approved by the City Engineer.

STORMWATER MANAGEMENT: FLOW CONTROL

Flow control is intended to protect downstream properties, infrastructure, and natural resources from the increases in stormwater runoff peak flow rates and volumes resulting from development. LID's goal is to mimic a site's predevelopment hydrology, where predevelopment conditions are defined as the naturally vegetated land cover and contour (*i.e*. shape and slope) that would historically have been on a site prior to any construction.

The purpose of flow control is to ensure the following for stormwater flows from the site:

- Does not exceed the capacity of the receiving conveyance facility.
- Does not increase the potential for stream bank and channel erosion.
- Does not create or increase any flooding problems.

All proposals related to development and redevelopment that create more than or equal to 2,500 square feet of new or replaced impervious surface **must manage both water quality and flow control**.

The following is required to manage flow control:

- **Post-development peak flow must be ≤ Pre-development peak flows**
  - ❖ For all BMPs including Detention and Retention structures, maintain peak flow rates at or below their pre-development levels for the 2-year, 5-year, 10-year, and 25-year, 24-hour storms.

Applicants may discharge their runoff into off-site stormwater facilities that have capacity or retain or detain flows on-site with an approved infiltration facility.

Flow control is also required for development in areas where the downstream capacity of an open or closed stormwater system is not sufficient to convey the post development flows.

Methods to address flow control

Flow control must be managed to meet the site requirement of "Post-development peak flow must be ≤ Pre-development peak flows". Flow control is addressed by using one or a combination of BMPs until all impervious is managed. To meet the flow control requirements, surface infiltration and filtration facilities are required to the maximum extent feasible. Water can also be managed using runoff prevention from hardscaped areas by implementing BMPs shown in **Chapter 5** under Forms "*C. Prevent Runoff from Hardscape Areas (Entire Site)*" and "*E. Prevent Runoff from Impervious Areas (Basin)*". Siting, design, construction, and maintenance information for runoff prevention BMPs can found in **Chapter 4**.

Separate sizing factors were developed for flow control (**Chapter 5**). **Flow control sizing factors are considered to manage both water quality and flow control when all requirements are met**. Factors were developed using the process summarized in Appendix B. Detention and Retention structures can manage water quality and flow control with the Engineered Design Approach to provide storage capacity and flow control if the other BMPs do not provide adequate flow control.

Detention Facilities
Detention facilities temporarily store stormwater runoff in a pond, tank, vault, or pipe. The water is slowly released from the facility, typically over several hours.

Retention Facilities
Retention facilities also store stormwater runoff. Rather than storing and releasing the entire runoff volume, however, the facility permanently retains a portion of the water on-site, where it infiltrates and recharges the groundwater aquifer, and in the case of surface retention facilities, evaporates or is absorbed and used by surrounding vegetation. Retention facilities reduce the total volume of water released downstream.

Flow control facilities include detention and retention ponds:

- Wet pond
- Wet extended pond
- Dry detention pond

(Refer to Table 2-1 for BMPs applicable flow control management)

Requirements for flow control management methods

1. **Simplified Sizing Approach**: flow control sizing factors for BMPs may be used when the following requirements are met:
    a. **Chapter 4** conditions for "*Siting*", "*Design*", "*Construction*", and "*Maintenance*" are followed for BMPs being implemented.
        i. Any changes are approved by City Engineer.
    b. Design each BMP with required overflow.
        i. All BMPs must have overflow for the 25-year, 24-hour storm.
    c. Facilities are designed to receive and manage stormwater runoff from contributing impervious surfaces only.
    d. Project site is <10,000 square feet.
    e. Project is on private property only.
    f. Project is not in public right of way.
    g. Project is not a Public Improvement.
    h. All submission requirements are met.
    i. Designs are approved by the City Engineer.
2. **Engineered Design Approach**: BMPs are sized according to the hydrologic conditions in Appendix B and meets the following criteria:

a. Designed by a licensed engineer.
b. **Chapter 4** conditions for "*Siting*", "*Design*", "*Construction*", and "*Maintenance*" are followed for BMPs being implemented.
    i. Any changes are approved by City Engineer.
c. Post-development peak flow must be ≤ Pre-development peak flows.
    i. for the 2-year, 5-year, 10-year, and 25-year, 24-hour storms.
d. Design each BMP with required overflow.
    i. All BMPs must have overflow for the 25-year, 24-hour storm.
e. Design must follow BMP Implementation criteria in **Appendix B**.
f. All submission requirements are met.
g. Designs are approved by the City Engineer.

3. **Engineered Design Approach (Detention and Retention structures)**: Wet, extended wet, and dry detention ponds:
    a. Designed by a licensed engineer.
    b. Post-development peak flow must be ≤ Pre-development peak flows.
        i. For the 2-year, 5-year, 10-year, 25-year, 24-hour storms.
    c. Wet, extended wet, and dry detention ponds must safely overflow the 50-year, 24-hour storm shown in Appendix B.
    d. **Chapter 4** conditions "*Detention and Retention structures: Wet, extended wet, and dry detention ponds*" are followed.
    e. Design must follow BMP Implementation criteria in **Appendix B**.
    f. All submission requirements are met.
    g. Designs are approved by the City Engineer.

CHAPTER 3: LID PROCESS

Table of Contents

CHAPTER 3: LID PROCESS

THE LID SITE PLANNING PROCESS[1]

The purpose of this chapter is to illustrate that a variety of parties are responsible for protecting and improving water quality and to provide critical information and tools to achieve water quality goals. This must be done holistically at the site scale, at the BMP scale (see **Chapter 4** "*Choosing and Implementing BMPs*" and Appendices), and at the drainage area scale (see **Chapter 5** "*LID Implementation, Step-by-Step*").

Site Planning Tools

Throughout the planning process, gather information about a variety of conditions. Three tools have been provided for site assessment and design.

Site Assessment Checklist, Appendix A. The Site Planning Checklist includes a comprehensive list of environmental, social, and financial considerations that might direct decision-making about best practices. A set of 6 steps, each with their own checklist items, are critical to the planning phase of low impact development sites. Consider:

1. On-site natural resources
2. On-site infrastructure/built environment
3. Off-site natural resources
4. Off-site infrastructure/built environment
5. Municipal, state, and federal guidelines/laws
6. Programmatic requirements

In each of the steps, the checklist reminds you to look for and log information as it relates to water resources, land forms, air quality, soils, livability, micro- and macroclimate, vegetation, renewable energy, cultural resources, staging and storage considerations, utilities, local suppliers and services, regulations, fire hazards, zoning, and stakeholder process. Additionally, **Appendix A** includes steps for making a site survey plan, infiltration testing report, tree inventory report, and for making a depaving project checklist.

Checklist is required for Simplified Sizing Approach and recommended for the Engineered Design Approach.

BMP Suitability Matrix. A list of the BMPs detailed in this guidance can be found in **Appendix G**, ***Table G-1* BMP Suitability Matrix**. This table serves as a guide for gathering preliminary information to help choose appropriate BMPs for a variety of natural conditions, land uses, and water quality considerations.

- Additional BMPs for protecting Oregon's water resources can be downloaded from the OSU Stormwater Solutions website[2].
- **LID Implementation Form.** The LID Implementation Form (**Chapter 5**) steps users through a preferred stormwater hierarchy, introducing the most preferred BMPs first. The Low Impact Development Worksheets (Excel sheets) remind the user which information is most critical to implementing the BMP and assist with sizing the BMP.

---

[1] *This section adapted from the Southeast Michigan Low Impact Development Manual with permission from the Southeast Michigan Council of Governments.*

[2] *Oregon State University, Outreach & Engagement. Site Planning Check List. retrieved from:* http://extension.oregonstate.edu/stormwater/site-planning-check-list

Steps to Planning an LID Site

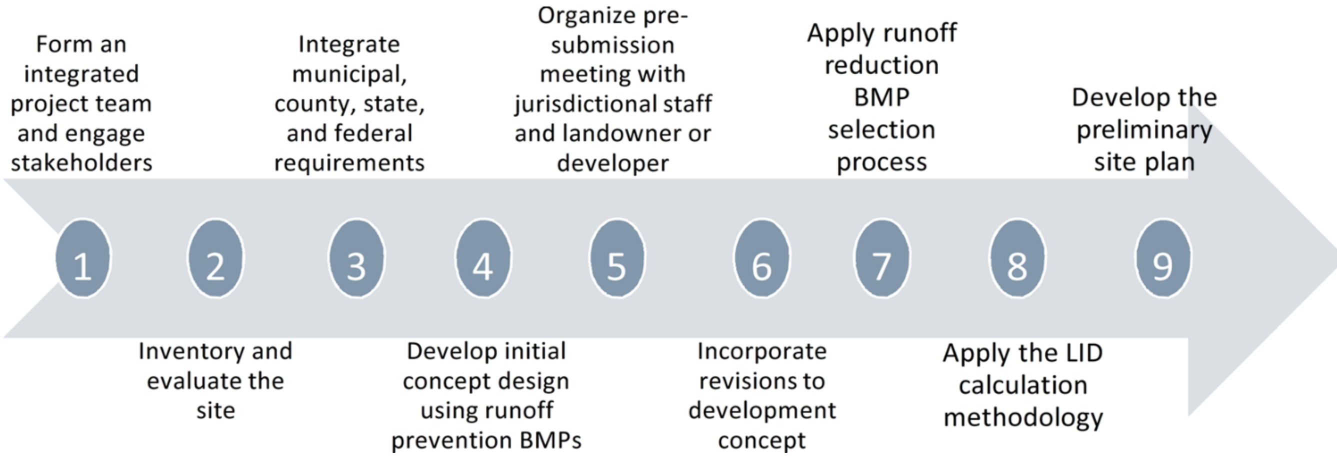


Figure 3-1. The LID site design process could be consolidated into nine basic steps as follows.

Planning Step 1: Form an integrated project team and engage stakeholders.

Table 3-1. Examples showing just a few ways various disciplines might affect water quality and runoff volume during the planning phase of a project with a building. Not all disciplines are needed on every project.

THIS DISCIPLINE:	MIGHT AFFECT RUNOFF VOLUME BY:
Architect	Choosing a building footprint or by stepping the finished floor elevations inside the building to reduce cut and fill on-site.
Geotechnical Engineer	Determining site suitability for infiltration. Infiltration rates of soils impact structural facility feasibility and sizing; however, non-structural practices may still be employed.
Contractor	Ensuring the design is within budget and constructible without causing damage to natural features intended to be protected.
Mechanical, Electrical, and Plumbing Engineer	Locating the sanitary, storm, and water main connections at the building exterior, which can limit where infiltration facilities are located.
Wetland Scientist	Delineating wetlands, which may be used to disperse stormwater if appropriate, but may limit application of LID practices. Wetland scientists can also help ensure that appropriate plants are chosen for the facility based on the calculated flood frequency and water depth.
Arborist	Performing an analysis of tree health to determine hazard trees and make recommendations for trees to be protected. A tree risk assessment will offer information such as preventative and remedial actions, tree related conflicts, tree defects in the crown, branches, trunk, root collar, and roots.
Landscape Architect	Responding to programmatic needs that generate impervious surfaces associated with roofs, driveways, parking lots, or sidewalks, or that generate semi-pervious surfaces such as lawns. Reduce runoff by locating trees and BMPs in the remaining landscapes and choosing low maintenance plants that will not require pesticides or herbicides.
Licensed Engineer	Prioritizing LID development facilities that improve water quality by reducing runoff and avoiding flow-based only facilities that allow excess volumes to leave the site.
Biologist	Identify threatened and endangered species on-site or provide guidance on soil restoration techniques.
Landscape Contractor	Installing vegetated stormwater facilities, protecting soils and porous surfaces through careful stockpiling of materials.
Facility Manager	Providing input on available maintenance equipment and current techniques so maintainable BMPs are implemented.

Figure 3-2. A stormwater planter and permeable pavers enhance the RCC/SOU Higher Education Learning Center in Medford, OR. All of the disciplines listed in Table 3-1 might have a stake in this design.

Planning Step 2: Inventory and evaluate the site. Site assessment includes inventorying and evaluating various natural resources that may pose challenges and/or opportunities for stormwater management and site development. Natural resources include floodplains, riparian areas, wetlands, natural and human-made drainage ways, soils and topography, geology, groundwater supplies, and vegetation. Mapping these resources in relationship to one another is one of the most helpful ways to understand the existing site-scale resources to identify places to build desired infrastructure. Although mapping at the watershed-scale may be outside the scope of most projects, understanding watershed-scale opportunities and constraints, such as the quality of receiving waters or the source of uphill run-on to your site, is also important.

See the items under the headings "*Consider regional natural resources*" and "*Consider regional infrastructure/built environment*" in the "*Site Assessment Checklist*" in **Appendix A**. Included are suggestions for information that might be needed in early site investigation reports including a site survey, an infiltration testing report, and a tree assessment report.

Planning Step 3: Integrate municipal, county, state, and federal requirements. Stormwater is regulated through multiple local, state, and federal regulatory organizations. The following are just a few of the most common jurisdictions you should be aware of when applying for a permit:

- **City**. Grants Pass can help you navigate requirements. Contact Public Works at (541-450-6110).

Figure 3-3. In accordance with the Fairview Masterplan, an existing ordinance in Salem, the Pringle Creek Community implemented numerous BMPs on a site with clayey soils and high groundwater. Pictured here are pervious concrete, porous asphalt, vegetated roofs, a preserved tree grove, and new trees.

- **State of Oregon**. The Oregon Department of Environmental Quality (DEQ) has jurisdiction over water quality at the state level.
  - The DEQ Water Quality Permitting program limits pollution allowed in stormwater discharges from sites in communities (Municipal Separate Storm Sewer System (MS4)), under construction (1200-C or 1200-CN), industrial activities (1200-A, 1200-Z, and 1200-COLS) and through individual permits[3].
  - Underground Injection Control (UIC)[4] Program" is responsible for regulating the construction, operation, permitting, and closure of injection wells that place fluids underground for storage or disposal."
  - The Oregon Department of State Lands regulates work in wetlands and waterways through the Removal-Fill Permit[5] "to protect public navigation, fishery and recreational uses of the waters".
  - The DEQ 401 Water Quality Certification program evaluates federal actions (like US Army Corps of Engineers permits) that impact waters of the state to certify that state water quality standards, policies and programs are met[6].
- **United States of America**. For in-stream work, US Army Corps of Engineers permits[7] are "necessary for any work, including construction and dredging, in the Nation's navigable waters"[21].

Refer to the heading "*Consider municipal, state, and federal guidelines/laws*" in the "*Site Assessment Checklist*" in **Appendix A.**

---

[3] *Oregon Department of Environmental Quality. Water Quality Permit Program. Retrieved from: http://www.oregon.gov/deq/wq/wqpermits/Pages/default.aspx*

[4] *Oregon Department of Environmental Quality. Underground Injection Control Permit Program. Retrieved from: https://www.epa.gov/uic*

[5] *State of Oregon website. Wetlands/Waterways Removal-Fill. Retrieved from: http://www.oregon.gov/deq/wq/wqpermits/Pages/Section-401.aspx*

[6] *Oregon Department of Environmental Quality. Water Quality. Section 401 Removal/Fill Certification. Retrieved from:* http://www.oregon.gov/deq/wq/wqpermits/Pages/Section-401.aspx

[7] *U.S. Army Corps of Engineers. Obtain a Permit. Retrieved from: http://www.usace.army.mil/Missions/CivilWorks/RegulatoryProgramandPermits/ObtainaPermit.aspx*

Planning Step 4: Develop initial concept design using runoff prevention BMPs. Consider runoff prevention BMPs such as tree protection, cluster development, minimizing impervious surfaces, and conserving soil (discussed in detail in **Chapter 4**). See the ***Table G-1*** *BMP Suitability Matrix* in **Appendix G** and "*Site-Scale Treatment Trains*", also in **Chapter 4**, for more information.

Planning Step 5: **Organize pre-submission meeting and/or site visit with jurisdictional staff and the landowner or developer.** For development on private or public property, a predevelopment meeting between the Director and the developer and/or contractors are required to effectively communicate each entity's perceptions of the project early on, and potentially discern how each other's needs can be incorporated into the development concept. Consider incorporating site visits into the pre-submission meeting to minimize or prevent future problems with the development. Discuss goals for stormwater management regionally and highlight runoff prevention and runoff reduction BMPs that could be considered. Not all BMPs are appropriate for every site or stakeholder.

Planning Step 6: Incorporate revisions to development concept. Integrate the information collected from the previous steps and revise the initial development concept, if appropriate.

Figure 3-4. Pervious concrete and a stormwater planter were chosen for this public Park and Ride parking lot in Veneta, OR.

Planning Step 7: Apply runoff reduction BMP selection process. After applying runoff prevention in site planning step 4, determine the blend of runoff reduction BMPs for the remaining infrastructure impacting water quality and runoff volume. The calculations done in step 8 may be needed to make decisions on the runoff reduction BMPs that can be used at a site. Therefore, it may be necessary to combine steps 7 and 8 iteratively to complete the selection of BMPs. *See the* ***Table G-1*** *BMP Suitability Matrix.*

Planning Step 8: Apply the LID calculation methodology. Follow the water quality and flow control requirements of **Chapter 2** and in the LID Implementation Forms and Worksheets (**Chapter 5**). BMPs can be sized using the worksheets included with the LID Implementation Form described in detail in **Chapter 4**. BMPs may be designed with sizing factors when meeting the Simplified Sizing Approach requirements in **Chapter 2**; otherwise, BMPs must be sized using the Engineered Design Approach (see **Chapter 2**, "*Applicability*", "*Stormwater Management: Water Quality*", and "*Stormwater Management: Flow Control*").

Once sizing is completed, if space is limited or budgets are constrained, revisit the opportunities for incorporating runoff prevention BMPs and redesign the site to be less reliant on runoff reduction BMPs.

Planning Step 9: Develop the preliminary site plan. Once steps 1-8 of the site design process are implemented, the preliminary site plan is complete and ready to submit for planning review.

THE LID DESIGN PROCESS

Detailed Plans

Successful implementation of any kind of stormwater controls requires detailed and site-specific information. Existing natural and built conditions at the boundaries of any project drive the overall site layout, which, in turn, drives, the design at the BMP scale (see **Appendix B**). The grading plan is often integral to directing stormwater overland towards shallow facilities and may have to account for "run on", which is runoff from beyond the project boundary (usually the property line). Tight tolerances for inlets, outlets, weir structures, and other infrastructure might apply to rain gardens and stormwater planters and careful detailing of these to ensure proper construction and function is essential.

Even if an approach is familiar, such as tree protection, extra detail over conventional developments will be helpful. For instance, tree protection fencing should be shown on the tree protection plan, the grading plan, the utility plans, and the landscape plans at minimum. Different contractors may be working on different portions of the work, but all of them need to know the limits of disturbance and where they may and may not stockpile materials.

Figure 3-5. A meticulous grading plan and a willing contractor limited disturbance by protecting many existing trees in this newly developed parking lot.

Permit Application Package Requirements for All Projects

At minimum, permit application package requirements include:

When Engineered Design Approach is used:

- Determine if the Engineered Design Approach requirements are met as directed in **Chapter 2**.
- Hydrologic modeling calculations (See **Appendix B** and **Chapter 2**) stamped and signed by a licensed engineer.

When the Simplified Sizing Approach is used:

- Determine if the Simplified Sizing Approach requirements are met as directed in **Chapter 2**.
- The LID Implementation Form and Worksheets for chosen BMPs must be submitted with the building or public works permit application. The LID Implementation Form and Worksheets documents to what extent BMPs are used and the size of those facilities for each basin on the project. Delineate the boundary of single or multiple basins, labeling them with capital letters (See **Chapter 5**).

- Submit Simplified Sizing Approach Infiltration Testing Form for each BMP infiltration test.
- Submit **Appendix A** checklist for at least "blue font" items.

For All BMPs:

- Location of BMPs in relation to the proposed buildings, parking lots, driveways, and street frontage. Label all setbacks and easements.
- Size of BMPs with dimensions labeled on the drawings.
- Areas that drain to BMPs (drainage area) should be outlined and labeled in square feet, if applicable.
- Safe overland path(s) downhill where water will flow when a storm size or intensity exceeds the capacity of any BMP.
- BMP scale treatment train elements and high flow bypass structures or strategies (see **Appendix B** "*BMP Implementation Criteria*"), if incorporated.
- Signed and recorded Operations and Maintenance Agreements (see Chapter 6) for privately owned and maintained facilities.

For All Infiltration BMPs:

- Infiltration testing (see **Appendix C**) results summary.
- Determine which BMPs require infiltration testing by looking at Table C-1 in Appendix C.

For All Vegetated BMPs:

- For all BMPs with vegetation, include the treatment soil specifications to be used if different from those provided in **Appendix D**, a detailed planting plan with species, size of plantings, and spacing noted. See Appendix E "*Planting Specifications*" and Appendix F for planting layout details.

For Tree Protection BMP and Tree Planting BMP:

- Size and species of new or existing trees to receive stormwater management credit. Size for new trees is the projected canopy area. Size for existing trees is the existing canopy area.
- Typical cross-section of vegetated roofs, rain gardens, stormwater planters, LID swales, porous pavements, soakage trenches, drywells, water quality conveyance swales, and/or dispersion BMPs to be implemented. Label depths, materials, and all dimensions. Typical cross-sections can be found in Appendix F or downloaded online (in jpg, pdf, and AutoCAD dwg format): [TBD]

For Porous Pavement BMP:

- 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. Specifications are provided in Appendix D.
- Pervious surfacing materials such as concrete, grasscrete, or paved tire strips can be approved for use in the City of Grants Pass following review and approval by the City Engineer.
- The pervious surfacing material must have similar structural characteristics to asphalt or concrete and be capable of withstanding the normal wear and tear associated with the parking and maneuvering of vehicles. In addition, drainage should not adversely affect the public right-of-way or adjacent properties and the pervious material must be maintained throughout its use so that it continues to function as originally approved by the City Engineer.

- Porous pavements must include a geotechnical report that includes infiltration testing results and a pavement section design based on the project's predicted traffic loading or H-20, whichever is larger. The report must be signed and stamped by a licensed engineer.

For Vegetated Roof BMP:

- Vegetated roof designs must include a structural analysis of the roof's capacity to support all vegetated roof elements and the soil in a saturated condition. This structural analysis must be signed and stamped by a licensed engineer.

For Depave Existing Pavement BMP and Restored Soil BMP:

- Depaving and restored soil retrofit projects that will remove more than 1500 square feet of pavement must obtain a grading and erosion control permit.

For Cluster Development BMP:

- For larger projects include:
  - Existing Conditions (see list of survey items in **Appendix A**)
  - Site Protection Plan
  - Demolition Plan
  - Grading and Erosion Prevention and Sediment Control Plan
  - Stormwater Plan
  - Utility Plan
  - Details
- Sign O&M agreement (**Chapter 6**)

Additional Requirements for BMPs in the Public ROW (aka Green Streets)

The same design guidance for private facilities applies to public facilities. The following are additional requirements for BMPs in the public right-of-way:

- When used in the public right-of-way, BMPs must be designed in accordance with all jurisdictional roadway standards, which includes right- of-way widths, cross-sections, and typical plan views for each street use designation.
- Plans must also include easements and right-of-way property lines

THE LID CONSTRUCTION PROCESS

The following is intended to provide an overview of general construction considerations. Construction considerations for BMPs are presented in detail in **Appendix B**. Suggested construction sequencing is provided for each BMP in **Chapter 4**.

Avoid Site Disturbance Impacts to Water Quality

The contractor should not disturb areas of the site that don't need to be altered. When land is in an undisturbed well-vegetated condition, the vegetation and soil work together to capture almost all rainfall and manage it through infiltration, evaporation, and transpiration. Unnecessarily clearing vegetation and grubbing or disturbing soils will greatly impact this balance and affect the long-term habitat value of downstream waterways and watershed health in general. More information on limiting site disturbance is provided in **Chapter 4**.

Healthy soil plays a crucial role in water quality as:

- A growing medium for vegetation

- Habitat for beneficial microbes that break down pollutants and larger fauna that mechanically loosen the soil and preserve air pockets
- Storage medium for rainfall until it can evaporate or infiltrate

Both intentional and unintentional compaction consolidates soil and greatly reduces void space. Compacted soils can have densities almost as high as concrete[8]. This has long-term impacts on water quality and quantity because these soils:

- Won't have voids to store water and air for plants resulting in higher irrigation needs and less healthy plants, which will tend to be maintained with increased levels of fertilizers, herbicides, and pesticides.
- Generate runoff flows and volumes that are more similar to impervious surfaces than pervious landscapes.

Soils disturbed by current or previous activities are difficult to fully restore so they should be protected as much as possible and restored with compost amendment[9]. See the soil restoration guidance provided in **Chapter 4**. Since soil life may have died due to poor air and water conditions, mycorrhizae (mushrooms) and biological (bacteria) treatments can be added to soil to enhance the soil's biology and ability to support plant life. This is likely to speed establishment and reduce water demand during this period.

Figure 3-6. The presence of beetles indicates healthy soil with voids that provide soil animals access to air and water so that they may live in the soil, creating soil structure and providing long-term permeability.

Erosion Prevention and Sediment Control

Due to the high negative impact on water quality caused by suspended solids, the DEQ closely regulates construction sites that disturb 1 acre or larger through the 1200-C or 1200-CA permit process but may also regulate smaller disturbance areas when part of a larger development. Sediment from several smaller sites can have a cumulative negative impact on water quality and the habitat of our waterways.

Erosion Prevention. Erosion prevention is defined by the Oregon Department of Environmental Quality (DEQ) as "any practice that protects the soil surface and prevents the soil particles from being detached by rainfall or wind." Preventing erosion is often thought of as solely the contractor's realm, but everyone on the project team can contribute to this important practice and should consider it during the planning and

---

[8] Center for Watershed Protection. The Compaction of Urban Soils (Table 1). Retrieved from: http://www.cwp.org/online-watershed-library/cat_view/63-research/75-monitoring.

[9] The ODEQ published a document in July of 2001 Restoring Soil Health to Urban Lands[9], and Washington State University Extension and Puget Sound Action Team have produced similar resources and promoted compost amendments as an important BMP.

design phase.

Sediment Control. Sediment control is defined by DEQ as "any practice that traps the soil particles after they have been detached and moved by wind or water". This means that a more active role to install, monitor, and maintain these systems is required over simply preventing erosion in the first place.

DEQ has determined from a literature review of research papers and EPA guidance that properly installed sediment fences are 0-20% effective for fine-grained soils (clays and silts).[10] This is because clay and silt particles are much smaller than the mesh opening of a sediment fence[11]. Alternatives that work well to control sediment from overland (*i.e*. non-concentrated) flows for any soil type include compost berms, compost socks, and wattles. At the end of the construction phase, compost used for erosion control can be spread over landscape areas.

Construction Sequencing

EPA defines construction sequencing as "a specified work schedule that coordinates the timing of land-disturbing activities".[12] This approach is critical to protecting permeability and other on-site natural resources, as well as preventing erosion and controlling sediment. See **Chapter 4** "*Construction Sequencing BMP*".

Additional Best Management Practices

Several other best management practices should be used during the construction phase to protect water quality:

- Cover loads to be transported with a tarp.
- Use water tight trucks when hauling saturated soils since polluted water and sediment can easily be leak out onto roads during transportation in regular dump trucks.
- Use native seed mixes when temporarily stabilizing slopes during construction to reduce weed control maintenance long-term.
- When removing healthy, native vegetation, grind it on-site for use as a compost berm or other compost erosion control method.

THE LID OPERATIONS AND MAINTENANCE PROCESS

Maintenance Responsibility

BMPs managing runoff from privately owned lands will be maintained by the private landowner as signed in the Operations and Maintenance Agreement provided in **Chapter 6** to ensure that necessary maintenance activities are defined and understood by landowners with BMPs.

Site Maintenance

Since rain may fall on any surface outdoors, all those outdoor surfaces are a part of the stormwater infrastructure that could treat or pollute stormwater. Site-wide maintenance activities that could be included in every operations and maintenance agreement for LID sites are as follows:

---

[10] *Oregon Department of Environmental Quality. (Feb. 2006). Best Management Practices for Storm Water Discharges Associated with Construction Activities. Retrieved from: http://www.deq.state.or.us/WQ/stormwater/docs/nwr/constrbmps.pdf*

[11] *Howland, M. (2000). When Silt and Sediment Controls Are Not Enough. Retrieved from: http://www.landandwater.com/features/vol41no4/vol41no4_2.html*

[12] *U.S. Environmental Protection Agency. Water: BMPS. Retrieved from:http://water.epa.gov/polwaste/npdes/swbmp/Construction-Sequencing.cfm*

- Asphalt pavement should not be sealed with coal tar sealants or PCBs, which are toxic to aquatic life and are a suspected human carcinogen. Alternatives to coal tar sealants[13] and caulks are commercially available.
- All pavements: Use an environmental deicer appropriate for the surface type instead of salt when ice on pavements must be addressed.
- If possible, avoid mossicides such as zinc strips on roofs. Use mechanical removal instead.
- Sweep pavements regularly. Degraded pavements and busy roads will require sweeping more often than newer, structurally sound pavements and lower traffic surfaces such as driveways.
- Remove sediment from structures and pretreatment facilities. Dispose of sediment in trash.
- Maintain landscape areas and lawns with integrated pest management techniques, which recommend using herbicides, pesticides and mossicides as a last resort. (See **Appendix E** "*Plant Specifications*" "*Integrated Pest Management*".)
- Restore eroded landscape areas by filling areas in with topsoil (not mulch) and planting.
- Use proper erosion prevention techniques such as covering the soil with jute fabric or compost per Appendix D: Specifications "*Organic Matter Compost*" or "*Mulch*" or vegetating, if needed.

Writing a Maintenance Plan

A maintenance plan for on-site stormwater infrastructure will help to ensure that operations and maintenance staff are holistically managing the site on a long-term basis. An operations and maintenance plan is required to be submitted to the City of Grants Pass, and provided to the owner before final permitting takes place (**Chapter 6**).

Figure 3-7. Overwatering and poor directional control waste water and increase runoff to streams.

[13] *City of Austin, Texas. FAQs. Retrieved from: https://www.austintexas.gov/content/1361/FAQ/2511*

Figure 3-8. Signage can help reduce maintenance by educating the public about their function.

CHAPTER 4: CHOOSING AND IMPLEMENTING BEST MANAGEMENT PRACTICES (BMP)

Table of Contents

A HOLISTIC APPROACH

This chapter provides in-depth information on planning, design, construction, and maintenance for a variety of BMPs to reduce costs and improve water quality benefits. To avoid unintended consequences, the entire project team, not just the team during the design phase, should apply the chosen practices according to the detailed guidance provided in combinations most meaningful for that development site (as discussed in **Chapter 3** "The LID Planning Process"). Where possible, the reason for a particular design element has been explained, but in cases where it is not, it's purpose will be to support long-term water quality and watershed protection[1]. Where applicable, each section includes the following:

- **"Siting" (*i.e.* locating facilities during early planning phase)**
- **"Design"**
- **"Construction"**
- **"Maintenance"**

Some sections include additional information, as needed. For instance, porous pavement surface types are discussed in detail under the "Porous Pavement BMP".

Site Scale Treatment Trains: Combining BMPs

Combine numerous BMPs on a single development site depending on natural conditions, stakeholder and designer preferences, and budget.

Figure 4-1. Site-scale treatment train. A rain garden (light green grassy area), porous pavement (parking lot), tree canopy, and native plants all work together to protect water resources, on and off site.

CRITERIA FOR CHOOSING BMPS: THE BMP SUITABILITY MATRIX

Many BMPs in this guidance are suitable for a variety of conditions; however, a few are not suitable or desired for some situations. The **BMP Suitability Matrix, in Appendix G** should be especially useful during planning to help identify the "best" best management practices for a variety of conditions. The matrix includes a relative measure of water quality treatment and protection effectiveness (high, medium, or low) and predicted ease of implementation (1, 2, or 3).

The following elaborates on the categories of the BMP Suitability Matrix:

BMP Suitability for Water Quality. Each BMP addresses water quality on-site; downstream water quality can be improved by reducing runoff volumes that cause excess streambank erosion. BMPs with simplified sizing factors may be used for water quality. If sizing factors aren't used, the Engineered Design Approach requirements for water quality in **Chapter 2** must be met. Dry Detention Facilities may be used for water quality when designed by a licensed engineer to include a LID swale in the bottom.

[1] *For additional information on how changes to facility designs are likely to impact function, see pdfs at Oregon State University Extension Service website. "Additional sustainability & design considerations for modifying details". Retrieved from: http://extension.oregonstate.edu/stormwater/swamp-lid-details*

BMP Suitability for Flow Control. BMPs with simplified sizing factors may be used for flow control. If sizing factors aren't used, the Engineered Design Approach requirements for flow control in **Chapter 2** must be met. Detention and Retentions structures may be used for flow control when designed by a licensed engineer according to the **Chapter 2** requirements.

BMP Suitability by Drainage Area. Each BMP may be applied to a certain stormwater runoff surface (*i.e.* rooftops, roadways, sidewalks, or landscapes). For instance, vegetated roofs are only suitable for roofs.

BMP Suitability for Challenging Site Conditions. Some sites are not suitable for infiltration of runoff. These sites may be challenged by steep slopes (which are prone to landslides); seasonal or permanent high groundwater tables; shallow bedrock (where runoff has insufficient soil voids to flow into); inadequate setbacks (where infiltrated water could flood a nearby structure); and/or contaminated soils (where infiltrated water could mobilize contaminants).

Slow draining soils are not automatically a barrier to infiltration, but will make runoff management facilities, like rain gardens larger, which may lead to inadequate setbacks. BMPs at these sites, like tree planting and porous pavement that intercept and infiltrate rain (versus managing concentrated volumes of runoff) can still significantly reduce runoff on sites where infiltration is challenging.

Contaminated sites are sites where hazardous chemicals have accumulated in the soil as a result of historic activities; they may not be limited to industrial sites. On a site with polluted soils, stormwater should not be infiltrated into the ground to protect groundwater. BMPs have been successfully applied in Oregon to create LID sites. Contaminated sites have a highly regulated development path with additional permitting. Coordination with the local DEQ Cleanup program is advised.

The City of Portland Source Control Manual includes helpful information on source control considerations[2]. In addition, there are various remediation pathways and programs, depending on the nature of the contamination (toxicity as well as adhesion, migration, and fixation tendencies) and land use. With the owner's consent and cooperation, it is appropriate to request consultation from the solid waste and/or groundwater divisions or another expert in brownfields to understand what is known about the site and what BMPs are best to pursue. When the site history does not include industrial activity or known spills, it is not necessary to test for soil contamination in areas planned for infiltration. But if staining, discoloration, or unusual odors are noted when soil is disturbed, consulting with DEQ prior to completing work on an infiltration facility is advised.

BMP Suitability by Land Use. There are many appropriate land uses/zoning classifications where LID can and has been implemented in Oregon, including residential, commercial, institutional, industrial, and public right-of-way.

Industrial Land and the DEQ **Water Quality Permit Program[3].** Stormwater runoff from industrial lands is regulated by DEQ under the following programs:

The 1200-A, 1200-COLS, and 1200-Z permits are issued "to industries that discharge stormwater into rivers, lakes and streams from pipes, outfalls or other point sources at a site. Based on federal regulations, National Pollutant Discharge Elimination System (NPDES) permit coverage is required for industrial facilities that discharge stormwater from their industrial areas to surface waters of the state, or to storm drains that discharge to surface waters. Examples of industrial activities that require a DEQ permit include manufacturing, transportation, mining, and steam electric power industries, as well as scrap yards, landfills, certain sewage treatment plants, and hazardous waste management facilities. "

[2] *City of Portland, Oregon, Bureau of Environmental Services website. Retrieved from:* https://www.portlandoregon.gov/bes/71086

[3] *Oregon Department of Environmental Quality, Water Quality Permit Program. Retrieved from:* http://www.oregon.gov/deq/wq/wqpermits/Pages/default.aspx

BMP Suitability by Land Ownership. The BMP suitability table illustrates which BMPs may be used in private development or public development.

BMPs in Roads and the Public Right-of-Way. When BMPs are installed in the public right-of-way, they are often called “green streets”. This term may apply to streets that incorporate a variety of BMPs, which often include “narrow streets”, rain gardens, stormwater planters, porous pavements, or tree planting.

BMP Suitability by Development Type (Retrofits, Redevelopment, and New Development). Implementation of BMPs is often similar regardless of whether it is being used in a retrofit, redevelopment or new development, although site preparation can vary tremendously. For example, in a retrofit situation, replacing existing impervious pavement with a porous pavement will require some soil restoration techniques or additional excavation to reach a layer of soil that has not been compacted. Where implementation considerations are different by development type, this has been noted in the detailed guidance for BMPs that follows.

STORMWATER MANAGEMENT HIERARCHY

The BMP Suitability Matrix (**Appendix G**) reflects the preferred order of BMP choice to mimic pre-development hydrology as follows:

1. Lay out the site to minimize impacts to natural resources and to minimize impervious areas.
2. Prevent runoff by intercepting, evaporating, and/or infiltrating rainfall.
3. Reduce runoff using BMPs with surface storage (*i.e.* ponding) that infiltrate and to a lesser extent, intercept and evaporate runoff and the rainfall they receive.
4. Reduce runoff using BMPs with underground storage that infiltrate runoff.
5. Reduce runoff using flow-based BMPs without storage (*i.e.* conveyance) that infiltrate lower volumes and to a lesser extent, intercept and evaporate runoff and the rainfall.
6. If the first five choices are not feasible, then the only remaining LID choice is to improve the water quality of runoff, without significantly reducing the volume, using a lined BMP or proprietary device. This is not preferred. (See **Chapter 1** “*Why Use Low Impact Development*”, “*Protecting Water Quality by Addressing Water Quantity*”).
7. Stormwater Retention and Detention Facilities may be used for larger sites to manage stormwater flow control. Water quality can be addressed by Dry Detention Facilities when designed with a LID Swale by a licensed engineer.

BEST MANAGEMENT PRACTICES: QUICK REFERENCE TABLE

The quick reference table (***Table 4-1***) shown below is designed to show what each BMP can manage, what sizing approaches can be used, and if infiltration testing is required. The three factors that need to be managed for applicable sites are landscaped area, water quality, and flow control (See **Chapter 2**). Boxes that are gray filled represent which factors can be managed for each BMP when requirements in **Chapter 2** are met. Sizing approaches that can be used to design each BMP are gray filled; white boxes mean the respective sizing approach can either not be used or is not applicable. BMPs that are not applicable for both sizing approaches will have the siting, design, construction, and maintenance requirements in their respective sections within this chapter.

Table 4-1. Quick reference table for applicable BMP management factors, sizing approaches, and infiltration testing requirements. Refer to respective BMP sections within this chapter for more details.

Best Management Practice (BMP)	Landscaped Area Management	Water Quality Management †	Flow Control Management †	Simplified Sizing Approach	Engineered Design Approach	Is Infiltration Testing Required
Conserve fast(er) draining soils BMP						
Cluster Development BMP						
Tree Protection BMP						
Minimal Excavation Foundation BMP						
Construction Sequencing BMP						
Depave existing pavement BMP						
Restored Soil BMP						
Contained Planter BMP						
Tree Planting BMP						
Vegetated Roof (Green Roofs) BMP						
Porous Pavement BMP						
Rain Garden						
Stormwater Planter						
LID Swale BMP						
Soakage Trench BMP						
Drywell BMP						
Water Quality Conveyance Swale BMP						
Dispersion BMP						
Wet Pond						
Extended Wet Pond						
Dry Detention Ponds						

† Applies when meeting requirements in Chapter 2 =YES =NO or N/A

LIMIT DISTURBANCE BMPS

Limit disturbance in areas of the site that don't need to be altered. When land is in an undisturbed well-vegetated condition, the vegetation and soil work together to capture rainfall and reduce runoff through infiltration, evaporation and transpiration. Unnecessarily clearing vegetation and grubbing or disturbing soils will greatly impact this balance and could affect the long-term habitat value of downstream waterways and watershed health in general (see **Chapter 3**, "The LID Construction Process").

There are a variety of opportunities to limit disturbance during the planning, design and construction phases of any kind of development, even retrofits. These include:

Limit disturbance BMPs

1. Conserve Fast(er) Draining Soils BMP
2. Cluster Development BMP
3. Tree Protection and Planting BMP
4. Minimal Excavation Foundations BMP
5. Construction Sequencing BMP

Detailed information on implementation of each BMP is provided, as follows.

LIMIT DISTURBANCE: CONSERVE FAST(ER) DRAINING SOILS BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management*			
Flow Control Management*			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form A		
Worksheet	N/A		
Drawings			
Title	**Detail**		
-	-		
* This BMP does not offer this type of management			

This BMP strategy places impervious surfaces on the slower draining areas of a site.

There are two aspects of this BMP to conserve fast(er) draining soils:

1. **Runoff prevention**: Conserve the faster draining soils, leaving them open to the sky to manage rainfall more effectively than slower draining soils.
2. **Runoff reduction**: Plan for the runoff reduction BMPs that will infiltrate the remaining surfaces. Placing these in fast(er) draining soils can often significantly reduce the size of a runoff reduction BMP, saving money during construction and long-term maintenance. Step-by-step instructions for calculating the field-tested infiltration rate are in **Appendix A** and **Appendix C**.

Siting

Existing soil or geologic maps are often used in the planning phase to evaluate the site's potential for infiltration; however, these maps don't accurately reflect the conditions at the site scale. Infiltration testing, described below, is the best way to identify faster draining soils. To discover the areas of fast(er) draining soils, multiple areas throughout the site should be tested for the infiltration rate using the following guidance.

Infiltration Testing. Perform an infiltration test to determine the soil's capacity to absorb and percolate water down into the lower layers. See Appendix C for detailed guidance on field testing to find the rate that water can pass through the soil and how to interpret that data.

Design

Once the location of fast(er) draining soils have been identified and mapped, locate landscape areas in faster draining soils. Locate impervious surfaces such as roads, roofs, and sidewalks in slower draining soils. Porous pavements may also be located in either faster or slower draining soils per guidance below under "Porous Pavement BMP".

To reduce the size of vegetated infiltration facilities such as rain gardens, stormwater planters, and LID swales, locate them in the landscape areas with soils that drain quickly, up to 12 inches/hour. If an area drains faster than 12 inches/hour, the water quality treatment capability of the facility is less, so plan to amend those soils to slow them or replace the soil with an imported soil for a depth of 18 inches where water will pond. (See **Chapter 4** "*Rain Garden, Stormwater Planter, and LID Swale BMPs*", "*Design*", "*Soil*" and **Appendix D**: Specifications "*Treatment Soil*" for more information.) Draw protection fencing on the plan set around all infiltration areas so that they are protected from disturbance and are still capable of infiltrating when construction is complete.

Construction

Fence off areas of fast(er) draining soils that do not need to be accessed by equipment. Regardless of the site's various infiltration rates, contractors should take great care to limit compaction in any future landscape areas (see **Appendix B**: BMP Implementation Criteria, "*Construction*").

Contractors should choose equipment that reduces loads transferred through the soil. These include:

- Use the lightest (usually smallest) piece of equipment possible.
- Use track equipment.
- Use equipment with flotation tires.
- On infiltration areas or areas identified as Fast(er) Draining Soils, avoid blade grading, working instead from outside the infiltration footprint.

Figure 4-2. Track hoe equipment reduces soil compaction.

To reduce compaction, haul roads through landscapes may be created from a combination of geotextile and rock. Sometimes, low weight organic debris is placed between the geotextile and rock. Consult a licensed engineer to assess the site's soils and recommend appropriate depths and materials to spread the weight of equipment loads out.

Wet weather construction in clays. Cement modified soil (CMS) is a mixture of cement and water mixed into soil commonly called for in geotechnical reports to stabilize soils for erosion prevention during wet weather construction or to strengthen poor soils under asphalt or other flexible pavements. This makes the soil impermeable, so avoid cement and/or lime treatments in future proposed landscape and porous pavement areas, at a minimum.

Maintenance

Maintenance activities for fast(er) draining soil areas are no different than for conventional landscapes where soils have not been protected. The intensity of maintenance required for plants in protected areas should be lower to much lower than for unprotected areas. If soils were compacted or cement modified (see above) as an erosion control practice during construction in landscape areas, maintenance activities for plant establishment are likely to be very high and consist of repeated plant replacement.

LIMIT DISTURBANCE: CLUSTER DEVELOPMENT BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management†			
Water Quality Management*			
Flow Control Management*			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form B		
Worksheet	N/A		
Drawings			
Title	**Detail**		
-	-		
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Cluster development is a planning approach that locates buildings and other infrastructure requiring road access in one place on a site. Water quality is protected by cluster developments because total impervious area is less and natural areas are protected to provide a variety of water quality and quantity benefits. Depending on the type of resource (land or water), these services may include runoff prevention, runoff reduction, flood control, and treatment of air quality (which preserves water quality since many pollutants are the result of air deposition).

Siting

Subdivisions, corporate campuses and similar projects with potential open space are suitable for implementing this BMP. To further improve the water quality benefit of this practice, locate development away from surface water resources (*i.e.* streams, lakes, rivers, estuaries, wetlands), sensitive land resources (*e.g.* steep slopes, native tree stands (see **Chapter 4** "*Limit Disturbance: Tree Protection BMP*")), and fast(er) draining soils (see **Chapter 4** "*Limit Disturbance: Conserve Fast(er) Draining Soils*").

Design

Larger natural areas, contiguous to other natural areas, located between runoff sources (the development) and the sensitive resource (streams, lakes, wetlands, *etc.*) are preferred, since this provides the greatest amount of water quality/hydrologic function, compared to small, disconnected pervious/natural areas.

In developing a grading plan for the site, it is advised to avoid creating slopes greater than 3:1 (horizontal:vertical) (*i.e*. 33%) or disturbing existing steep slopes.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Construction

Carefully employ strategies to protect on-site natural resources. These might include a staging and stockpiling plan (see **Chapter 4** "*Construction Sequencing BMP*"), weekly meetings with sub-contractors, signage, and/or cyclone fencing around areas to be protected.

Maintenance

In addition to detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*" and **Appendix B**: BMP Implementation Criteria, "*Maintenance*", review **Chapter 6** Operations and Maintenance Agreement to determine who is responsible for maintenance and confirm early stakeholder buy-in of maintenance practices before settling on the mix of BMPs. Maintaining natural areas reduces overall landscape maintenance costs compared to formal landscaping of the same area. Natural areas generally do not need, or sometimes would even be negatively impacted by, the intensive maintenance approaches that are often applied to landscapes in urbanized areas such as pruning, watering, fertilizing, spraying, and mulching. Weed and pest management is perhaps the most important maintenance task. Integrated pest management (IPM) is a systematic approach to reducing toxics use in landscapes. IPM is recommended. (See **Appendix E**: Plant Specifications "*Integrated Pest Management*".)

Steep slopes that are graded during construction and left grassy as open space tend to have problems with erosion and sometimes even landslides. Managing soils from these areas could become very high maintenance, including the need to address erosion (*i.e.* redirect runoff from areas above slope), frequently revegetated, clean material deposited at the base of the slope, retrofitting landslide prevention, and re-grading the slope. Under the definition of limiting disturbance, which is to preserve and protect natural resources, these areas may not really be considered natural areas, although maintenance staff seeing them for the first time may think so. In this case, steep slopes should be re-vegetated with materials that can resist erosion. (See **Appendix E**: Plant Specifications.)

LIMIT DISTURBANCE: TREE PROTECTION BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management†	■		
Water Quality Management*			■
Flow Control Management*			■
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			■
Engineered Design Approach			■
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			■
Design Information			
Title	**Form/Worksheet**		
LID Form	Form B		
Worksheet	N/A		
Drawings			
Title	**Detail**		
Tree Protection	BMP 11.01		
Tree Protection - Boring Under Dripline	BMP 11.02		
Tree Protection - temporary Access Road	BMP 11.03		
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Protecting individual and groves of trees can help maintain the existing hydrology and water quality functions of that portion of the development. Preserving groves often provides greater economic and environmental benefit than preserving individual trees; however, both are beneficial. The following is guidance adapted from the Oregon State University Extension publication "Tree Protection on Construction and Development Sites"[4].

[4] *Download Oregon State University, Extension Service. (Dec., 2009) Tree Protection on Construction and Development Sites. Retrieved from: http://goo.gl/Tl5kOU*

Figure 4-3. Protected trees at a commercial development in Wilsonville, OR

Construction around trees can sometimes be difficult, but protecting trees in new development and redevelopment has many benefits:

- Reduces long-term tree maintenance and replacement costs.
- Reduces site preparation and grading costs.
- Provides immediate aesthetic and economic benefits. Properties with more mature trees and greater tree canopy cover sell faster and accrue property value faster compared to properties without these assets.
- Generates positive response from neighbors and the surrounding community.
- Generates good public relations.
- Can provide healthier trees, forest ecosystem, and environment for a healthier, safer, more vital community.
- Additional benefits supported by scientific studies can be found on Washington State University's website "Green Cities: Good Health"[5].

Siting

Forest Remnants and Stands. Stands, groves, or patches of the native Pacific Northwest forests that previously covered the area, such as Oregon white oak, Western red cedar, Red alder, Big leaf maple, and Douglas-fir, are often found in urban or urbanizing areas. High tree densities with an undisturbed understory are some characteristics of a high-quality forest remnant worth preserving. An excellent stand to protect has the following characteristics:

- Trees structurally support one another.
- Soil remains undisturbed.
- Wildlife uses are relatively unimpaired, except during construction.
- Shady microclimate encourages natural woodland plants.
- Natural forest succession continues and forest regeneration is ongoing.
- The stand is visually attractive.
- Ecological functions are relatively unimpaired.

[5] *Retrieved from: http://depts.washington.edu/hhwb/*

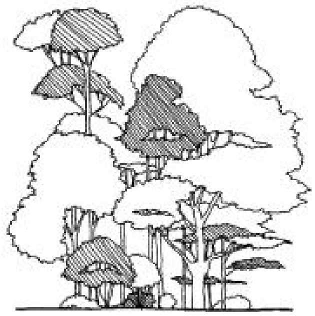


Figure 4-4. A stand to protect. Reproduced with permission by the City of Chattanooga

Scattered trees with a highly disturbed or missing understory may not be worth saving. A poor stand protection zone has the following characteristics:

- Trees have blown over due to lack of support.
- Soil has dried out and soil erosion occurred due to disturbed soils and lack of understory.
- Forest microclimate has been disturbed.
- Sunlight and temperature within the stand are higher than in high quality stands.
- Weeds and invasive species have taken over.
- Forest succession has been interrupted and little regeneration is occurring.
- The stand is visually unattractive.
- Ecological functions have been severely interrupted.

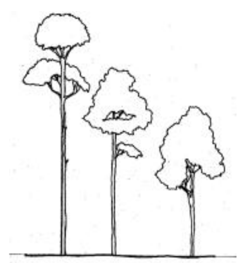


Figure 4-5. A stand that may not be worth saving. Reproduced with permission by the City of Chattanooga.

Individual Trees. Individual trees can be protected during the planning phase in a number of ways:

- Employ an International Society of Arboriculture (ISA) certified arborist or an urban forester to assist in tree-protection planning, implementation, monitoring, and follow-up maintenance.
- Plan to protect trees located on adjacent property, including those portions of the roots, trunk, and crown growing into or over the developing property.
- Evaluate existing on-site trees. Protect the healthiest, largest trees. Locate buildings, other structures and infrastructure outside of the critical root zone, as described in the next section.
- Complete preconstruction tree maintenance, including mulch, fertilization, supplemental irrigation as necessary, and pruning to remove dead, structurally weak, and low-hanging branches.
- Engage construction contractor and maintenance staff in early decision-making and education on care of retained trees.

In the following cases, trees should be removed:

- Remove trees within 10 feet of the proposed building or structure.
- Remove trees that cannot be adequately protected. Trees damaged during the construction phase will decline slowly over several years. Dropping limbs is one sign of decline. This creates a danger to site users and a lot of maintenance effort and cost, pruning dead limbs.

- Remove trees with less than one-quarter of their total height composed of tree crown (tall and spindly), or those with more than one-third of the trunk circumference wounded.

Critical Root Zone. Unless an arborist report indicates otherwise, plan infrastructure outside the Critical Root Zone (CRZ). The International Society of Arboriculture (ISA) defines the critical root zone as an area equal to 1-foot radius from the base of the tree's trunk for each 1 inch of the tree's diameter at 4.5 feet above grade (referred to as diameter at breast height).

Table 4-2. Critical root zone radius distances calculated by tree diameter at breast height

Tree diameter	Critical root zone radius	Total protection zone diameter including trunk
2 inches	2 feet	4+ feet
6 inches	6 feet	13.5 feet
20 inches	20 feet	42 feet
46 inches	46 feet	96 feet

Another common general rule is to use a tree's dripline to estimate the CRZ (**Figure 4-6**). The designer must evaluate both of these and choose whichever provides the larger CRZ.

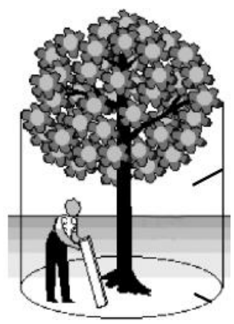


Figure 4-6. Using dripline to estimate critical root zone (CRZ). Adapted with permission by the City of Chattanooga.

Design

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per Appendix B: BMP Implementation Criteria, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by Chapter 2 "*The LID Design Process*".

Forest Remnants and Stands. Forest remnants and stands can be addressed during the design phase as follows:

- Show a fence line around the CRZ on every site plan and call for it to be a sturdy material that cannot be easily moved, such as cyclone fencing.
- Refer to an arborist report to identify vigorous, healthy trees and vegetation that should be avoided when locating infrastructure to be constructed.

Individual Trees. Individual trees are primarily protected in the design phase by developing a thoughtful and informed grading plan. Grade changes within the CRZ, where possible, should be avoided to prevent serious damage or death to a tree.

Raising the Existing Grade. Trees access air and water primarily through soil. Avoid and minimize fill within the CRZ of protected trees, which smothers roots and can kill the tree when placed in the CRZ. Never place fill against the tree trunk even for a few days.

Lowering the Existing Grade. Lowering the grade is less damaging than filling, but do not expose or damage

large amounts of root. Removing 1 to 2 inches of soil normally will not affect a tree adversely, especially if steps are taken to ensure that drought damage does not result from loss of roots or root cover.
To protect trees during the design phase:

- Locate new pavement or structures at least 5 feet from tree trunks.
- Limit fill to 2 to 4 inches around existing trees and avoid significant damage by specifying a fill with a coarser texture than the existing soil.
- Design retaining walls or terraces instead of creating steep slopes to avoid excessive soil loss in the area of greatest root growth.

Standard Details. See standard details BMP 11.01, 11.02, and/or 11.03 to include applicable details in construction documents. These are available in pdf, jpg, and AutoCAD .dwg format.

Construction

Forest Remnants and Stands. To protect forest remnants and stands during construction:

- Fence the entire stand, grove, or patch, as shown on the plans (or field directed), to protect understory vegetation and soil as well as trees.
- Unless directed by an ISA certified arborist, do not apply fertilizers, pesticides, or irrigation. Healthy soils require little, if any, to support tree health.
- Do not retain isolated single, tall, spindly trees. Such trees are more likely to become structurally unstable, bend or blow over in storms, or become diseased and/or infested with insects.
- Do not create new forest edges that may not be wind-firm; retain large trees on the windward side of a stand to support and protect the interior of the stand.

Individual Trees. To protect individual trees during construction:

- Erect barriers or sturdy fencing around individual trees to define and protect CRZs before construction begins.
- Never place any fill or organic materials directly against the tree.
- Never compact the soil within the CRZ.
- Protect high-value trees with stem, branch, and root padding or wraps in addition to fencing around the CRZ. Protect the trunks of high-value trees from scraping and gouging to a height of at least 8 feet.
- Establish one access route into the site and one exit route out of the site outside of the CRZ.
- Confine construction offices, vehicular parking, worker break sites, and material storage to locations outside CRZs.
- Do not trench through the CRZ of protected trees. Alter routes of underground infrastructure or tunnel or bore at least 18 inches beneath CRZs to install utility lines.
- Where tree roots must be cut, make only sharp, clean cuts to promote root callusing and regeneration.
- Engage an arborist to evaluate the potential of dead, damaged, or dying trees for wildlife habitat, to be used either as standing dead or woody debris if left onsite.
- Spread 2 to 3 inches of mulch over the exposed root area to prevent soil erosion, reduce moisture loss, and keep soil temperatures lower.
- Prune roots according to the arborist report to reduce pruning stress when lowering grades.
- Prune exposed jagged roots back to the point of emergence from the soil using a handheld pruner or pruning saw to make sharp, clean cuts.

Maintenance

Maintenance levels may vary with how well trees were protected during development. Review detailed guidance for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*" and Operations and

Maintenance Agreement in **Chapter 6** to determine who is responsible for maintenance and confirm early stakeholder buy-in of maintenance practices before settling on the mix of BMPs.

Activities include:

- Mulch, fertilize, irrigate, aerate the soil, and prune where necessary.
- In the absence of adequate rainfall, apply at least 1 inch of water per week by deep soaking methods.
- Fertilize lightly with nitrogen after 1 year. If recommended by an arborist, light annual applications of nitrogen may be made for the next 3 to 5 years.
- Fertilize trees immediately with phosphorus, potassium, calcium, magnesium, and other macro- and micro-nutrients as indicated by a soil test.
- Inspect trees annually for at least 3 to 5 years after construction to detect changes in condition and signs of insects or disease.
- Remove trees that are badly damaged or in irreversible decline if unsuitable for wildlife habitat or pose a safety hazard.
- Mulch trees on a regular schedule, ensuring that mulch does not rest against tree trunk.
- Develop a regular maintenance program that incorporates fertilization and integrated pest management techniques to get best results at lowest cost.
- Never top a tree.

LIMIT DISTURBANCE: MINIMAL EXCAVATION FOUNDATIONS BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form C		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	

* This BMP does not offer this type of management
† Applies when meeting requirements in Chapter 2

Minimal excavation foundations, such as pier foundations, allow water to pass through shallow subsurface soil to more closely approximate pre-developed groundwater flow conditions. For watersheds in a natural, predeveloped condition, a portion of annual rainfall soaks into the ground and flows through voids in the soil (even very dense clayey soils) seeping downhill to keep waterways flowing days, weeks, and sometimes months after a rainfall event. Basements and slab-on-grade foundations exclude previously available soil voids that stored and conveyed water downhill. Fewer voids in the watershed generates runoff and exacerbates flooding.

Figure 4-7. Building with pier footings.

Siting

Minimal excavation foundations can be installed anywhere but are especially beneficial on steeply sloping sites and areas prone to flooding.

Design

As with any foundation, hire a licensed engineer to design and implement this BMP. The following are examples of minimal excavation foundations, suitable for protecting watershed health:

- Pier
- Post
- Block
- Walls that create a shallow crawl space.

At the end of construction, soil within the footprint of the building should still be able to store and convey water (*i.e*. be uncompacted and the soil voids not emptied of water, such as via underdrains and/or a sump pump). Protect soil permeability beneath the building using techniques described in Appendix B: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*". If necessary, the soil surface beneath the building may be covered in plastic to prevent moisture from entering the building. Or, in the case of post, piling, and pier foundations, leave an adequate distance between the building and ground for air circulation.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**: BMP Implementation Criteria, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

LIMIT DISTURBANCE: CONSTRUCTION SEQUENCING BMP[6]

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management*			
Flow Control Management*			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form A		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	
* This BMP does not offer this type of management			

Construction sequencing represents a specified work schedule that coordinates the timing of land-disturbing activities and the installation of erosion prevention and sediment control (EPSC) measures. The goal is to prevent erosion and control sediment by minimizing the extent of cleared land at one time and to install EPSC measures before land clearing begins[7].

Siting

Construction sequencing might be used throughout any site large enough that some cleared areas of the site would be "open" without construction activity for more than a month during the rainy season from September to early May.

Design

Design could be impacted by array of construction considerations, for example, when materials can be delivered or where and how they can be stored on-site. Consider the following elements of this BMP during

[6] *This section is adapted from the Environmental Protection Agency Menu of BMPs. Retrieved from:* https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#constr

[7] *Smolen, M.D., Miller, D.W., Wyall, L.C., Lichthardt, J., and A.L. Lanier. (1988.).* Erosion and Sediment Control Planning and Design Manual. *North Carolina Sedimentation Control Commission; North Carolina Department of Environment, Health, and Natural Resources; and Division of Land Resources, Land Quality Section, Raleigh, NC.*

planning and design phases and communicate this information on the construction/bid/permit set.

Phase disturbances. Construction site phasing involves disturbing only a portion of the site at a time to prevent erosion from areas where no work will take place in the near future. Grading activities and construction are completed, and soils are stabilized on this portion before grading and construction begin at another part.

When phasing construction activities:

- Manage runoff separately in each phase.
- Determine whether water and sewer connections and extensions can be accommodated.
- Protect already completed downhill phases.
- Provide separate construction and public accesses to prevent conflicts between site users traveling to completed stages of the site and construction equipment working on later stages[8].
- Incorporate wet weather erosion prevention and sediment control techniques if excavation cannot be scheduled for the dry season.

Minimize grading. In general, grading should be minimized. Design proposed site improvements to work with existing grades, as much as possible. If buildings are proposed, this may mean working with that designer to step building foundations.

Cut and fill grading activities should be coordinated and, if possible, conducted during the dry season, to minimize the movement and storage of soils on, off, and around the site. Keeping soils in-place for as long as possible protects the quality and infiltration rate; thereby reducing runoff during and after construction. It also reduces long-term maintenance effort and costs. This differs from the more traditional practice of construction site sequencing, in which site-disturbing activities are performed initially for all or a large section of the site, leaving portions of the disturbed site vulnerable to erosion.

Develop a schedule. Construction sequencing schedules should, at a minimum, include the following:

- Erosion prevention and sediment control (EPSC) measures to be installed and the proposed schedule for each measure.
- A protocol for changing the EPSC plan due to wet weather and unforeseen problems.
- Principal development activities (*e.g.* site clearing, utility installation, BMP installation, site stabilization).
- Which measures should be installed before other activities are started.
- Compatibility with the general contract construction schedule.

Delineate staging and stockpile areas. This is critical for protecting vegetation and soils. The designer and contractor would ideally collaborate on this plan during the design phase. The contractor should share this plan with the team, especially subcontractors, in a pre-construction meeting or at weekly construction meetings, as needed. Stockpiling areas, the haul road, and other construction equipment such as site trailers should be located in the footprints of demolished infrastructure or areas of future disturbance.

<u>Plans and narratives should clearly identify:</u>

- Sensitive areas to be protected with fencing, if this isn't already shown on the construction documents (which may include wetlands, floodplains, steep slopes, habitat conservation areas, *etc.*)
- Other areas (infiltration facility locations, tree canopy, or any area without proposed improvements) to be protected with fencing

[8] *U.S. Environmental Protection Agency. (2004.).* Development Document for Final Action for Effluent Guidelines and Standards for the Construction and Development Category. EPA-821-B-04-001. Washington, DC.

- The haul road and other means of access between stockpiles, delivery locations and proposed infrastructure. Avoid stockpiling and parking vehicles under the canopy of trees to be protected, which compacts soil and can kill trees.
- Phasing of clearing and construction activities
- When materials will be delivered, how much space will be needed, and where they'll be stored until used

Construction

Do not stockpile materials and equipment under the canopy of trees to be preserved, since this can compact soils and kill trees. Unfortunately, it usually takes many years for construction impacts to trees to become evident, saddling the landowner with an unexpected expense, a maintenance hassle, and a loss of land value.

Throughout construction, implement appropriate erosion prevention and sediment control measures per 1200-C permitting requirements.

Depending on the project type, the sequence of construction events is often as follows:

1. Preconstruction meeting. Hold a preconstruction meeting to explicitly review the construction sequence, identification of no-work and restricted work areas, and the erosion and sediment control plans.
2. Fencing. Place fencing around areas to be protected. Fencing off areas can effectively limit disturbance. Plastic fencing is often used, but it has not been as effective as cyclone fencing at keeping sub-contractors out of areas. If a contractor doesn't want to make this investment, it can usually be rented for a reasonable fee. Fence off:
    A. Sensitive areas such as wetlands, floodplains, riparian areas, habitat conservation areas, steep slopes, etc.
    B. The critical root zone of trees (see Tree Protection BMP below)
    C. Future infiltration facility areas where rain gardens, stormwater planters, LID swales, vegetated filter strips, or porous pavement may be located.
    D. Any other areas not proposed for improvements
3. Build construction access, entrance to site, construction routes, and areas designated for equipment parking.
4. Protect bare soil. As soon as construction begins, stabilize any bare areas with straw, compost, gravel and/or temporary vegetation.
5. Sediment traps and barriers, basin traps, outlet protection. After the construction site is accessed, install principal basins to drain runoff into. Avoid using future locations of LID facilities. Add or relocate traps and barriers as contours change with grading operations.
6. Runoff control diversions, perimeter dikes, water bars, outlet protection. Install key practices after installing principal sediment traps and before land grading. Install additional runoff control measures during grading.
7. Runoff conveyance system, stabilize stream banks, storm drains, channels, inlet and outlet protection, slope drains. If necessary, stabilize stream banks as soon as possible, and install a principal runoff conveyance system with runoff control measures. Install the remainder of the systems after grading.
8. Land clearing and grading, site preparation (cutting, filling, and grading, sediment traps, barriers, diversions, drains, surface roughening). Implement major clearing and grading after installing principal sediment and key runoff-control measures, and install additional control measures as grading continues. Clear borrow and disposal areas as needed, and mark trees and buffer areas for preservation.

9. Surface stabilization, temporary and permanent seeding, mulching, sodding, riprap, shredded wood chips. Apply temporary or permanent stabilizing measures immediately to any disturbed areas where work has been either completed or delayed. Permits may have explicit duration limits for unprotected ground that is not being actively worked on.
10. Building construction, buildings, utilities, paving. During construction, install any erosion and sedimentation control measures that are needed.
11. Landscaping and final stabilization, top-soiling, trees and shrubs, permanent seeding, mulching, sodding, riprap. This is the last construction phase. Stabilize all open areas, including borrow and spoil areas, and remove and stabilize all temporary control measures.

Maintenance

Maintain EPSC measures on a schedule per construction documents. Follow the construction sequence throughout the project and then modify the written plan before any changes in construction activities are executed. Update the plan if a site inspection indicates the need for changes to the erosion prevention or sediment control.

MINIMIZE IMPERVIOUS AREA BMPS

Minimizing impervious pavement on new, redeveloped, and existing sites reduces runoff by replacing what is, or would be, impervious, with a better draining land cover. Thoughtful site design can reduce the amount of impervious surface, preserving open ground and reducing construction costs. Opportunities to limit disturbance by reducing impervious areas exist for a variety of different land uses.

These BMPs include:

- Share Parking Spaces BMP
- Minimize Front Setbacks BMP
- Share a Driveway BMP
- Depave Existing Pavement BMP

Siting and Design

Design of "*Minimize impervious area BMPs*" are site specific. These BMPs are recommended for reducing the impervious area to manage by Runoff BMPs. A checklist for these items are shown in **Form A** of the **LID Implementation Form** (Depave Existing Pavement in Form C). A short description of each are shown below:

Minimize Impervious Areas: Share Parking Spaces Bmp

In commercial districts, it may be possible to share Off-Street parking with another organization that has different peak hour use from your land use.

Minimize Impervious Areas: Minimize Front Setbacks Bmp

The closer a building is to the street, the shorter the driveway and sidewalk are to it, thus minimizing impervious area.

Minimize Impervious Areas: Depave Existing Pavement BMP

(See next section)

Maintenance (Common to all Minimize Impervious Area BMPS)

Impervious pavement remaining after minimization should be maintained according to guidance provided in **Chapter 3** "*LID Operations and Maintenance Process*", "*Site Maintenance*" to avoid polluting downstream waterways.

Figure 4-8. Volunteers learn about the connection between impervious pavement and water quality as they work together to remove unnecessary asphalt in their community.

MINIMIZE IMPERVIOUS AREAS: DEPAVE EXISTING PAVEMENT BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form C		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	

* This BMP does not offer this type of management
† Applies when meeting requirements in Chapter 2

Tearing out pavement and replacing it with landscaping is known as depaving. Depaving reduces the amount of runoff from an existing developed site by allowing infiltration and evaporation of rainfall and by providing area for runoff BMPs, such as rain gardens. Key steps to take during a depaving project are included in **Appendix A**.

Siting

There may be many small and large paved areas throughout the watershed that no one needs or uses, but that collectively impact water quality. Investigate how people use or don't use different sections of paved areas.

Consider current and past land use and be cautious with contaminated soils. Soils that smell bad or look unusual may be contaminated. Hydrocarbons from oils are easily broken down by microbes in the soil, which will be more numerous on the roots of plants. For hydrocarbons, exposing contaminated soils and replanting should not impact overall water quality; however, if there is any question or other contaminants are found, engage an environmental scientist or licensed engineer to devise a strategy for your project or find an alternative place to depave. (For more information on contaminated soils, see **Chapter 4** "*Criteria for Choosing BMPs: The BMP Suitability Matrix*", "*BMP Suitability for Challenging Sites*" above.)

Design

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**: BMP Implementation Criteria, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 2** "*The LID Design Process*".

Stormwater flows. Determine where water currently flows on-site. If runoff flows to the proposed depaved area, see **Chapter 4** "*Vegetated Stormwater Facilities BMPs*", "*Dispersion BMPs*", "*Vegetated Filter Strip BMP*" below for additional design considerations.

Developing Plans and a Budget. Develop a landscape plan (see **Appendix E**: Plant Specifications). Avoid lawn, if possible. Plan to restore the permeability of the soil according to **Chapter 4** "*Restored Soils BMP*" below. Soil will expand, and additional excavation and removal off-site may be necessary, so incorporate this into a budget.

Pavement edge stabilization. In asphalt areas with a pavement thickness of less than 2 inches, consider stabilizing the pavement edge. Approaches for this include installing extruded curbs around the top edge to redirect runoff, placing a flush curb adjacent to the pavement, cutting the pavement at a 45-degree angle, or installing a 12-inch level spreader (see **Chapter 4** "*Dispersion BMPs*", "*Supporting Infrastructure: Level Spreader*").

Deconstruction

Removing pavement can be a cost-effective way to add permeability to your site.

Figure 4-9. Large areas of depaving can be done by heavy equipment.

To effectively implement depaving:

1. Call 811 to request the marking of public utility lines to the property line. If the location of lines within the property is still uncertain, hire a private utility locating company to mark private utilities behind the property line. Take care when removing pavement over utility lines.
2. Notify neighbors about the proposed work and observe noise regulations.
3. Implement erosion prevention and sediment control measures. Keep soil covered with a natural, breathable material like jute. Install wattles, biobags, or compost socks at the bottom of stockpiles and encircle catch basins and area drains. Avoid sediment fences, which aren't effective at controlling fine soil particles like clay and silt. Additional measures may be called for (see **Appendix B**: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*").
4. Remove the pavement. Prepare the surface by cutting it into manageable 2-to-3-foot square pieces with a diamond-blade pavement saw. Asphalt removal can be done using a backhoe or with simple tools and cooperative muscle power. Once asphalt is pried up, it typically breaks down into smaller manageable pieces easily. Concrete is much tougher to remove by hand and will require a jackhammer to break it into smaller pieces. Asphalt and concrete can be readily recycled, often by recycling companies and pavement contractors.
5. Remove any rock installed below the pavement. Rock can be recycled or repurposed; however, avoid re-using crushed concrete in stormwater facilities. In studies, crushed concrete has increased the pH of runoff that has come in contact with it.
6. Amend the soils with organic matter compost (see **Chapter 4** "*Restored Soil BMP*") or shredded wood chips. The use of mycorrhizal treatments (*i.e.* mushroom roots) can kick start the biological activity and aid plant establishment, increasing the effectiveness of plant root areas to find nutrition already in the soil and reducing irrigation needs. (See **Appendix E** "*Soil Amendment Specifications*", "*Mycorrhizae*".) Depending on the pavement and rock depth removed, clean topsoil may need to be imported so that the landscape area can meet and match existing grades.
7. Re-vegetate the area with native grasses and grass-like plants, flowers, and shrubs. Trees will need to be planted in at least 140 square feet of soil. (To be healthy and long-lived, depending on the species, trees need access to at least 140 to 340 square feet of soil that is a minimum of 3 feet deep (see **Chapter 4** "*Tree Planting BMP*".)
8. Mulch the area with 2 – 3 inches organic matter compost or mulch per specifications in **Appendix D**. Avoid sawdust, which robs soil of nitrogen, and bark chips and bark mulch, which do not provide adequate nutrition.

Figure 4-10. Depaving, and the replanting that goes with it, is a great learning opportunity at schools.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Maintenance for depaved areas is the same as conventional landscape:

- Remove weeds twice a year, around May and October.
- Replenish compost in gardens to a depth of 2-3 inches and lawns 1/4 inch, annually.
- Irrigate per the guidance provided in **Appendix E:** Plant Specifications "*Establishment Period Irrigation*".

RESTORED SOIL BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management†			
Water Quality Management*			
Flow Control Management*			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form B		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	
* This BMP does not offer this type of management			

The practice of amending disturbed soils (*i.e.,* any soil in a town, city, or other historically populated area) is a simple, cost-effective practice for restoring and preserving the long-term permeability of soils compacted by vehicular or, in the case of clayey soils, even foot traffic. The practice also conserves water and reduces pesticide, herbicide, and fertilizer use. Soil health is a key element of watershed health[9,10]; however, soils at developed sites are highly impacted (see **Chapter 3**, "*The LID Construction Process*"). Loss of topsoil and compaction resulting from recent or long-past construction activities can be addressed by restoring soil quality.

Why Amend

Compaction reduces soil voids, reducing permeability. Restoring soil to a healthy condition is important because[11]:

[9] *EPA. (2011). Evaluation of Urban Soils: Suitability for Green Infrastructure or Urban Agriculture. EPA Publication No. 905R1103. Retrieved from: http://water.epa.gov/infrastructure/greeninfrastructure/upload/Evaluation-of-Urban-Soils.pdf*

[10] *USDA NRSC. (2005). Urban Soil Primer: For homeowners and renters, local planning boards, property managers, students, and educators. Retrieved from: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052835.pdf*

[11] *Center for Watershed Protection (CWP). (1999.). Diazinon sources in runoff from the San Francisco Bay region. Technical Note 106. Watershed Protection Techniques 3(1): 613-616, and Schueler, T. 1995a(1995). Nutrient movement from the lawn to the stream. Watershed Protection Techniques 2(1): 239-246.*

- Plant establishment depends on roots' access to air and water in soil voids. Thus, compaction results in unhealthy plants by leading to diseased leaves, poor or no flowering, or even early death. Landowners often respond to unhealthy plants by applying pesticides, herbicides, fertilizers and additional irrigation, which increases runoff pollution.
- Rain falling on compacted soil can no longer be absorbed and conveyed downward into the soil, but instead runs off, carrying pollutants with it. In fact, out of a number of different land uses, lawns are the most likely to export sediment to waterways. This is significant, because many pollutants attach to sediment and sediment is a pollutant itself.

Figure 4-11. Restored soils can be used in any kind of landscape to reduce long-term maintenance and reduce or eliminate the need for pesticides and herbicides and irrigation.

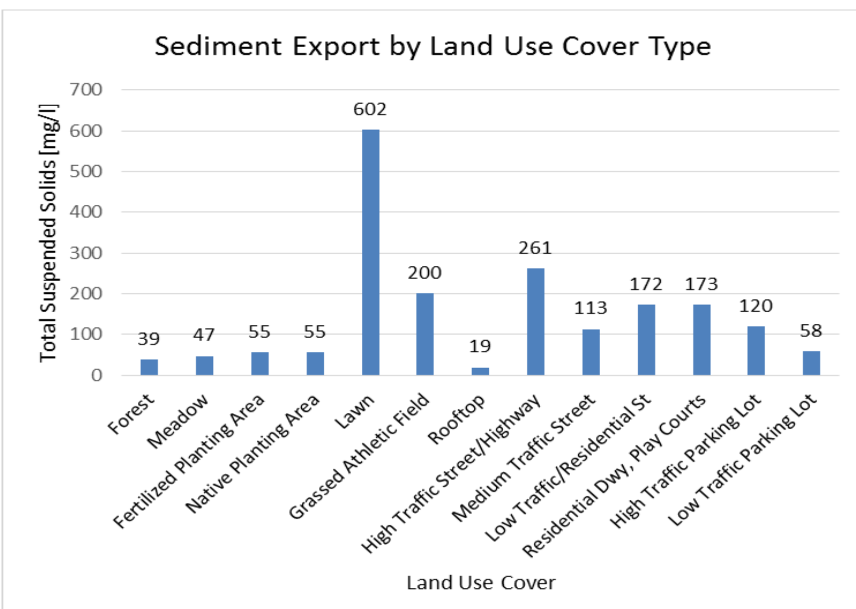


Figure 4-12. Soil exported from a variety of different land-use covers, after construction is completed. Even though runoff volumes are lower from lawns than impervious surfaces like highways, sediment export is much, much higher. [12]

[12] *Adapted from the Pennsylvania Stormwater Best Management Practices Manual", (Table 8.3). Retrieved from: (http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-68851/363-0300-002.pdf) with more recent data for some values, incorporated from the Center for Watershed Protection. Urban Stormwater Retrofit Practices, Appendices. (2007).*

In studies done by Washington State University Extension Service, simply ripping or tilling soil allows the soil to slump back into a compacted state. These studies found that when compost was applied to disturbed soils runoff was reduced by 50% annually from lawn areas and by 80% annually from perennial shrubs areas. Equally important, the areas continued to be permeable over time. The practice also increases the water holding capacity of soil[13]. In Western Washington this practice is required in their Western Washington Stormwater Management Manual for all jurisdictions and projects because it helps to "regain greater stormwater functions in the post development landscape, provides increased treatment of pollutants and sediments that result from development and habitation, and minimizes the need for some landscaping chemicals, thus reducing pollution through prevention"[14].

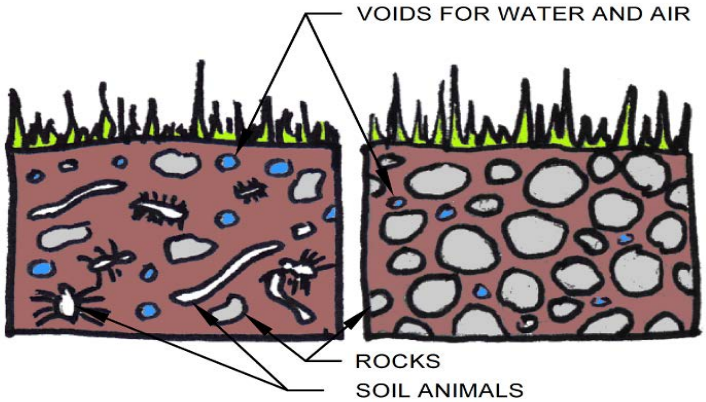


Figure 4-13. In undisturbed soils (left), beneficial soil animals, from tiny microbes to beetles and other larger fauna, chemically break down some pollutants and provide nutrition to plants. As they move through the soil, they protect long-term permeability and promote soil formation. In disturbed soils (right), compacted soils tend to have fewer voids and significantly less soil life.

Siting

With a few exceptions noted below, restored soils should be used anywhere soils have been disturbed and where a future landscape area is proposed. Any soil texture will benefit from compost amendment, but sites with clay will benefit the most.

Soil restoration should **NOT** be performed:

- Within sensitive areas. Avoid digging under tree canopies or other established landscape areas to be preserved since the tilling process damages roots. Avoid other protected sensitive areas, as shown on the plans by temporary protection fencing (see **Appendix B**: BMP Implementation Criteria "*Protecting Permeability*").
- On slopes greater than 2:1 (horizontal: vertical).
- Over utilities with any material that may be less than 12 inches deep.

Design

Grading plans should show a 5% minimum slope away from buildings for a distance of 10 feet in landscape areas to ensure adequate drainage during large storms, which are expected to generate high volumes of runoff. This is a common rule of thumb and shouldn't change the grading design from that of a conventional stormwater approach.

[13] *USDA NRCS website infographic. Retrieved at: http://www.nrcs.usda.gov/Internet/FSE_MEDIA/stelprdb1143828.jpg*
[14] *Washington Department of Ecology. Building Soil. Retrieved from: http://www.buildingsoil.org/tools/Soil_BMP_Regs.pdf*

Figure 4-14. Urban soils, especially clayey soils, are easily compacted, even by foot traffic, generating runoff volumes similar to that of hardscape surfaces like impervious sidewalks and roads.

Soil Elevation Considerations
Compacted soils have few voids, which makes them "compact". When soil is loosened by tilling and amending, the finished soil elevation, or "grade", will be a few inches higher than previous grades.

If landscape grades are raised above pavement grades and tip towards that pavement, when stormwater runoff does occur, much more sediment is conveyed to downstream waterways.

Plan to excavate deeper than expected or place the soil where it will not runoff towards a drain and/or a waterway. The volume of soil to relocate on-site or haul away will depend on the soil type and the extent of compaction within the first 12 inches of depth. Consult a general contractor or a landscape contractor to estimate depths and volumes for your site.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**: BMP Implementation Criteria, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Incorporate Organic Matter Compost. For all proposed landscape areas in the disturbed area (clearing, vehicular and/or foot traffic, re-grading), specify compost to be tilled into the top few inches of native soils. The ideal organic content is 10% for landscaped beds. A lower target rate for turf areas of 5% is recommended since a higher organic content could make mowing more difficult. (See **Appendix D** "*Specifications*", "*Organic Matter Compost*".)

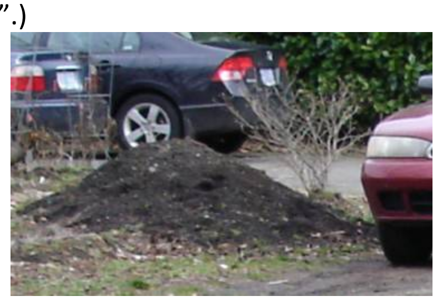


Figure 4-15. Compost should be fully composted (in other words, have an earthy smell, not ammonia) and be dark colored.

Construction

Like all stormwater management facilities, special care must be taken to properly construct BMPs. Protecting the infiltration capacity of the soil is crucial to the long-term functioning of any infiltration facility. See Appendix B: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project. Mistakes in construction can lead to unintentional damage to the facility (*i.e.* clogging) or to long-term maintenance challenges (*i.e.* plant replacement). Amending soils should happen at the end of construction or at least at the completion of concrete work. "Building Soil"[15] contains a detailed methodology to calculate the appropriate depth of compost to use to

[15] *Washington Department of Ecology. Building Soil. Guidelines and Resources for Implementing Soil Quality and Depth BMP T5.13. Retrieved from: http://www.soilsforsalmon.org/pdf/Soil_BMP_Manual.pdf*

achieve the desired percentages discussed above, but the following guidance is a method that can safely and easily be applied, without calculations or lab testing, to all soils (sandy, clayey, silty, *etc*.). Soil moisture will ideally be lower than 50% of field capacity, at the time of amendment[16].

To amend proposed gardens:

1. Till or scarify soil 12 inches deep.
2. Place 3 inches of compost and till into 5 inches of soil (a total amended depth of about 9.5 inches, for a settled depth of about 8 inches).
3. Rake beds smooth and remove surface rocks larger than 2 inches in diameter.
4. Mulch planting beds with 2 – 3 inches of organic mulch.
5. Install plants.
6. Water plants.

To amend proposed turf areas that will be mowed:

1. Till or scarify 12 inches deep.
2. Place 1.75 inches of composted material and till into 6.25 inches of soil.
3. Water or roll to compact to 85% of maximum dry density. Rake, level, and remove surface woody debris and rocks larger than 1 inch diameter.
4. Install plants or seed.
5. Water plants or seed.

Figure 4-16. Lawn or garden, the same cross section of loosened and amended soils applies.

Protect areas from compaction by heavy equipment with fencing and signage. Apply appropriate erosion prevention and sediment control techniques (see "*LID Construction Process*" in **Chapter 3**), as appropriate, until landscape stabilizes the soil, usually in 3-6 months, but more time may be required depending on the vegetation and the time of year.

Figure 4-17. A range of construction equipment (cat mounted ripper, tractor-mounted disc, tiller, etc.) or hand tools such as broadforks and rakes may be used to till and amend soils, depending on the extent of the area to be amended and equipment access.

[16] *USDA NRCS. Deep Tillage. Conservation Practice Standard, Code 324. (2011). Retrieved from: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1241314.pdf*

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Maintenance of restored soils is similar to any landscape area.

- Reduce or eliminate the use of irrigation, fertilizers, herbicides and pesticides, especially if using all or predominantly native plants.
- Leaf litter left on grass over the winter may kill it; however, leaf litter left to decompose on landscape areas, instead of raking in the fall is an effective mulch.
- If the leaf litter aesthetic is not desirable, Mulch once a year with 2 – 4 inches of organic matter compost (see Specifications in **Appendix D**) in perennial garden areas or turf areas, aerate and top-dress with ¼-inch fine mulch[17].
- Alternative: Mulch once a year with 2 – 4 inches of shredded wood chips for perennial gardens and single trees. See Tree Planting BMP for more information on maintenance of individual trees.

[17] *Washington State University LID Course, Soil Management.*

CONTAINED PLANTER BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form E		
Worksheet	N/A		
Drawings			
Title		**Detail**	
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Contained planters placed over existing impervious areas, on the ground or roof, intercept rainfall and then evaporate it back into the air, even in the winter. As an alternative to depaving, place a potted plant anywhere there is unused pavement. Acting much like vegetated roofs, contained planters can reduce annual runoff by 40% to 60% from the area on which they are placed while also improving the aesthetics of paved areas.

Siting

Contained planters should be placed over impervious areas only. Placing them over porous pavements will not reduce runoff – the porous pavement is already designed to do that – and dirt washing through the system could clog the pavement.

Design

Container Materials. The container must drain from the bottom. Since these will be outside year-round, consider durability.

Avoid:

- Plastic, since it is photodegradable and will break down in sunlight and can leach phthalates, a pollutant often found in groundwater.
- Treated wood. Even "environmentally friendly" treated wood will leach copper, which is a potent pollutant that affects endangered aquatic species.

Suitable materials include:

- Untreated wood. Choose cedars or other naturally rot-resistant woods for more longevity. Wine barrels cut in half are a popular aesthetic.
- Fabric "sack gardens" such as jute, hemp, flax, linen, burlap, *etc*. Ensure that the fabric is not treated with fire retardants.
- Ceramics. Long-lasting and safer than plastic. Avoid containers with metal glazes that could leach into the environment.
- Concrete or cement.

Container Size. Deeper containers are better suited to deeper rooting plants and dry out less quickly than shallow containers. Twelve (12) inches of soil is considered a minimum to be considered a deeper container, although the type of plant may dictate a deeper container. (See **Appendix E** "*Plant Specifications*" for more information on what depth of soil is needed by different plants.) The larger the container's diameter, the more impervious area it will cover, which makes it more effective at reducing runoff.

Plant Choices. Annual plants are suitable for use in contained planters, although native perennials that won't require as much irrigation after an establishment period of 2 – 3 years are preferred. Flowering plants and vegetables that take more fertilization than non-flowering plants should be avoided, minimized, or not fertilized.

Trees are generally not suitable for containers. Trees often become root bound in a container without adequate soil volume, which impacts overall health and longevity. (See **Chapter 4** "*Tree Planting BMP*".) Consult an arborist for assistance in choosing from tree species that will be healthy and low maintenance, since species choices are limited. Choose hardy species adapted to dry conditions. There are some species that will not thrive in the harsh environment of a container, which is subject to large temperature swings and can easily dry out. See **Appendix E**: Plant Specifications for more information on choosing the right plant for the right place.

Figure 4-18. Contained planters are a common beautification project that benefit the watershed when placed over impervious surfaces. In a dense, "main street" application like this photo, the planter footprint shouldn't exceed the width of the furnishing zone (i.e. the pavement area between the curb and the walking area of the sidewalk), which is the area where signs, benches, parking meters or other similar infrastructure might be placed. This will ensure that sidewalk traffic is not impeded by a narrowed throughway.

Soils. Consider using a native soil, an amended native soil per amended soil mix specifications in **Appendix E**, or imported topsoil[18] instead of store-bought potting soil (even if formulated specially for containers) because:

- Potting soil is designed to over-nourish plants. As rainfall runs quickly through potting soil, it leaches nutrients out, which are carried downstream to impact water quality.
- Potting soil is sterile. Plants benefit from microbes, mushroom roots (mycorrhizae), and larger soil animals like beetles, which move and process nutrients and preserve permeability. If you do use potting soil, throw a handful of organic soil into the pot.
- Potting soil is usually less dense than native soil, which makes it less resistant to temperature swings.

If the native soil is clayey or sandy, amend it with compost, using 2 parts native soil and 1 part compost (per compost specifications in **Appendix D**). If your soil is sandy, folding in some compost will help slow water as it passes through, which will reduce runoff and help keep some water in the soil for the plants to access. For any kind of soil, mycorrhizal treatments will make your plantings more resilient and reduce water demand. (See **Appendix D** for mycorrhizae specifications.) For contained planters on roofs with adequate structural integrity or shallow pots on the ground, you may want to consider purchasing engineered lightweight growing medium. See **Chapter 4** "*Vegetated Roof BMP*" for soil mixes, loading capacity, and other design considerations when putting plants on roofs.

Figure 4-19. Contained planters can be dual purpose. These benches were created to intercept some rainfall while also providing seating on a roof terrace.

Construction

See **Appendix E**: Plant Specifications "*Planting Technique*".

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

[18] Be aware that some topsoil is a source of horsetail, which is often considered undesirable. Even though horsetail is native to Western Oregon, it spreads rapidly, pushing other species out. Due to its deep roots (up to 12 feet), there are no known effective means for removing it once it is introduced to a site. If this is a concern, instead of importing soil from off-site, use the method outlined in Appendix D "Treatment Soil" to amend soils from the development site where horsetails are not growing.

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Since contained planters are above ground, they are more susceptible to freezing and may drain faster than the soil around plants that are in the ground; however, maintenance for contained planters is similar to conventional landscape maintenance practices:

- Remove weeds twice a year.
- Replenish compost to a depth of 2-3 inches annually. Avoid NPK fertilizers (nitrogen -- phosphorus -- potassium) as nitrogen is a common pollutant found in waterways and will easily dissolve in water, flow out of the container bottom onto an impervious surface, and likely into a pipe that drains to a waterway. Replenishing the 2-3" of organic compost every year should provide adequate nutrition slowly and safely.
- Repot plants with native soil and compost, or imported topsoil, on a schedule as desired or needed to keep plants healthy. Avoid potting soil, which will over nourish plants and cause nutrient pollution as described above.
- Irrigate per Establishment Period Irrigation guidance in **Appendix E**: Plant Specifications.
- Since contained planters will be on and presumably surrounded by impervious pavement or hot roofs, water plants once a week from July to mid-September after establishment period.

TREE PLANTING BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management†			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Forms	Form B (Landscape) Form E (Hardscape)		
Worksheets	Worksheet B1 Worksheet E1		
Drawings			
Title		**Detail**	
Tree with Berm		BMP 10.01	
Tree with Berm (Existing Soils Restored)		BMP 10.02	
Tree on Slope		BMP 10.03	
Tree on Slope (Existing Soils Restored)		BMP 10.04	
† Applies when meeting requirements in Chapter 2			

New trees are often required for a variety of reasons during the development process, for example, to screen conflicting uses, improve livability and health, reduce energy demand (windbreaks and shading), or to express a community's historical and cultural identity. Trees also provide important water quantity regulation and water quality treatment benefits (see **Chapter 1** "*Why Use LID*"). The benefits of new trees are often small when first planted and accrue over time. Proper tree planting, using the following guidance, is essential to long-term tree survival, health, and safety.

Siting

Trees have minimum above and below ground requirements as follows:

- Plant trees where they have plenty of room to grow to maturity. Make sure there is now, and will be at tree maturity, adequate clearance from overhead utility lines, pedestrian and vehicular traffic, buildings, signs, street lights, and any other permanent infrastructure, as well as sight lines at intersections.
- Call 811 to locate utilities in the public right-of-way[19] and/or hire a utility locater to paint utility locations on private property.
- Refer to Article 23 for landscape and buffering standards.

Figure 4-20. Tree roots grow far beyond the tree canopy when given the space to grow. Courtesy of Casey Trees.

- Provide trees with adequate soil volume for tree growth and stability. Recommended volumes range between 400 to 1,000 cubic feet as follows: 2 cubic feet of soil volume for each square foot of mature canopy is recommended[20].

[19] *Oregon 811-Utility Notification Center. Retrieved from: http://digsafelyoregon.com/*

[20] *Lindsey, P. and N. Bassuk. (1991). Specifying Soil Volumes To Meet The Water Needs Of Maturing Urban Street Trees And Trees In Containers. Journal of Arboculture. 17(6):141-149. Retrieved from: http://www.hort.cornell.edu/uhi/research/articles/JArb17(6).pdf*

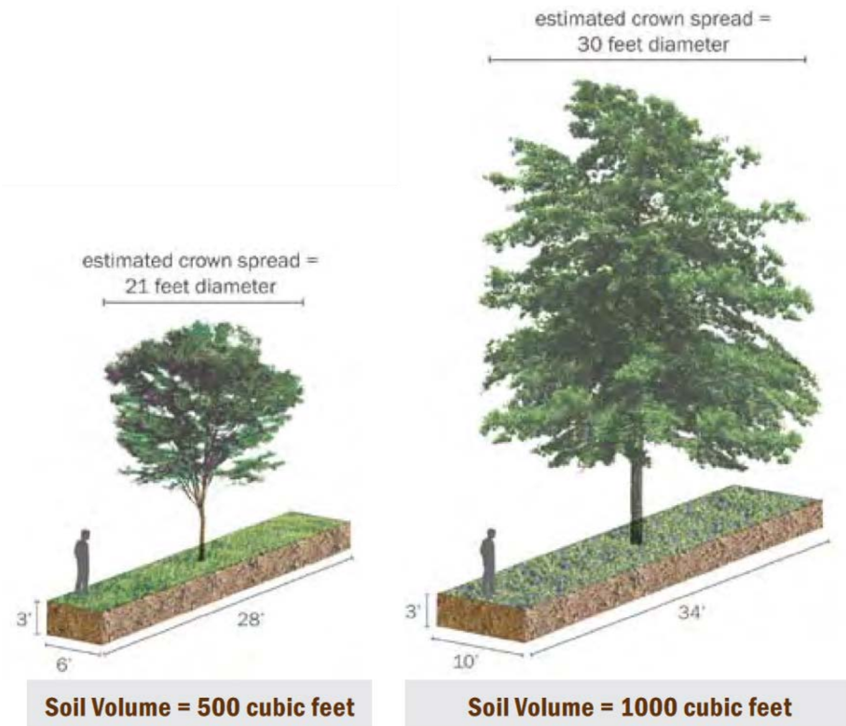


Figure 4-21. The greater the mature canopy, the greater the soil volume needed to support a healthy, low maintenance, and long-lived street tree. Courtesy of Casey Trees.

- Provide adequate soil depth. While tree root depths vary with species, a general minimum rule is 3 feet.
- Provide adequate soil quality using **Chapter 4** "*Restored Soil BMP*" or soils per Appendix D: Specifications, "*Treatment Soil*" or **Appendix D**: Specifications "*Structural Tree Soil Mix Specifications*".
- In parking lot islands or in planting strips, an ideal width is at least 5 feet. The minimum width is 1 foot plus the projected trunk diameter at the soil line, which includes the trunk flare and varies with species.
- Refer to Article 23 for a list of recommended street trees.
- For sites with overhead utility lines, choose a tree species whose maximum height at maturity will be less than the height of the overhead utility line.
- To maximize stormwater value, consider using evergreen trees, which actively manage stormwater in the winter, instead of deciduous trees.

Design

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Site Design to Achieve Adequate Soil Volume for Constrained Spaces. When planted in spaces with inadequate soil volume, many trees will push up the surrounding pavement to access air and water, causing damage.

For tree planting in existing locations with no new development planned, choose long linear areas that are at least 5 feet wide and 80 feet long. Since most tree pits are much shorter than this, special design considerations for new and redevelopments, street trees in a planting strip between a sidewalk and a road, trees in a parking lot island, and trees in other constrained spaces should be followed.

<u>On new and redevelopment projects, to achieve the recommended soil volume and depth:</u>

- Provide a long linear area where soil may be shared by multiple trees, instead of small pockets of soil in cutouts, either in open or covered soil areas.

Figure 4-22. Open soil areas can be continuous or separated by pavement. Open soil areas can be planted with groundcover, ornamental plants or grass, or covered with mulch as shown in the images above. Photos courtesy of Casey Trees.

Figure 4-23. A variety of pavements, both impervious and permeable, can be used to create a covered tree space. Pavers, such as granite cobbles and permeable paver blocks (shown above left and middle), placed with gaps between the stones allow water to flow to the soil below. Grates can be used as a soil covering when they are not immediately adjacent to the tree. Photos courtesy of Casey Trees.

- Provide multiple root paths underneath sidewalks and other narrow pavement areas that have soil on the opposite side of the pavement where the mature canopy is projected to grow (***Figure 4-24***).

Figure 4-24. Root paths under construction, shown in ground trench (above left) and extending out from a tree space (middle, photos courtesy of James Urban). Root paths run under the pavement to connect tree spaces to landscape areas (above right). Photos courtesy of Casey Trees.

- Plant a tree in the site's available soil and use structural tree soil underneath porous or impervious pavement to expand the available soil. Compact the structural soil just enough to provide structural support for pedestrian or vehicular traffic but not so compacted that roots are unable to penetrate the material, as is the case in most impervious sidewalks and pavements. (See **Appendix D**: Specifications "*Structural Tree Soil Mix*".)

<u>To determine the appropriate depth of material, there are two options:</u>

- With compaction of subgrade. Excavate to a depth of 3 feet. Compact the subgrade as you would for a road and place 3 feet of structural soil (placement described in "Construction" below). The compaction effort for roads is usually a standard described as "95% modified proctor density" but consult your specifications or a qualified licensed professional. This may be the most cost-effective method for small or simple projects, and for projects solely concerned with tree planting and not protecting the infiltration capacity of the soil.
- No compaction of subgrade. A licensed engineer determines the mix density at 85 to 90% compaction. They will also inspect the site soils to determine their structural stability under a wet, uncompacted condition. Then, they determine the depth of structural soil, at 85% compaction, needed to support the predicted traffic loads on the wet, uncompacted native soil below. This may be the most cost-effective method for larger, more complex projects since money is saved by reduced excavation and disposal (or reuse) and no compaction. This may also reduce the depth of structural soil, a comparatively expensive material, needed by one foot or more.

Figure 4-25. Structural soil is a blended soil mix of angular open-graded (i.e. all the same or similar size) rock, clay, stabilizer, and water that, when correctly and lightly compacted supports traffic loads and healthy tree root growth. The keychain is for scale.

Figure 4-26. This project used structural soil in 4-foot-wide strips underneath the pavement, on either side of the (also 4-foot-wide) planting strip to support traffic loads and healthy root growth. This system (called a Parking Forest www.parkingforest.org) can be used in existing parking lots to increase canopy without losing parking spaces.

- Plant a tree in the site's available soil and use a suspended pavement system (Figure 4-27) to provide the remainder of the soil volume needed. There are some suspended pavement systems on the market or these are often constructed of concrete (Figure 4-27). When using a concrete system, consult a licensed engineer for roadways or sidewalks or other qualified licensed professional for sidewalks.

Figure 4-27. The same elevated pavement in a parking area during three different stages of development. (Left and center photos courtesy of Jim Labbe. Right photo courtesy of Jeff Mandel.)

Tree Selection. Using the following guidance to select trees for your site:

- Select a tree of appropriate mature size for the site.
- Select a tree with a 1 ¾ inches caliper (diameter of trunk at 12 inches from the ground) per Grants Pass code that guides caliper size.
- Select the right plant for the right place. See Appendix E: Planting Specifications for more information on choosing the best kind of tree (native versus non-native and other considerations) for your site.
- Use a diversity of tree species and varieties to build resilience to such common challenges as pest or disease infestation and to add visual interest.
- While most tree roots are found in the top 3 feet of soil, some species like Maples tend have a higher percentage of shallow surface roots. Pick a species suitable to the site and if planting near pavement, avoid trees that tend to have shallow surface roots.

Standard Details. See standard details BMP 10.01, 10.02, 10.03, and/or 10.04 to include applicable details in construction documents. These are available in pdf, jpg, and AutoCAD .dwg format.

Construction

Site Preparation. The following guidance should be used to plant any tree, regardless of how adequate soil volume is provided:

- Call your local utility locate service – dial 811[21] – before digging. Always have utilities located prior to installing trees on any site.
- Break up compacted soils in an area 5 to 10 times the width of the new tree's root ball or container.
- Dig a planting hole that is at least twice the width of the new tree's root ball or container; larger is even better.
- Dig the planting hole no deeper than the height of the root ball from its base to the bottom of the root collar.
- Do not add fertilizer or other soil amendments to the planting hole.

Tree Planting. Refer to Figure 4-28 when considering the following tree planting guidance.

- Move the tree using only the root ball or container. (Using the tree trunk as a "handle" to move trees can break tree roots or even the trunk.)
- Plant the root collar at or slightly above ground level, never below.
- Remove all, wires, string, straps, burlap, and wire baskets from the root ball. Remove plant tags only after City approval/inspection of tree.

[21] *Oregon 811-Utility Notification Center. Retrieved from: http://digsafelyoregon.com/*

Avoid adding fertilizer or compost to the hole. This causes the roots to stay in the more fertilized area of the hole instead of spreading out into the native soil. Trees become root bound, as if they were in a container and the long-term health of the tree is greatly impacted. To avoid this, either amend at least 300 square feet around where the tree trunk will be using the "*Restored Soils BMP*" (see Chapter 4) or do not amend the hole or any area around it all, choosing a tree that will do well in existing native soils. If you choose to fertilize anyway, avoid high nitrogen content fertilizers because they can be polluting. Use only slow release fertilizers just in the planting hole or applied during the summer.

- Backfill the planting hole with the original soil.
- Water thoroughly when the planting hole has been filled halfway and again when completely backfilled to lightly compress soil around roots and eliminate air pockets.
- Build a bermed watering ring with leftover backfill soil around the tree a few feet from the trunk unless soil conditions are very wet.
- Place coarse organic mulch or shredded wood chips (per **Appendix D**: Specifications, "*Mulch*") in the watering ring to a depth of 4 to 6 inches to conserve water and keep the root zone cool. Do not let mulch touch the tree trunk.
- Do not stake the tree unless it is unable to stand upright on its own or is in a high traffic area. Remove stakes and guying materials after 1 year or when the tree feels firm in the ground.
- Wire should not be used as a guying material; even enclosed in tubing, it tears the thin bark of young trees and may girdle the tree as it grows; girdling kills trees eventually. Use soft rubber links or other stretchy materials that are not abrasive.

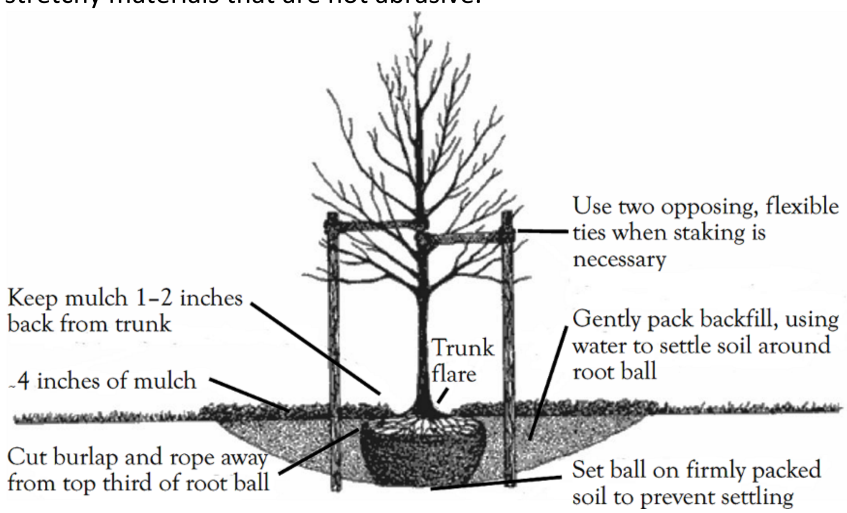


Figure 4-28. Recommended tree planting method. Adapted with permission by the International Society of Arboriculture.

Structural Soil Placement. Where adequate soil volume is provided using structural soil, see **Appendix D**: Specifications, "*Structural Tree Soil Specifications*" for information on mixing and placement.

Maintenance

The amount of maintenance a tree requires depends on the species, the tree's location in the landscape, its age, and the care (or abuse) it has been given throughout its lifetime. Basic tree maintenance begins with regular inspections to determine a tree's needs, which may include pruning, mulching, fertilization, irrigation, and pest management.

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

New Tree Care after Planting. Maintenance specific to new trees is as follows:

- Prune only dead, broken, crossed, or rubbing branches; inspect for pruning needs annually.
- Water per **Appendix E**: Plant Specifications, "*Establishment Maintenance*", "*Irrigation*".
- Establish tree protection zones (see **Chapter 4** "*Limit Disturbance: Tree Protection*") around new trees.
- Inspect newly planted trees regularly to evaluate condition and maintenance needs.
- Remove tree watering rings after one year.
- Remove stakes and guying materials after one year or the tree feels firm in the ground.
- Develop an integrated maintenance and care program using integrated pest management practices to reduce costs as well as negative environmental impacts.

Long-term maintenance.

- Don't top trees. Cutting off the top of the main stem of trees will makes trees hazardous and require more maintenance. Topping makes a tree more susceptible to storm damage and drastically reduces its ability to feed itself through photosynthesis. Open wounds make a tree more susceptible to internal rot, insects, and disease.
- Pruning is the deliberate removal of tree branches and limbs to achieve a specific objective in the alteration of a tree's health and form. Regular inspections to determine a tree's pruning needs should be a part of every tree maintenance program. Always determine the objective for pruning before beginning the work. For detailed information on pruning techniques, see the Oregon State University Extension publication "Tree Protection on Construction and Development Sites"[22]. In addition, the American National Standards Institute (ANSI) publishes tree pruning and safety standards, known as ANSI A300 (Part 1): Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Pruning). The ISA has developed BMPs for pruning in relationship to the ANSI standards; these guidance documents are available for sale through the ISA Web site[23].
- Properly remove and replace trees as needed. For more information on proper tree removal and replacement, see the Oregon State University Extension publication Tree Protection on Construction and Development Sites". For deciduous trees, a pruning schedule and specific guidance to improve tree stability during storms is provided in "Developing a Preventative Pruning Program: Young Trees"[24].
- Mulch trees once a year per guidance provided in Appendix D: Specifications, "*Mulch*".

Pitfalls and Common Mistakes

Common mistakes made in tree planting and establishment include the following:

- Selected species or variety not appropriate for site conditions (available growing space, soil moisture and pH, sunlight, temperature, or general climate). See Appendix E "*Plant Specifications*".
- Poor quality planting stock is chosen. Select only good quality planting stock. Select nursery stock that meets the minimum standards for root ball size and quality as defined in ANSI A300 (Standards for Nursery Stock). Consider engaging a qualified licensed landscape professional, such

[22] *Oregon State University, Extension Service. (Dec., 2009) Tree Protection on Construction and Development Sites. Retrieved from: http://goo.gl/Tl5kOU*

[23] *International Society of Arboculture. Retrieved from: http://www.isa-arbor.com/*

[24] *Gilman, E. and A. Bisson. (2007). Chapter 12: Developing A Preventive Pruning Program: Young Trees. Document 1062. School of Forest resources and Conservation and the Environmental Horticulture Department. University of Florida Extension. retrieved from: http://edis.ifas.ufl.edu/pdffiles/EP/EP31500.pdf*

as a landscape architect, arborist, or landscape contractor to identify and physically tag desirable plants at the nursery.

- Tree is planted in a hole that is too small.
- Inappropriate soil amendments or mixtures are added to the transplanting hole.
- Roots of transplant stock are not protected from heat and wind damage during transportation and pre-planting storage. Protect trees from wind damage during transport by wrapping the whole tree including roots with a tarp or landscape fabric.
- Trees are planted too deep. Root collar must be planted at or just above soil level.
- Regular after-planting care, especially supplemental water, is not provided during the 3-year establishment period.
- Trees are staked unnecessarily and/or incorrectly.
- Stakes and guy wires are left on the tree too long.
- The root ball is unprotected. Protect the root ball of transplant stock with mulch or other protective measures during storage, transport, and planting activities.

VEGETATED ROOF (GREEN ROOFS) BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form E		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Vegetated roofs are roof system assemblies that manage stormwater by holding rainfall in the pores of the growing medium, the drainage layer below if used, and by plants. While the term "green roof" is a more commonly used term, the term "vegetated roof" is more appropriate for The City of Grants Pass dry summers, where some plants are dry and inactive until the rainy season begins again.

Evaporation from the growing medium and evapotranspiration from the plants releases a high volume of moisture back into the atmosphere, even in winter, which is unique amongst all the BMPs in this guidance. Vegetated roofs usually consist of a waterproof membrane, an optional drainage layer, an engineered growing medium or soil, and a layer of plants and optional mineral mulch for non-irrigated systems, see BES Red Cinder Guidance[25].

They are an attractive alternative to conventional roofs and provide several benefits in addition to reducing stormwater runoff. These structures can attract wildlife by creating habitat, establish green/open space for social or aesthetic purposes, moderate indoor building temperatures in summer and winter reducing cooling bills[26], minimize the effects of urban heat islands, reduce noise, and improve air quality. Vegetated roofs have proven successful in Europe, outlasting traditional roofs by as much as 30 years.

Figure 4-29. A vegetated roof above an underground parking facility serves as a park at the street level. Trees need three feet of soil and can add a lot of weight; however, one strategy for accommodating trees is to add soil depth and place trees only over building columns or load bearing walls.

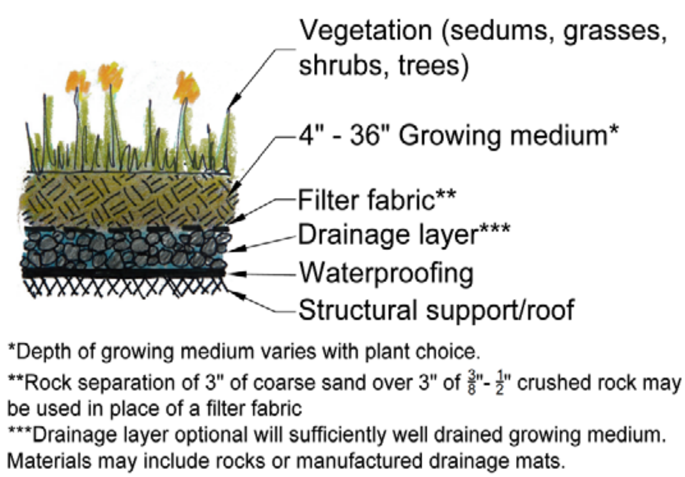


Figure 4-30. Typical vegetated roof cross section showing a range of growing media depths. Many new techniques are emerging. For instance, at Pringle Creek in Salem and other places as well, the growing medium drained quickly enough that no drainage layer or filter fabric is needed.

---

[25] *City of Portland, Bureau of Environmental Services.(Sep 2013) "Red Cinder Ecoroof Design Guidelines" Retrieved from: https://www.portlandoregon.gov/bes/article/464519*

[26] *City of Portland. (2008). Cost Benefit Evaluation of Ecoroofs. Retrieved from: https://www.portlandoregon.gov/bes/article/261053*

Siting

Roof Slopes. Vegetated roofs can be installed on a variety of sloped roofs. The maximum possible slope is related to the friction that can build up between the different components. Roofs up to a slope of 20 degrees generally will not slump and need no special design to keep the growing medium in place. Those with slopes greater than 20 degrees require a system such as horizontal strapping, laths, battens, or grids that prevents the growing medium and vegetation from slumping. These systems will also slow water flow through the assembly.

Figure 4-31. Growing medium was stabilized with lumber to keep it from sliding down the steep slope.

Roof Aspect. Roof aspect is the direction that a sloped roof is facing. North and east directions are considered excellent aspects for vegetated roofs, since they have reduced exposure to the sun and require less, and sometimes no, irrigation, depending on plant choices. South and west directions may require increased growing medium depths and more irrigation to support plant life. Shading from nearby vegetation and structures may reduce the need for permanent irrigation; reflection of light from nearby structures may increase it.[27]

Design

Depending on the scale and complexity of the project, the design of vegetated roofs may involve a number of qualified licensed professionals, including a structural engineer, landscape architect, architect, and/or a "Green Roof Professional" (certification offered by Green Roofs for Healthy Cities[28]).

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Structural Capacity. A licensed engineer with experience in structural design should determine the

[27] *City of Portland. (Fall, 2008). Ecoroof Seminar Series.*

[28] *Green Roofs for Healthy Cities. GRP Accreditation. https://greenroofs.org/education-1/*

structural capacity and structural details of the building/structure upon which vegetated roofs are to be installed, regardless of whether the project is for a new development, redevelopment, or retrofit. Loading calculations should include all the materials in the vegetated roof assembly, assuming they are fully saturated, as well as any additional water that may be ponded above the level of the soil as a result of the chosen overflow structure. The roof load capacity must be calculated separately from the snow load capacity.

Growing Medium. The growing medium is an engineered soil mix that provides nutrition to the plants and helps manage peak runoff volumes. Choose the depth of the growing medium based on the following criteria:

- **Stormwater Management.** The minimum depth for stormwater management is 4 inches. Studies in Portland and Seattle indicate that vegetated roofs can reduce annual runoff volumes by 40-60%. If the remaining runoff is infiltrated, vegetated roofs are the only BMP in this guidance that can restore the regional pre-developed water balance (see **Chapter 1**, "*Why Use LID*", "*Protecting Water Quality by Addressing Water Quantity*").
- **Plants.** Growing medium must be deep enough to contain adequate water and nutrients to support the chosen plants or conversely the plants must be chosen to match the soil depth per Appendix E: Plant Specifications.
- **Structural Capacity**. More shallow depths are applicable to new, re-development, and retrofit situations. Deeper growing medium is likely to be most cost-effective in new or re-development projects if structural upgrades to an existing structure are already needed on a retrofit project.

Growing Medium Specification. A commonly available growing medium consists of a mix of 70% porous material, 20% organic material and 10% digested fiber. Other growing medium mixes may be proposed by a licensed engineer willing to sign and stamp the design. Water retention rates should be 40% by weight or greater. Bulk dry densities should be 20 to 50 pounds per cubic feet.

Vegetation. Plant species choice drives other costs and decisions about irrigation, soil depth, root barriers, and structural capacity. A variety of trees, shrubs, herbs, succulents and grasses can meet the criteria below. Sedums are highly successful.

<u>Criteria for plant selection are as follows:</u>

- Adapted to the pH of the chosen growing medium.
- Sun, heat, wind, moisture, and drought tolerant.
- Successful colonizers, perennial or self-sowing.
- Easy to maintain (such as those that outcompete weeds and don't require mowing/trimming).
- Self-sustaining (no need for fertilizers or pesticides).
- Fire-resistant.
- Appropriate for the soil depth and composition.
- Will not require fertilizers, pesticides, or herbicides.

Figure 4-32. Sedums are well adapted to the harsh conditions of vegetated roofs.

When locating plants, consider that the growing medium is likely to drain more rapidly at peaks and remain saturated longer near gutters or drains. As with any stormwater management facility, seeds, rhizomes, and clippings can easily be transported downstream during overflows. For this reason, we recommend selecting native species and non-invasive non-native species. Never choose plants on Oregon's Noxious Weed List[29]. (See **Appendix E**: Plant Specifications.)

Coverage. Plantings should cover 95% of the vegetated roof area within 2 years of planting, excluding gravel areas for buffers, maintenance access, and other intentionally non-vegetated areas. 80% of the plants should be evergreen and active during most of the year except the coldest parts of the winter to provide runoff reduction through interception and evapotranspiration.

Waterproofing Membrane. Since water will be ponded on a roof during a storm, a watertight membrane must be placed at the very bottom of a vegetated roof.

Membrane Specifications. The longevity of a green roof is gained by covering the impermeable membrane with growing medium and/or gravel and plants. For best protection, the final assembly should leave no part of the membrane exposed to sunlight, although this is often not possible. Suitable waterproofing membranes include:

- Asphalt (modified to protect against breakdown by microbial activity)
- Reinforced thermal plastics such as Acrylonitrile butadiene styrene (ABS).
- Synthetic rubber such as Ethylene-Propylene-Diene-Monomer (EPDM). EPDM is considered more environmentally friendly than the alternatives; however, EPDM edges are more difficult to bind together than PVC. For this reason, EPDM may be more suitable and cost-effective for small projects where a single sheet of material will completely cover the desired roof area.
- Thermoplastic polyolefin (TPO)
- PVC

Root Barrier. A root barrier is always needed when an asphalt roof material is specified. Many other membranes such as EPDM, PVC and TPO offer sufficient root penetration protection for shallow low profile vegetated roofs. For roofs with deeper soils and larger plants and potentially trees, an added layer of root protection material may be desired. Root barriers should not be manufactured with pesticides or chemicals, which could pollute stormwater.

[29] *Oregon Department of Agriculture. Oregon Noxious Weed Profiles. retrieved from: http://www.oregon.gov/ODA/programs/Weeds/OregonNoxiousWeeds/Pages/AboutOregonWeeds.aspx*

Drainage Layer. A drainage layer is sometimes placed above the waterproof membrane and root barrier. This layer collects water seeping from the growing medium and directs it to downspouts or gutters; however, the growing medium specified above drains very quickly. Many successful vegetated roofs with fast-draining soils have been installed in Western Oregon without a drainage layer, and it is increasingly considered an option rather than a necessity. Slightly heavier soils with more compost are beginning to be specified, and in this case, the drainage layer is less optional. Regardless, it should be lightweight material such as rubber or plastic. Gravel, lava and expanded clay are also acceptable.

Filter Fabric. If a drainage layer is incorporated, place a filter fabric geotextile between the drainage layer and the growing medium to keep the fine soil particles of the growing medium from draining out of the system (see Appendix D: Specifications, "*Geotextile fabric*"). However, almost all of proprietary drainage layer products come with the fabric already attached.

Proprietary Tray Systems. There are a number of proprietary vegetated mats and tray systems, which can greatly speed installation, since the drainage mat and other fabrics, growing medium, and established plants may already be incorporated into the assembly.

Irrigation System. Long term irrigation is controversial. Depending on how irrigation is triggered, for instance whether there are automatic weather sensors for just the hot days or based on a regular schedule, watering can reduce the effectiveness of the vegetated roof by saturating soils just before they are needed to absorb rainfall. Others say that a single 100-degree day can kill every plant on the roof, requiring the plants to be replaced. Since conditions on a roof are much hotter and windier than on the ground and plant roots cannot reach the groundwater table, depending on the plant palette and other project goals (*i.e.* evaporative cooling), irrigation may be crucial through the summer. Overhead irrigation may be more effective than drip if highly porous soils are used on roofs[30].
Choose an irrigation system specifically designed to withstand the harsh elements of a rooftop. Traditional irrigation systems are installed underground where soil protects the plastic from harmful UV light and temperature swings, but vegetated roofs may not have enough growing medium to provide long-term protection. Pipes easily warp and become exposed to sunlight. In addition, traditional irrigation systems can vibrate and wear through roof materials causing damage overtime.

<u>Minimum irrigation system recommendations vary with the size of the roof:</u>

- **Vegetated roof area < 1,000 square feet.** You may choose to hand water. A rain gauge is an easy and cost-effective way to know whether your vegetated roof has received a sufficient amount of rain recently.
- **1,000 square feet < Vegetated roof area < 5,000 square feet.** Install an automatic irrigation system. Consider including a controller to adjust the amount of irrigation based on the season (see Appendix E: Plant Specifications, "*Establishment Period Maintenance*", "*Establishment Irrigation*") or actual rainfall data. These controllers are relatively inexpensive, but plan for power requirements, which may be either wired directly or battery powered. Some systems are computerized, while others use an independent small-scale weather station. Vegetated roofs larger than 5,000 square feet may benefit from an irrigation flow meter, which also detects leaks. Winterize the irrigation system.
- Vegetated roof area > 5,000 square feet. All irrigation system recommendations for vegetated roofs from 1,000 to 5,000 square feet apply plus install an irrigation flow meter. Monitoring water usage can help ensure that a leak in the irrigation system does not lead to structural damage of the building.

[30] EPA Region 8 Green Building webpage (2015). "Green Roof". Retrieved from: http://www2.epa.gov/region-8-green-building/green-roof

Minimize irrigation. Regardless of the irrigation approach, minimize irrigation using the following strategies:

- Apply mineral mulch to surface.
- Choose native plants, especially sedum (see **Appendix E**: Plant Specifications).
- Shading vegetated roofs with buildings, solar hot water heaters, photovoltaic (PV) panels, or trees.

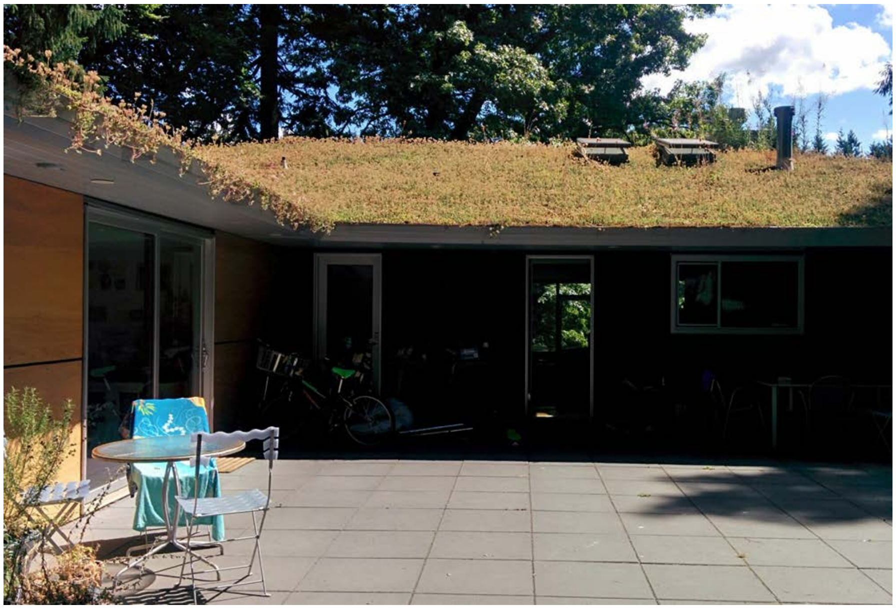


Figure 4-33. Irrigation was not installed on this vegetated roof and no supplemental water has been applied to the roof in a number of years since its establishment. This is acceptable for the chosen plant palette. The vegetated roof will regain its green color when the rain returns. This roof has considerable shade from existing tall trees much of the day.

Access. Provide year-round access for people and maintenance equipment, regardless of roof type, for operations and maintenance. Some common maintenance equipment and materials for vegetated roofs includes rakes, buckets, ladders, irrigation supplies, plants, and hoses.

Hydraulic Routing. Depending on the frequency and size of a storm event and the season, vegetated roofs may not retain the entire volume of stormwater. Therefore, all vegetated roofs should include an overflow drain to deliver excess runoff to an approved discharge point, in a manner that is safe and protects infrastructure.

Construction

If using a proprietary system, follow the individual manufacturer's guidelines carefully. Requirements vary.

Protect the membrane. The waterproof membrane is crucial to protecting the building from water intrusion. Punctures in it are easy to make, but difficult to detect and fix.

- Install protection boards, usually made of a soft material, to get around the roof before soil is in place.
- The vegetated roof installers should be the last contractors on the roof, brought in after all other contractors have completed their work.
- Throughout the process, carefully protect skylights, mechanical systems, vents and parapets.

Other important considerations.

- Stockpile materials at a depth that can be accommodated by the roof structure. Consult the structural engineer for the maximum stockpile depth for each material delivered to the roof.

- Protect materials from blowing off the roof, before and after installation. Wind conditions on the roof are often very different from wind conditions on the ground.

Figure 4-34. Carefully protect the vegetated roof at all times through the construction process through signage or other means. A variety of contractors, not directly related to the vegetated roof installation, could damage it.

Construction Steps. For retrofit projects, vegetated roofs may begin with an upgrade to the structure. In general, the rest of the steps to constructing a vegetated roof are as follows:

1. Install drains or scupper as specified in plans and specifications.
2. Place the specified impermeable membrane per manufacturer's guidelines, ensuring that the membrane rises to the maximum possible ponding area assuming that the drain or scupper gets clogged in the future. Membranes may be mechanically attached and/or sealed with heat depending on the manufacturer's recommendations for the material chosen. If a parapet is being constructed with the vegetated roof, as in a new development, build the parapet, bring the liner up above the top, and cap with a second parapet piece so that the membrane is not exposed, long-term, to the sun.
3. Flood test the impermeable membrane to check for leaks by stopping up the drains or scupper and submerging the roof with about 1 inch of water. Because of roof slopes this may mean that portions of the roof are several inches deep with water. If necessary, repair leaks per manufacturer's guidelines and repeat flood test.
4. Protect the membrane from further foot traffic and punctures between flood testing and placing additional layers, installing protection boards or other means if necessary.
5. Place optional drainage mat and fabrics next.
6. Place growing medium. Growing medium can be brought up to the roof manually (wheelbarrow, bucket, shovel) or via a crane, conveyor, or blower.
7. Place other materials that may be included in the design, such as stepping stones or gravel ballast pathways.

8. Install plants. Plants can be installed via hydroseeding, cuttings (for sedum, especially), and plugs. Pots are often discouraged, because they become established in nursery soil and often don't transition well to a growing medium with so much less organic matter.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Designers should specify in an operations and maintenance manual which plants are weeds, or alternatively, which plants are not weeds and that anything other than them is a weed to be removed. This might include plants with deep roots such as trees that might damage the membrane, plants that might become a fire hazard, and plants on the Oregon Noxious Weed List.

Past experience in the Pacific Northwest has shown vegetated roofs are surprisingly easy to maintain after the establishment period. Maintenance is most demanding during the 3-year plant establishment period. Ongoing inspection and maintenance activities (including during the plant establishment period), include:

- For roofs designed without irrigation, watering is left to nature. Where some plants may die, they can be replaced by casting sedum cuttings over the soil in the fall at less cost than watering all summer.
- For roofs with irrigation, water plants during the dry season with no more than 1 inch of water every 10 days. During the wet season, do not irrigate at all. Wet summers or over-irrigation may encourage weed growth.
- Inspect plants in early summer and early fall for overall health and coverage. Replace plants as needed in the fall. Perform weeding at the same visits and more often as needed, removing weeds before they go to seed. In Western Oregon, checking for weeds in late May or early June may limit the necessary weeding to once a year. Remember, irrigation encourages weed growth, so weeding may be needed more often. Do not apply herbicides or pesticides since these pollutants will be efficiently exported downstream.
- Inspect structures such as membrane (if visible), irrigation system, drains, parapets, and access structures annually. As necessary, remove sediment and debris around drains and unclog. Repair the structural integrity of the systems. Contact the manufacturer to repair leaks or tears in the membrane.
- Inspect plant health. If plants are struggling, correct the causes, which may include too much or too little water, pests, condensate from the HVAC system, or chemical spills from rooftop equipment maintenance.
- Inspect for and correct any erosion after large storms (*i.e.* 2 inches in 24 hours or extreme/high intensity cloud bursts) until plant coverage has been achieved.
- Some vegetated roofs may be designed to receive many visitors, who may not understand what they are visiting. This may increase the level of maintenance, for example by requiring more frequent trash pickups.
- Inspect the irrigation system annually. Look for exposed piping, broken irrigation heads, and especially leaks, which could be very detrimental to the stormwater performance of the vegetated

roof and greatly increase vegetation related maintenance activities. Winterize and de-winterize the irrigation system make repairs as needed.

- Install erosion control fabrics against wind as needed to prevent loss of growing medium when replanting.

POROUS PAVEMENT BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form C Form F		
Drawings			
Title	**Detail**		
Pervious Concrete Pavement	BMP 5.01		
Porous Asphalt Pavement	BMP 5.02		
Manufactured Permeable Pavers	BMP 5.03		
Salvaged & Poured Concrete Permeable Pavers	BMP 5.04		
Vehicular Permeable Paver Edges	BMP 5.05		
Catch Basin Outlet Control Structure for Infiltration Facilities	BMP 8.01		
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Porous pavement (also known as permeable pavement and pervious pavement) is a stormwater management facility that allows water to move through void spaces within the pavement surface and rock below and infiltrate into underlying soils. It has many applications ***(Table 4-4*** below) and in many cases, it can be used instead of conventional, impervious pavements for both vehicular and pedestrian traffic. Porous pavements reduce runoff volumes that would otherwise be produced by impervious surfaces such as parking lots, roads, and sidewalks by intercepting rainfall or carefully managing runoff from other areas.

Figure 4-35. Decorative pervious concrete stamped and colored to look like bricks. Photo courtesy of Scott Erikson.

Siting

Figure 4-36. Porous pavement that manages only the rainfall it receives can be safely placed adjacent to a building without setbacks. This shared driveway has the added benefit of increasing landscape area. Photo courtesy of Scott Erikson.

Infiltration Testing. Have a qualified professional perform an infiltration test to determine the soil's capacity to absorb and percolate water down into the lower layers. See Appendix C for detailed guidance on field testing to find the rate that water can pass through the soil and how to interpret that data.

Rainfall versus Runoff. Porous pavement has been used to manage only the rainfall it receives or manage the rainfall it receives in addition to receiving runoff from impervious areas (**Figure 4-51**). Porous pavements that manage only rainfall have more flexibility in where they may be sited than porous pavements that also manage runoff.
Site Suitability for Porous Pavements Managing Runoff. Porous pavements that receive runoff from impervious areas in addition to rainfall should be located using the same criteria as soakage trenches (see Chapter 4 "*Soakage Trench BMP*", "*Siting*").

Site Suitability for Porous Pavements Managing Only Rainfall. Porous pavements can be used in a variety of conditions[31] and land uses (**see Appendix G Site Suitability Matrix**), including:

- Where the seasonal high groundwater table, bedrock, or other impermeable layer is more than 18 inches from the bottom of the base rock (which is the open graded aggregate below the surface, designed to store water until it infiltrates).
- Situate porous pavement on native, uncompacted soil. Porous pavement should never be placed on areas of proposed fill that is compacted to 95% modified proctor density and not specifically designed to protect the porosity of the fill (*e.g.* structural tree soil per Appendix D: Specifications, "*Structural Tree Soil Mix Specifications*"), because this kind of fill is compacted so much that it is no longer capable of infiltrating water.
- Where infiltration rates are 0.3 inches/hour or greater. Historically compacted/fill soils may have adequate infiltration capacity because soil animals move into compacted soils slowly, over time.
- In limestone bedrock
- Under trees to be protected, when carefully excavated in the presence of an International Society of Arboriculture certified arborist
- On projects where spills are not an issue (see below for unsuitable locations)
- Where the pavements will be hydraulically isolated, meaning that they do not receive run-off from any other areas. These have been known to be maintenance free for decade (ex. porous pavement at Walden Pond installed in 1977[32]) as opposed to the example in Figure 4-37 below.

Figure 4-37. Impervious pavement is tipped toward the permeable pavers, which has clogged the entire first few feet of the pavers. Where the pavers were not installed flat, ponding makes this clogging evident.

[31] *Pennsylvania Stormwater Best Management Practices Manual. (2006). Publication No. 363-0300-002.*

[32] *Miller, A.R. (1997). Porous Pavement: Pavement That Leaks. Retrieved from: http://www.millermicro.com/porpave.html*

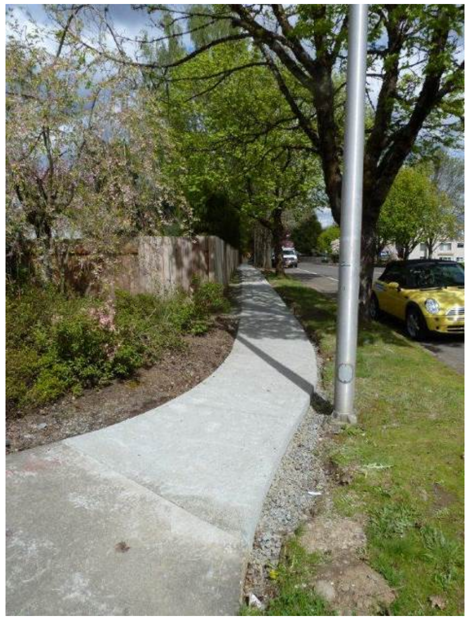


Figure 4-38. Porous pavements can be used to replace sidewalks damaged by trees. The material is open to the air and will provide the roots with water they need, without having to push up sidewalks for access to air and water. (See Chapter 4 "Tree Protection BMP" for more information to protect trees during repaving.) Photo credit: Scott Erikson

Unsuitable Sites for Porous Pavements Managing Only Rainfall. Because porous pavement is an infiltration technique, situations where groundwater contamination could occur or be exacerbated should be avoided. In addition, the seasonal elevation of groundwater and other conditions that could lead to saturation, clogging, or other failure must be considered.

Porous pavements should **NOT** be used in the following cases:

- Where the seasonal groundwater table, bedrock, or other impervious layer is higher than 18 inches from the bottom base rock. This depth may be reduced with the guidance of a licensed engineer.
- In areas of proposed well-graded fill (*i.e*. a distribution of small and large rocks such as ¾ inch-minus that is compacted to 95% modified proctor density (general rule: fill < 5 years old).
- Over septic drain fields.
- In contaminated soils.
- In expansive soils, although pockets of it discovered during construction can be removed and replaced with base rock, under the guidance of a licensed engineer.
- On slopes exceeding 8%.
- On land uses where spills are likely, which may include but are not limited to:
  - Fueling stations
  - Commercial nurseries
  - Auto recycle facilities
  - Vehicle service and maintenance areas
  - Vehicle and equipment washing/steam cleaning facilities
  - Commercial/industrial parking lots
  - Marinas (service and maintenance)
- Hazardous material generators (if the containers are exposed to rainfall).
- Outdoor loading and unloading facilities.
- Public works storage areas.

- High traffic areas.
- Over known sinkhole areas.
- Where cars or trucks may track a significant amount of dirt onto the surface, such as construction yards.
- Porous pavement may not be suitable in windy areas. Sand and larger soil particles are generally not a factor in clogging; however, if fine dirt particles, like clay and silt are likely to be carried on the air, then they are likely to be deposited on the surface. A more frequent pavement-cleaning schedule is likely to address this. Whether a windy site is suitable should be left to the discretion of a licensed engineer.
- Where pavement will receive overland runoff from impervious areas uphill. The small, frequent water quality storm transports sediments, so premature clogging and higher maintenance consistently occurs when impervious pavement flows towards a porous pavement.

Pavement Surface Types Overview

There are several types of porous pavement surfaces, including porous asphalt, pervious concrete, permeable pavers, flexible pavement systems, and porous gravel. The first four are the terms preferred by the industries that produce or promote them and do not necessarily reflect a difference in porosity. Each will be addressed individually as design, construction and maintenance varies, but the following is an overview of these types.

Porous Asphalt and Pervious Concrete. Porous asphalt and pervious concrete are similar to their impervious counterparts but are made with “open-graded aggregate”, which includes few to no fines (*i.e.* small particles). When bound together, interconnected voids between the aggregate allow water to flow through. The larger pieces of crushed aggregate provide the structural stability for conventional and porous pavements alike, even for loadings such as large trucks and semi-trailers (*e.g*. AASHTO H-20 loading). The fines in a conventional mix only serve to make compaction easier, which would prevent infiltration.

Permeable Pavers. Permeable pavers are paver units of stone, concrete or other durable impervious material with gaps between or within the pavers that provide voids for water to reach sub-soils. Porous commercial pavers, like porous asphalt or pervious concrete discussed above, are now available and need no space between them.

Figure 4-39. Permeable pavers

Porous Flexible Paving Systems. Porous flexible paving systems are prefabricated grids made of plastics or other solid materials finished with clean sand/gravel or turf. Grids with porous media provide a stable surface and sometimes resemble lawn.

Figure 3-40. Flexible paving systems are often made of plastic grids with numerous openings, as shown here. Photo credit: Teresa Huntsinger

Figure 4-41. The grids of a flexible paving system can be seen on the edge here. In this case, the flexible paving system reduces the depth of excavation otherwise needed to install permeable pavers (which sat on top of this system at the end of construction). Reducing excavation, among other best practices such as careful root pruning (see Chapter 4 "Tree Protection BMP"), protected the health of the two trees pictured on either side of the roadway.

Porous Gravel. Conventional gravel pavements (*i.e*. without a permeable sub-base) are not inherently free draining, as many assume. During conventional gravel pavement installation, soil is compacted to support vehicular loads, making the pavement essentially impervious. Gravel with many small particles (usually a material like "¾-inch minus drain rock", discussed above) is installed, compacting it in lifts (*i.e.* smaller portions of the total depth). This results in a low void ratio with little storage for stormwater, even if the soil could infiltrate, and may cause fine particles from the pavement to pollute downstream waterways, especially on slopes.

Gravel driveways and walkways are porous pavement alternatives that can be especially helpful in retrofit situations where drainage problems exist. To create a porous gravel pavement, specify “Coarse Aggregates” as described in Appendix D: Specifications, which is the same material used as base rock in other porous pavements and has no fine particles.

Siting Considerations by Porous Pavement Surface Type. Descriptions of porous pavement surface types are provided in the “Design” section below. Settings and weather conditions vary by surface. An X in the table below indicates which surface type is suitable for which application or condition.

Table 4-4. Porous pavement applicability by surface type.

	Porous Asphalt	Pervious Concrete	Permeable Pavers	Porous Flexible Paving Systems	Gravel
Any pedestrian application	X	X	X	X	X
Public or private roads, speed < 45 miles per hour	X	X	X	X	
Parking lots, driveways, other low speed roads	X	X	X	X	X
Slopes up to 30% grade	X	X	X	X	
Ambient Air Temperature During Installation < 55 degrees Fahrenheit		X*	X	X	X
50 degrees Fahrenheit < Ambient Air Temperature During Installation < 100 degrees Fahrenheit	X	X	X	X	X
Ambient Air Temperature During Installation > 100 degrees Fahrenheit	X		X	X	X
*Pervious concrete can be installed when temperatures are between 40 to 90 degrees F. When ambient temperatures exceed 90 degrees F, there may be inadequate time to cover concrete in plastic for proper curing and durability. The drying effect of wind can also shorten installation and plastic cover time. NOTE: Porous pavement on highways is not supported by ODOT.					

Porous Asphalt Mix Frequently Asked Questions

Porous asphalt is less likely to leach hydrocarbons into groundwater than conventional asphalt. The binder in porous asphalt is a petroleum product capable of leaching hydrocarbons, but so is the binder in conventional asphalt. Unlike conventional asphalt, porous asphalt provides excellent treatment of hydrocarbons. The voids in the pavement and the base rock, open to air and water, are an ideal habitat for a microbial community that breaks down hydrocarbons. In numerous studies[33], hydrocarbons are not elevated in the soil beneath porous pavements.

Porous asphalt is available. In Oregon, an asphalt plant with some experience mixing and installing

[33] *Pratt, C.J., Newman, A.R., and P.C. Bond. (1999). Mineral Oil Degradation within a Permeable Pavement: Long Term Observations. Wat. Sci. Tech. 39(2):103-109. Retrieved from: http://goo.gl/nDmLfq*

porous asphalt is probably nearby. The Oregon Department of Transportation have used what its specifications call an "Open Graded HMAC" (Hot Mix Asphalt Concrete) as an overlay on conventional asphalt on highways for 30 years. Find an ODOT Certified Mix Design Technician (CMDT) to install porous asphalt. For those not able to find a certified installer, porous asphalt installation is very similar to conventional asphalt; it's rolled into place, but more lightly compacted. See **Appendix D**: Specifications, "*Porous Asphalt (Bituminous) Pavement Specification*".

Porous asphalt is durable when designed, installed, and maintained correctly. Several issues arise when considering durability:

- Porous asphalt is durable in parking lots and low traffic roads when a styrene-butadiene-styrene (SBS) polymer or other polymer modified binder is added to the pavement mix. Unfortunately, use of studded tires on Highway I-5 and I-26 has caused clogging of a permeable overlay (porous pavement surface installed over impervious asphalt) 7 to 14 years after installation. A study from 2011 from ODOT[34] suggests limiting the use of Open Graded HMAC to roads with less than 30,000 Average Daily Traffic (ADT).
- In freeze-thaw areas, porous asphalt is more durable than conventional asphalt. In Pennsylvania, porous asphalt was installed side-by-side with conventional asphalt in a commercial parking lot. After 25 years, the porous asphalt has not needed replacement, while the conventional asphalt has developed many potholes and has needed resurfacing twice.
- As in conventional asphalt, porous asphalt is more durable when shaded and is more durable when the pavement section is correctly designed to accommodate predicted traffic loads.

Porous asphalt mix can be installed to minimize clogging. To avoid clogging issues specific to porous asphalt:

- Porous asphalt must be installed with a roller. On retrofits, consider how an existing infrastructure may impact equipment access to all portions of the pavement.
- Draindown is a physical property of the asphalt binder and measures viscosity. If the draindown is higher than the specification, the binder will melt on hot days, collect on the top of the base rock and harden into an impermeable barrier. Make sure the draindown is per specifications. One way is to check the truck after the mix has come out. If there's no binder left in the truck, then draindown won't be a problem. If binder is left in the truck, reject the mix.

Pervious Concrete Mix Frequently Asked Questions:

Pervious concrete will not leach pollutants into the ground long-term. During construction, pervious concrete, like conventional concrete, may change the pH of the soil, surface water, and/or ground water if wash water from mixing trucks is not properly isolated on-site. After construction, studies have found that the soil beneath porous concrete does not have pollutants leaching from the pavement itself.

Pervious concrete is available. The National Ready Mixed Concrete Association (NRMCA) trains and certifies technicians to install pervious concrete nationwide. Find a certified technician in your area by going to their website[35]. Hiring an experienced, certified technician is important because pervious concrete installation is significantly different from conventional concrete.

Pervious concrete is durable. Some raveling may occur during the first few weeks following installation

[34] Oregon Department of Transportation. (2011). Open-Graded Wearing Courses in the Pacific Northwest. Final Report-SPR 680. Retrieved from: https://www.pavementpreservation.org/wp-content/uploads/2011/06/Oregon-DOT-OGWC-Final-Report.pdf
[35] National Ready Mixed Concrete Association website. Retrieved from: http://www.nrmca.org/

due to loosely bound rocks on the surface popping out, but if this happens, it will be greatly reduced over time. Durability can be enhanced by:

- Engaging an experienced, NRMCA certified technician with a track record of good installations.
- Not installing pervious concrete in very hot weather.
- Incorporating expansion joints (as with impervious concrete)
- Raising snow plows slightly to avoid abrading the surface.

Pervious concrete mix can clog during installation. Avoid clogging:

- Engage an experienced NRMCA certified technician for installation.
- Don't overwork the pavement during installation.

Design

Porous pavement is an assembly of materials that includes not only the pavement surface, but also the rock, geotextile fabric, and soil below and conveyance structures, if necessary. Like all pavements, porous pavements should be designed and detailed by one or more licensed engineers with experience in civil and geotechnical engineering.

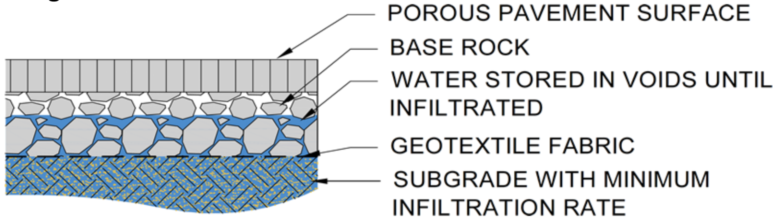


Figure 4-42. A typical porous pavement section.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Structural Design for Porous Pavements Required. Porous pavement surface thicknesses and base rock are calculated relative to estimated traffic weight and frequency[36]. Consult a licensed engineer with experience in geotechnical engineering to recommend the appropriate pavement section (surface and rock course thicknesses) for the site's soils in a "wet, uncompacted condition" for the anticipated traffic loading (*e.g.* AASHTO H-20 or HS-25 loading). If a full depth of saturated rock will not be structurally stable, an additional depth of rock that will stay dry (because it is located above an overflow elevation) should be added to the pavement section. Pavement design thicknesses for the surface and base rock will vary by porous pavement surface type. As with conventional pavements, structural capacity can be increased with a thicker pavement surface and/or a thicker base rock depth.

The following resources are available for download to assist with porous pavement design:

- **Porous Asphalt**. The Asphalt Pavement Association of Oregon offers guidance on structural design and pavement surface specification of porous asphalt in **Chapter 3** of its guide "*Asphalt Pavement Design Guide*"[37].

---

[36] *Urban Drainage and Flood Control District. Drainage Criteria Manual (Vol 3). (Revised 2008). Denver, CO,.*

[37] *Asphalt Paving Association of Oregon website. Retrieved from: http://www.apao.org/documents/APAO-DESIGN-GUIDE-1.pdf*

- **Pervious Concrete**. The American Concrete Pavement Association offers PerviousPave software to assist with developing an appropriate cross section[38]. The National Ready Mix Concrete Association offer software on mix design[39].
- Permeable Pavers. The Interlocking Concrete Pavement Association provides design software40.

Base Rock Depth. Two different design criteria drive the depth of base rock (see **Appendix D**: Specifications, "*Coarse and Choker Aggregate*") beneath a porous pavement:

- Structural: support traffic loads.
- Hydrologic: hold and infiltrate the design storm.

The following sections provide information on hydrology design criteria. The porous pavement surface thickness and depth of base rock needed to meet both criteria are usually different. Choose the deeper of the two.

Figure 4-43. Porous asphalt (left) was installed next to impervious asphalt (right) in a public street to solve flooding in a very flat area.

Hydrologic Design for Managing Rainfall. The depth of base rock for porous pavements that only manage the rain that falls on them must be designed and modeled by a licensed engineer per criteria provided in **Appendix B**: BMP Implementation Criteria, "*Design*", **Chapter 2** requirements, and the tested design infiltration rate (see **Appendix C**: Infiltration Testing). An infiltration rate of at least 0.3 inches/hour is recommended.

Hydrologic Design for Managing Runoff. There are several ways to direct runoff to a porous pavement rock base (see below). The depth of base rock for porous pavements that manage runoff from other areas, such as roofs and other pavements, in addition to rainfall on the surface, must be designed and modeled by a licensed engineer per criteria provided in **Appendix B**: BMP Implementation Criteria, "*Design*", **Chapter 2** requirements, and the following criteria:

- Model the porous surface itself as if it were impervious and draining to the base rock with 40% void ratio equal in size to the pavement surface area. Add other "real" impervious areas to the model and model these to drain to the base rock too.
- Time of concentration, the time it takes water to concentrate, is greatly increased by the base rock. Use a time of concentration of 19.2 minutes per inch of base rock[41] using a first assumption of 6 inches of rock for pervious concrete (recommended as a minimum by the National Ready

[38] *American Concrete Pavement Association. Retrieved from: http://www.acpa.org/perviouspave/*
[39] *National Ready Mix Concrete Association. Retrieved from: http://my.nrmca.org/scriptcontent/BeWeb/Orders/ProductDetail.cfm?pc=2PE001*
[40] *Interlocking Concrete Paving Institute website. Retrieved from: http://www.permeabledesignpro.com/*
[41] *Hydrocad Stormwater Modeling. Retrieved from: http://www.hydrocad.net/pavement.htm*

Mixed Concrete Association) and 12 inches for other flexible pavements (permeable pavers, flexible grids).

This is an iterative design since the base rock depth is assumed to calculate a time of concentration and the time of concentration impacts the base rock depth.
Alternative methods for modeling are provided on the OSU Stormwater Solutions website:

- Porous Pavement Hydrologic Calculator (xls): http://extension.oregonstate.edu/stormwater/porous-pavement-calculator. Detailed information on how to use this model is provided at the link above.
- Video on how to model porous pavement to receive runoff from impervious areas. See "Porous Pavement Video 3: Modeling Rainfall and Runoff": http://extension.oregonstate.edu/stormwater/videos

Standard Details. See standard details BMP 5.01, 5.02, 5.03, 5.04, and 5.05 to include applicable details in construction documents. These are available in pdf, jpg, and AutoCAD dwg format. See also BMP 8.01 if a control structure is needed.

Geotextile. Install a geotextile fabric to separate the native soils from the base rock. Without it, water infiltrating through the cross section will cause soil particles to migrate up into the voids of the aggregate, filling them and reducing storage volume for stormwater. The geotextile fabric also adds structural stability to the pavement. Specifications for geotextile fabric are provided in **Appendix D**: Specifications, "*Geotextile Fabric*". Take special care to wash the base rock as directed in **Appendix D**: Specifications, "*Geotextile*", "V*ery Clean Rock Required*" or the geotextile is likely to be clogged with dirt from the rock, creating an impermeable membrane at the bottom of the pavement and defeating the purpose of porous pavement.
Design Specific to Sloping Sites. As described in "Siting" above, porous pavement should not be installed on slopes greater than 8%. The following design guidance is offered for porous pavements installed on slopes less than 8%.

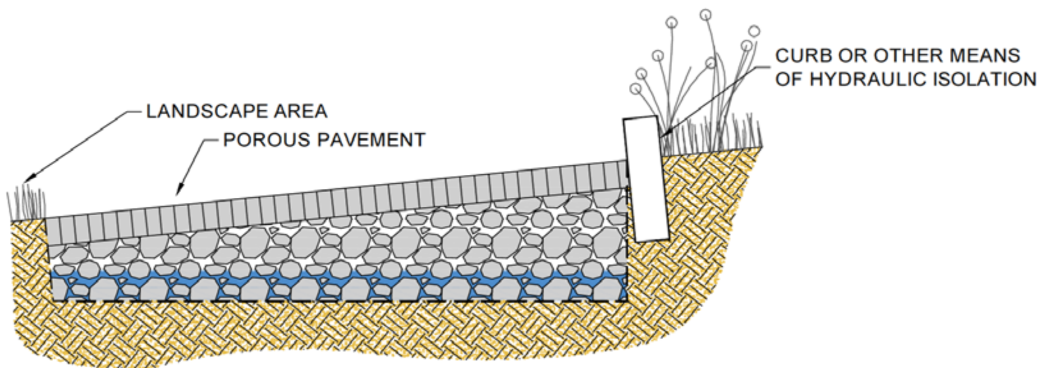


Figure 4-44. While the surface may slope, the bottom of the porous pavement (where the water is being stored before it infiltrates) should be flat.

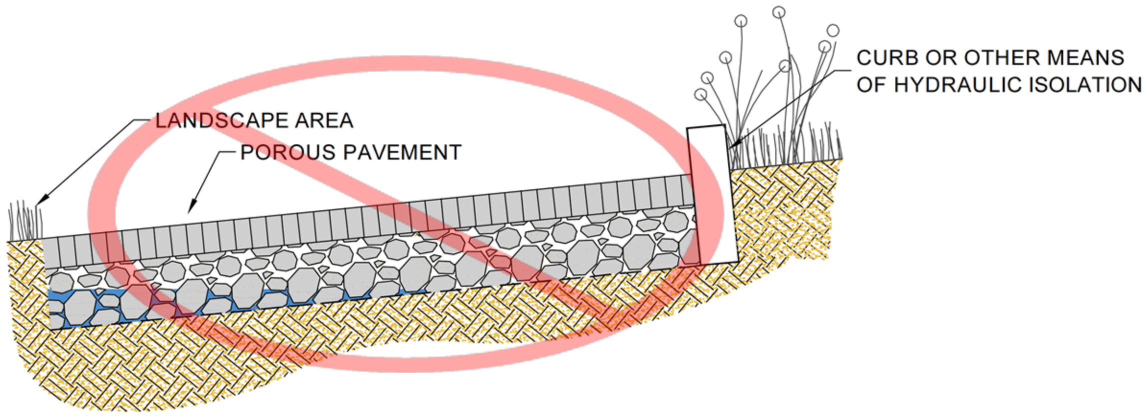


Figure 4-45. Porous pavement with a sloped bottom cannot be hydrologically sized using the simplified sizing approach in Chapter 5. This should be designed by a licensed engineer using a model that accounts for the variable infiltration area since it would shrink as water infiltrates.

As can be seen on the right side of ***Figure 4-45**,* a large quantity of rock, which will never be available to pond water for infiltrating might be needed to bring the grades up to the desired finished elevation. To save on rock, the bottom of the facility can be stepped down the hill with a series of berms as in ***Figure 4-46*** below. Adding a sub-surface grading plan to the construction plan set can be helpful for conveying critical information to the excavation contractor.

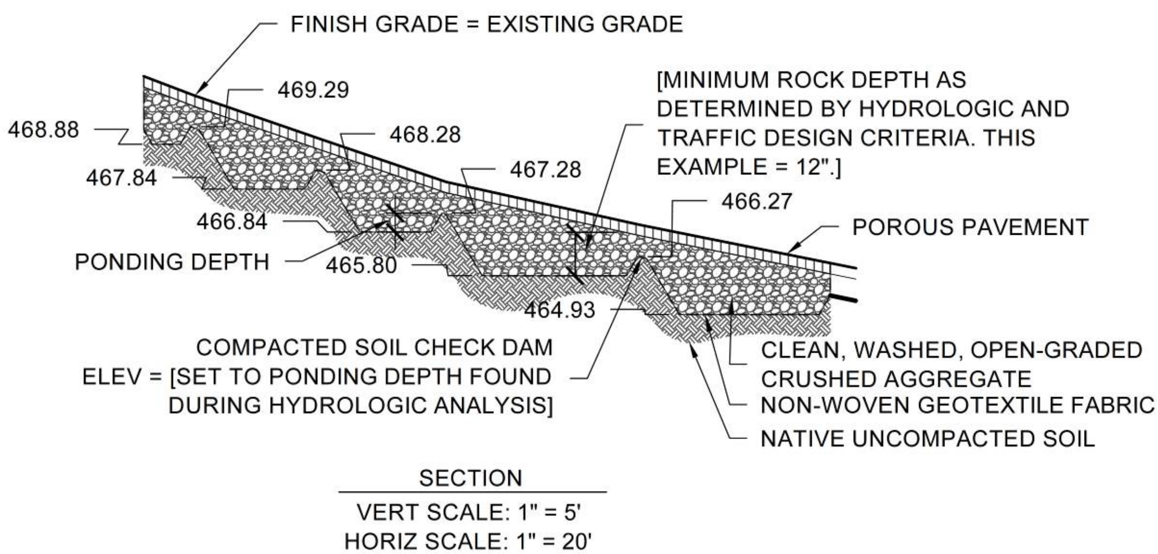


Figure 4-46. Cross section example on sloping sites. Bench flat infiltration areas down a sloping site to save money on the alternative, which is to excavate a single large flat area. Underground berms 6 inches below the pavement surface hold water back and spread it out to infiltrate before excess volumes overflow the dams during large storms. To significantly reduce excavation costs, the shape of the berms should follow existing contours, even though finish grade may not equal existing grade.

Grading Plans. A careful grading plan is needed to ensure that porous pavement adjacent to conventional pavements are hydraulically isolated (***Figure 4-47***) and that dirt from any landscape areas above a porous pavement can be captured behind a curb or depression.

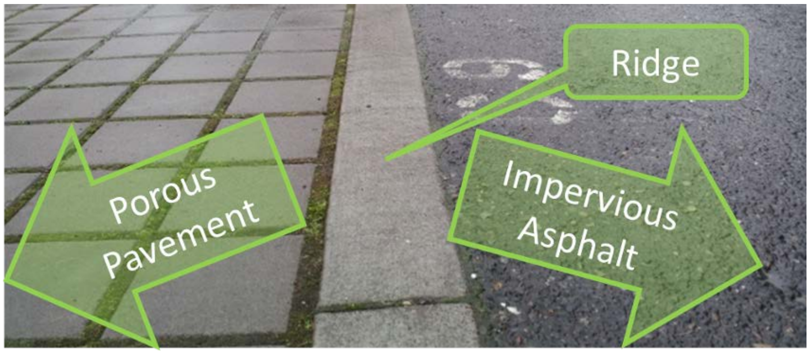


Figure 4-47. One way to achieve a hydraulically isolated pavement.

Subsurface Grading Plan. If the site is sloped and underground berms are used, as described in "Design Specific to Sloping Sites", an additional grading plan of the subgrade will be needed. With a subgrade grading plan, the contractor can fully understand the differences between subgrade elevations, where water will be stored to infiltrate, and proposed finish grades of the pavement surface.

Routing for All Porous Pavements. Porous pavements should convey the 25-year, 24-hour storm of 5.0 inches. For vehicular applications, this requires the construction of overflow and control structures to ensure the pavement infiltrates the desired volume but does not saturate and potentially destabilize the pavement. Pedestrian applications will be structurally sound without this overflow structure, as described in more detail below. Provide a safe overland route per **Appendix B**, "*Design*", "*BMP Design Criteria*", "*Safe Overland Route*".

Adequate Cover. To protect its structural integrity, bury pipes to provide adequate cover of 12 inches minimum.

Underdrains. Underdrains are pipes perforated on the top half and encased in gravel filled trenches (*i.e*. the base rock of the pavement serves as this gravel filled trench). They can be used for one or both of the following purposes:

- Overflow: To route excess volumes in the base rock to a stormwater conveyance system.
- Inflow: To convey runoff from other impervious areas into the base rock

Underdrains for Overflow. In pedestrian applications that manage only rainfall, loads are usually light enough for the fully saturated rock section to provide structural support; therefore, an underdrain is not needed (**Figure 4-50**). If there is a possibility that the pedestrian application could be driven over, then the pavement should be designed as if it were a vehicular pavement.

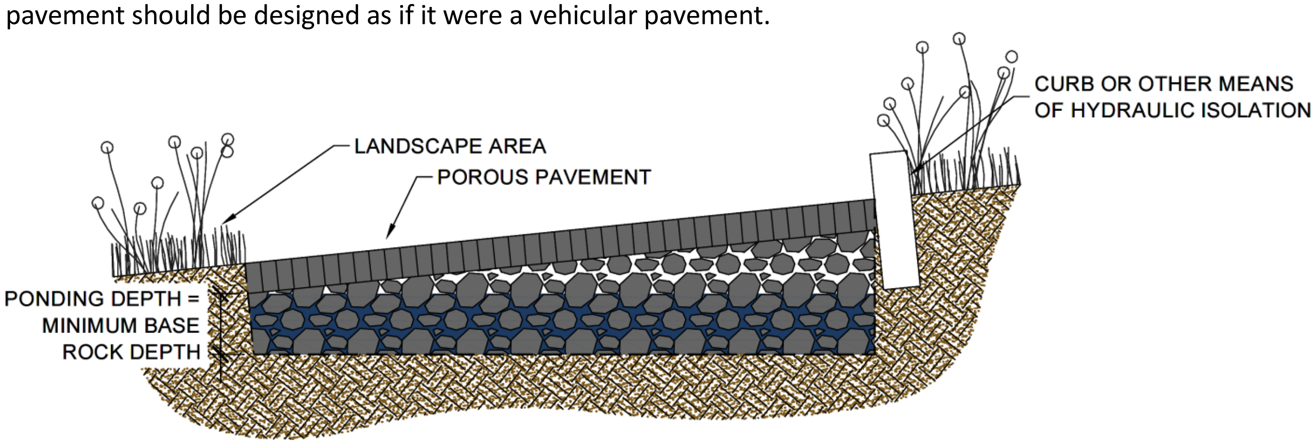


Figure 4-48. Porous pavements for pedestrian applications that manage only rainfall (i.e. do not receive runoff) do not need an underdrain unless they may be driven over.

Underdrains are recommended for all vehicular applications, regardless of whether they manage rainfall or runoff, to convey excess water from storms larger than the design storm. Buoyancy could destabilize a fully saturated pavement section under heavy loading.

It is desirable to place the pipe on the bottom of the facility for adequate cover of 12 inches minimum to protect its structural integrity. In this case, use a control structure such as a catch basin with a weir or another structure that will back up as much water as desired to infiltrate within the desired time. (See ***Figure 4-50*** and Detail BMP 8.01 Catch Basin Control Structure in **Appendix F**.) To avoid UIC requirements, use perforated pipes that are only perforated on the top and side instead of on all sides (see **Chapter 1**, "*Underground Injection Control Overview*".

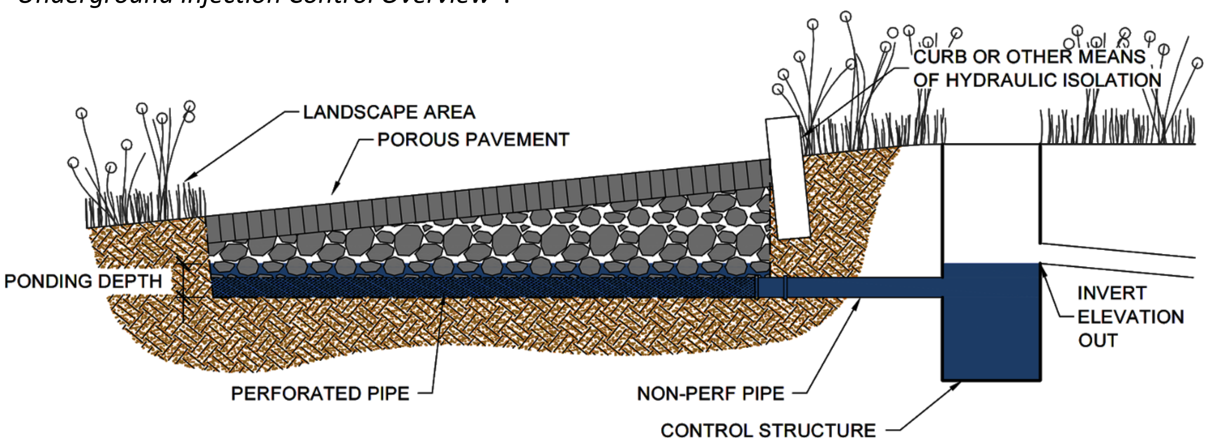


Figure 4-49. When a perforated pipe is placed at the bottom of a porous pavement, a control structure is required to ensure that the desired volume of water backs up into the pavement and infiltrates. CAUTION: Raising the pipe elevation instead of using a control structure to achieve adequate storage could provide the desired storage for infiltration but could also damage the pipe, as result of not being buried deep enough to be protected from vehicular or maintenance equipment.

If the underdrain is set on the bottom of the facility with no control structure (***Figure 4-68***), water will find the path of least resistance and will exit the system quickly via the pipe, instead of infiltrating. This is costly and low functioning, in terms of watershed health protection.

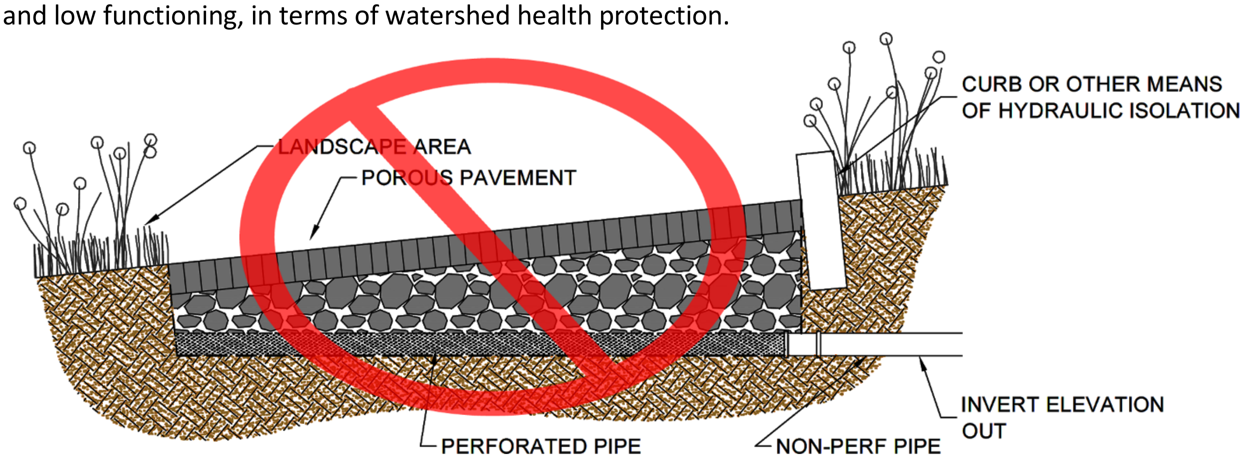


Figure 4-50. Avoid this configuration, where an underdrain has no control structure. Even though the microbial community breaks down hydrocarbons as oil passes through the pavement section, it provides none of the water quality benefits that result from runoff reduction, because runoff quickly leaves the system.

Underdrains for Inflow, Additional Routing Considerations for Porous Pavements that Manage Runoff. Water can be conveyed directly to the base rock via a perforated pipe. This design must be hydrologically modeled by a licensed engineer; however, this can be an effective use of land to infiltrate large volumes of runoff and protect water quality, since more rock is usually needed for structural capacity than hydrologic needs.

Figure 4-51. Non-perforated pipes convey runoff from uphill impervious areas to the perforated pipes pictured here at the bottom of the porous pavement before gravel has been placed.

Design Approaches to Address Clogging. The infiltration rate of porous asphalt and concrete may be as high as 1500 inches/hour[42] while long-term infiltration rates have been observed to fall to as low as 2 inches/hour[43]. Considering the high void ratio when first installed, a "mostly clogged" surface can still be very effective.

<u>Nonetheless, the design phase is a good time to address long-term clogging issues:</u>

- Runoff from other areas should never be via overland flow onto the pavement surface. Even the small, frequent water quality sized storm will convey sediment into the pavement voids, clogging them.
- Runoff conveyed by underground piping should be pretreated to settle out sediments, even if the surface areas are roofs. The amount of sediment that comes from a roof varies with local air quality conditions. For instance, a roof near a highway will generate more sediment-laden runoff than a roof farther away.
- Design landscape slopes around porous pavements, so that if they erode, the sediment will not reach the pavement surface. This is referred to as "hydraulic isolation" (***Figure 4-47***) and can be achieved with a curb (preferred) or a deep swale.
- Provide short-term and permanent signage to prevent workers from dumping construction and landscaping materials on it.

Design Specific to Porous Asphalt. In addition to the design guidance provided above, additional considerations for porous asphalt, addressed through the specifications provided in **Appendix D**: Specifications, "*Porous Pavement (Bituminous) Specifications*" are as follows:

- Porous asphalt (aka Porous Asphaltic Concrete) is a mixture of crushed aggregate (without the fines) and asphalt binder. The surface of a successfully designed and installed porous asphalt

[42] *Environmental Protection Agency (2010). Surface Infiltration Rates of Permeable Surfaces: Six Month Update (November 2009 through April 2010). Retrieved from: http://nepis.epa.gov/Adobe/PDF/P1008CH4.pdf*

[43] *Bean, E., Hunt, B., Bidelspach, D. and J. Smith. (2004). Surface Infiltration rates of Permeable Pavement. North Carolina State University. Retrieved from: http://www.usawaterquality.org/conferences/2004/posters/beanNC.pdf*

typically will have a void ratio of 10-20%. To reduce scuffing, use an additional polymer modified Performance Graded Asphalt Binder (PGAB).

- Because asphalt is a flexible pavement, the base rock serves not only as storage for stormwater, but also as an integral part of the structural support for the pavement surface.

Design Specific to Pervious Concrete. Concrete mixtures are made of aggregate and Portland cement. Because concrete is a rigid pavement, the base rock may only be needed to store stormwater, not to support the surface structurally. In soils draining at a rate that matches or exceeds the fastest rate at which rain from the 25-year 24-hour design storm of 5.0-inches might fall on the pavement, the base rock may not be needed. Nonetheless, the design specifications from the National Ready Mixed Concrete Association recommend a minimum of 6 inches of base rock in pervious concrete installations. The choker course is unnecessary, because porous concrete isn't rolled like asphalt; it's poured and screed into place.

Design Specific to Permeable Pavers. Pavers can be made of many different materials and can be bought new from a manufacturer or salvaged (e.g. bricks, stones, or sawcut concrete sidewalk squares). In vehicular applications, the entire facility area should be contained by a 6-inch wide perimeter of concrete or equivalent permanent structure to hold the pavers in place. (See Detail BMP 5.05 Vehicular Permeable Paver Edges). Avoid paver products that recommend native soil compaction and/or do not include a drainage/storage area as these are not likely to infiltrate sufficient rainfall volumes. Check with the manufacturer to make sure that they offer a warranty without compaction.

Design Specific to Porous Flexible Paving Systems. These concrete or plastic frameworks or matrices are filled with turf grass or gravel. Climate may drive the choice between grass and gravel, since the landowner may want to water turf through the summer in Western Oregon.
Plastic units tend to provide better turf establishment and longevity, since plastic doesn't absorb soil moisture the way concrete does.

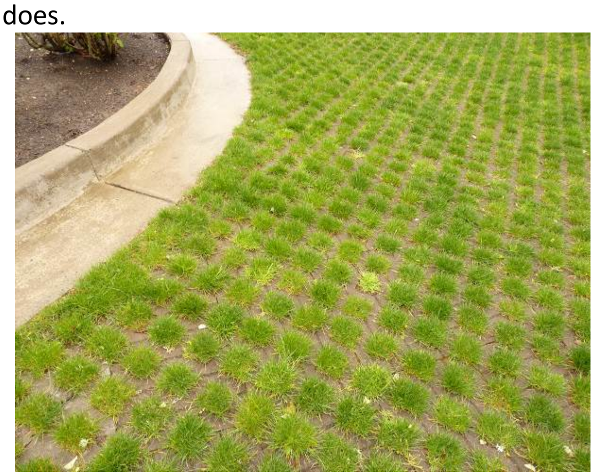


Figure 4-52. Concrete grass pavers are great for overflow parking areas to preserve site permeability in low traffic areas. (In high traffic areas, grass and turf will be shaded too much to grow grass. Use gravel in this case.)

Construction

Like all stormwater management facilities, special care must be taken to properly construct BMPs. Protecting the infiltration capacity of the soil is crucial to the long-term functioning of any infiltration facility. See **Appendix B**, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project. Mistakes in construction can lead to unintentional damage to the facility (*i.e*. clogging).

Construction Approaches to Address Clogging. The construction phase is a good time to address long-term clogging issues:

- Never stockpile landscape, soil, or other materials on porous pavements.
- Develop a circulation plan for different construction phases**.** (See **Chapter 4** "*Limit Disturbance: Construction Sequencing BMP*".) Construction of the porous surface and base rock is ideally completed at the very end of a project, because it may be difficult to protect from getting clogged with dirt. Alternate access roads should to be planned ahead of time. This is especially difficult for Planned Unit Developments (PUD). Contractors should budget for protecting the pavement from tracked sediment, especially when a few hundred yards of porous pavement are between the PUD entrance and the development site. In the case of where a PUD road is already installed, it is recommended to place rented steel plates over the length of the construction pathway (access road) each time a house is built. Some projects have had good experience protecting pavement with geotextile under sheet insulation (aka "blueboard") under then plywood. If protecting the pavement is not feasible using these or other equivalent methods, then the PUD may not be suitable for porous pavement. The designer should consider a soakage trench (see **Chapter 4** "*Soakage Trench BMP*") underneath a conventional pavement surface.
- Protect the soils beneath porous pavement from compaction. Porous pavement design is based on infiltration testing done before construction. All on-site contractors are responsible for maintaining that infiltration rate throughout the construction phase using the strategies described in **Appendix B**: BMP Implementation Criteria, "*LID Construction Phase*" and **Chapter 4**, "*Limit Disturbance: Construction Sequencing BMP*". If a designated porous pavement area must receive traffic before construction, consult a licensed engineer to develop a temporary haul road pavement section.
- Communicate to sub-contractors. Strategize with subcontractors at weekly meetings on how they can achieve their goals while protecting the pavement infiltration area and pavement surface. Effective construction signage can be as simple as plywood and spray paint.

The following guidance is provided for discussion with the contractor regarding the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP so its long-term function is achieved.

Basic Construction Steps. Construction varies with each pavement surface type; however, the first few steps are the same for all porous pavements:

1. Excavate to the lowest elevation as shown on the plans to install the geotextile using appropriate methods as described above.
2. Install the geotextile. (See **Appendix D**: Specifications, "*Geotextile Fabric*".) Overlap sheets at least 18 inches on the bottom and sides. At the sides, lay an additional 4 feet beyond the bed to ensure sediment and runoff do not enter the bed during construction.
3. Wash the base rock. (See **Appendix D**: Specifications, "*Coarse Aggregate*".) (Note: Depending on the structural capacity and drainage characteristics of your native soils, base rock may not be needed for pervious concrete installations.) Dust or fine particles not washed away could clog the geotextile[44], so not only should the base rock be delivered clean from the quarry it should also be washed carefully on-site. One method is to hose the rock off in the delivery truck when it arrives. Another is to dump the rock and wash off the pile. Since the wash water from these activities is wastewater, be sure to include such base rock washing in your erosion and sediment control plan for the construction site and take steps to ensure that this wastewater does not enter a stormwater

[44] *Hicks, P.C. and JamesJ.R. Lundy..(Revised Oct. 2003 by Jim Huddleston). Asphalt Pavement Design Guide. Prepared for: Asphalt Pavement Association of Oregon.*

conveyance system. In both instances, scoop the rock from the surface and closely monitor the rock for fines that have washed down in previous washes. If careful attention isn't paid to this step, the geotextile fabric could become clogged, creating an unintentional impervious layer below the pavement section.

4. Place the base rock in 6-inch lifts[45] by dumping rock at the beginning of the porous pavement area and backing over it to dump and spread the next 6-inch lift. Do not compact with vibratory equipment. Light compaction can be achieved by driving back over each 6-inch lift. Place lifts to the top of the base rock elevation as indicated on the plan set.

If porous gravel is being implemented, the pavement construction is complete. If another porous pavement surface type is being implemented, continue below.

Construction Specific to Asphalt.
Follow additional guidance provided in **Appendix D**: Specifications, "*Porous Asphalt (Bituminous) Pavement Specification*".

1. Complete steps 1-4 above (Basic Construction steps).
2. Install choker course. When the base rock is lightly compacted, it may be difficult to roll asphalt on top of it. The base rock rolls, causing a wavy appearance to the asphalt surface. The choker course sits between the base course and pavement surface to lock in, or choke, the larger base rock aggregate below and stabilize the surface for rolling. Field experimentation is sometimes needed, but depths will generally range from 1 to 2 inches[46] and should be composed of a smaller, uniformly graded, clean and washed crushed aggregate. Larger depths of choker course will not choke the pavement beneath it but will instead start to roll again like the base course. Depending on the size of the base course aggregate, exceeding a depth of 2 inches will probably not be helpful.

   The choker course is not always needed. At Pringle Creek, outside of Salem, for instance, the base rock was sufficiently hard with enough angular faces to lock together on its own, under light compaction. This is common in Oregon where volcanic bedrock can be hard, but if you're not sure whether you need it or not, except for the additional cost, it doesn't hurt to include it. Consider asking a licensed engineer to determine if the base rock you will source needs a choker course.
3. Place porous asphalt. Porous asphalt placement is similar to the process of placing impervious asphalt. It should be placed and rolled, but care must be taken to not over compact the surface by using a small roller and limiting the passes, usually to two. Careful construction staging will ensure installation happens during a time of the year when temperatures will not drop below 55 °F during placement. Asphalt mix temperature at the time of placement is important, too.

Construction Specific to Pervious Concrete.

1. Complete steps 1-4 above (Basic Construction steps).
2. Place pervious concrete. The installation of pervious concrete differs enough from impervious concrete that installation should always be done by a certified contractor. There are a number of certification programs in Oregon certified by the National Ready Mixed Concrete Association called the "NRMCA Pervious Concrete Technician" training[47].

[45] *Lifts is a common term in construction and refers a depth of material, usually a portion of the total depth.*
[46] *Puget Sound Action Team, (January 2005, Revised May 2005). Low Impact Development: Technical Guidance Manual for Puget Sound. Publication No. PSAT 05-03. Olympia, WA: Washington State University Pierce County Extension.*
[47] *National Ready Mixed Concrete Association website. Pervious Concrete Technician Certification. retrieved from: http://www.nrmca.org/certifications/pervious/*

Pervious concrete uses a low cement to water ratio. The mixture should be used within an hour of adding water. Water should only be added once, since additional water can cause the cement to weaken and fail. Depending on weather conditions, the concrete should be covered within 15 minutes or less. On some very hot, dry days, pervious concrete may not be installable at all because of the cover limitation.

Construction Specific to Permeable Pavers. Manufactured permeable pavers should be installed per manufacturer guidelines. Guidance for salvaged or poured concrete pavers are as follows:

Figure 4-53. One cost-effective solution for permeable pavers is this poured-in-place installation. Two-by-four lumber was used to create a grid on top of the base rock and conventional impervious concrete was poured between them. After curing, the lumber was removed and the gaps were filled with infill rock. (See Detail BMP 5.04.)

1. Complete steps 1-4 above (Basic Construction steps).
2. Place bedding course. Permeable pavers should be placed atop a lightly compacted leveling course of AASHTO No. 8 or equivalent crushed rock. (See **Appendix D**: Specifications, "*Crushed Aggregate*".)
3. Place pavers. Space between pavers, called the infill course, should be between 8-20% of the paver size to allow for infiltration per the paver spacing plan on Detail BMP 5.04. The infill is a course sand, AASHTO No. 8 or equivalent crushed rock.
4. Lightly compact pavers. The area should be lightly compacted with a handheld vibratory compactor.
5. Refill infill space. If the AASHTO No. 8 or equivalent crushed rock drops below the surface of the pavers, refill infill space to meet the paver grade.

Construction Specific to Porous Flexible Paving Systems. Flexible pavers should be installed per manufacturer guidelines. Use light compaction of the soil, by water compaction, saturating the soil and causing it to settle, or by a lightweight vibratory compactor.

Maintenance for All Porous Pavements

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".

- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

When properly installed and maintained, porous pavements have worked well for over 20 years and can outlast their impervious asphalt and concrete counterparts[47]. For instance, in areas with freeze-thaw cycles, the pores in the pavement give the water a place to expand without breaking up the pavement.
On private land, a maintenance agreement is required.

Maintenance activities include:

- Inspect landscape areas twice a year for erosion. Implement erosion prevention and sediment control measures as needed per the Oregon DEQ Construction Stormwater Erosion and Sediment Control Manual[48] and replant as soon as possible.
- Remove trash and litter, which may carry dirt that can clog pavements. Frequency will vary with foot traffic. Busy commercial districts will need more frequent litter pick-ups than suburban or rural residential streets.
- Notify all landscape contractors of their responsibility to help maintain the pavement. Require them to identify an alternative place to dump landscape materials.
- Control structures, such as catch basins and manholes should be cleaned out twice a year.
- "Potholes in pervious pavement are unlikely, though settling might occur if a soft spot in the subgrade is not removed during construction. For damaged areas of less than 50 square feet, a depression could be patched by any means suitable with standard pavement, with the loss of porosity of that area being insignificant. The depression can also be filled with pervious mix."[49] The pavement may be up to 10% patched with conventional asphalt.
- Maintain porous pavement and surrounding landscapes with integrated pest management. Fertilizers, pesticides, herbicides, or fungicides are all pollutants with the potential to leach through porous pavement.
- Remove snow and ice. Snowplows are good for any surface; however, avoid frequent snow plowing on porous asphalt, using deicers instead, which are suitable for any surface type. Because porous pavements allow air to pass through them and the ground tends to be warmer than the outside air, a convective process occurs that tends to melt snow and ice much faster on porous pavements than impervious pavements. Snowplowing is best; however, raise the plow when snowplowing over pavers, since the plow could catch edges[50]. In Oregon, cinders and never salt, are used to manage icy roadways; however, cinders will clog the pavement. Environmentally sound, salt-free, liquid deicers are available and should be used instead. According to the National Ready Mixed Concrete Association, deicers should not be applied to pervious concrete in the first year after installation[51]. Other pavements, do not have this sensitivity.
- Remove moss mechanically once a year during the dry season. All pavement in the Pacific Northwest is susceptible to moss. Do not apply mossicides. Some moss is acceptable.
- Inspect and maintain permanent signage, if applicable.

Maintenance Specific to Porous Asphalt and Pervious Concrete.

- Never seal coat porous asphalt.

---

[48] *Oregon Department of Environmental Quality. Water Quality Permit Program. Erosion and Sediment Control. retrieved from: http://www.deq.state.or.us/wq/wqpermit/docs/general/npdes1200c/ErosionSedimentControl.pdf*

[49] *Southeast Michican Council of Governments. Low Impact Development Manual for Michigan: A designDesign Guide for implementersImplementers and reviewers. ,Reviewers. (2008). Michigan Department of Environmental Quality and the U.S. Environmental Protection Agency,*

[50] *Barr Engineering Company. Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates. (2001). Metropolitan Council Environmental Services, St. Paul, MN,*

[51] *Storm Water Solutions website. Maintenance Pervades in Pervious Concrete. Retrieved from: http://www.estormwater.com/maintenance-pervades-pervious-concrete*

- Remove material on surface. The cleaning interval, which might range from every 6 months to every 3 years, should be based on possible exposure to sediments. There are three proven methods:
    - Vacuuming is often recommended. If the pavement is in a public ROW where agencies sweep the streets with a vacuum truck, then porous pavements will receive this recommended maintenance.
    - Pressure washing can be done at an angle to the pavement and not directly into it. Employ erosion control measures when pressure washing.
    - Leaf blowers during the dry season, when material can be blown, are also an option.
    - Leaf/Litter vacuums have been used successfully (The City of Olympia uses a Minuteman Parker Vac-35)[52].

Test Surface Permeability Specific to Porous Asphalt and Pervious Concrete. If the infiltration rate of the pavement slows over time, it may be desirable to test the infiltration rate. When the pavement is suspected of draining slower than needed for the design storm, test pervious concrete or porous asphalt surfaces per ASTM C1701.

Maintenance Specific to Permeable Pavers.

- Manage weeds. Permeable paver surfaces have a tendency to grow plants in the infill spaces. Use integrated pest management approaches such as hand-pulling, pouring hot water on weeds, or by using a torch. Commercial maintenance services with trucks that will burn all the weeds off at once are available in Oregon. If using a torch, adhere to all fire regulations and seasonal burning bans.
- Remove material on surface for maintenance or to unclog a clogged surface. Vacuum street sweeping, pressure washing, and leaf blowing may all be used on these systems; however, operations may remove or disturb the infill rock. Replenish it with clean rock meeting the AASHTO No. 8 or equivalent specification (see **Appendix D**: Specifications).

Test Surface Permeability Specific to Permeable Pavers. Same as porous asphalt and pervious concrete, but test permeability per ASTM C1781.

Maintenance specific to Porous Flexible Paving Systems. Refer to the specific manufacturer's maintenance requirements. Some general guidance is as follows:

- For porous flexible paving systems with grass, maintenance is similar to turf.
- For flexible paving systems with gravel, broom or rake dislodged gravel back in place.
- Manage weeds. Use integrated pest management approaches such as hand-pulling (during the wet weather when soils are softer, and roots can be effectively removed), or by burning or pouring hot water on weeds.
- Inspect for bare soil, exposed rings, ruts, poorly growing grass from too much shade, and thatch.
- In the case of spills, ruts, or disturbance to access underground utilities, flexible paving systems may be cut with a sod cutter, set aside, and put back in place after subgrade has been reconstructed.
- Avoid aeration since this machinery will damage the pavement.

[52] *Gwilym, K. (2014) WSU & Puget Sound Partnership Permeable Pavement LID Workshop: Operations and Maintenance. Page 23. SvR Design Company. Retrieved from: http://goo.gl/h5erqF*

- Snow plowing may be done by "using standard truck-mounted snow plowing blades with small skids on the corners to keep the bottom of the blade"[53] about 1 inch above the grass surface.

Maintenance Specific to Porous Gravel.

- Pull weeds during dry weather seasons.
- If the rock surface becomes clogged, carefully shovel the first 1 to 2 inches of rock and rinse it off. Employ appropriate erosion control techniques as described in **Chapter 2**, "*The Construction LID Process*". Rinse rock in a disconnected landscape area, which is an area that does not drain to any sort of structured inlet such as an area drain or towards any surface like a driveway or road that drains to a structured inlet.

RAIN GARDEN, STORMWATER PLANTER, AND LID SWALE BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form F		
Worksheet	Worksheet F1 Worksheet F2		
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

[53]Marine Amazing website. Storm Water Management. Retrieved from: http://www.psparchives.com/publications/our_work/stormwater/lid/2009_Local_Assitance/005_Appendices/Grasspave2MaintenanceGuide.pdf

Drawings	
Title	**Detail**
Rain Gardens	
Simple Infiltration Rain Garden	BMP 1.01
Infiltration Rain Garden with Area Drain	BMP 1.02
Infiltration Rain Garden with Amended or Imported Soil	BMP 1.06
Infiltration Rain Garden with Amended or Imported Soil and Area Drain	BMP 1.03
Lined Filtration Rain Garden	BMP 1.04
Infiltration Rain Garden with Rock Trench	BMP 1.05
Rain Garden Planting Schematic	BMP 1.07
Stormwater Planters	
Simple Infiltration Stormwater Planter	BMP 2.06
Infiltration Stormwater Planter with Area Drain	BMP 2.01
Infiltration Stormwater Planter with Amended or Imported Soil	BMP 2.05
Infiltration Stormwater Planter with Amended or Imported Soil and Area Drain	BMP 2.02
Lined Filtration Stormwater Planter	BMP 2.03
Infiltration Stormwater Planter with Rock Trench	BMP 2.04
Stormwater Planter Planting Schematic	BMP 2.07
LID Swales	
Simple Infiltration LID Swale	BMP 3.03
Infiltration LID Swale with Amended Native or Imported Soil	BMP 3.04
Lined Filtration LID Swale	BMP 3.01
Simple Infiltration LID Swale – Lowest Elevation Cell with Area Drain	BMP 3.07
Infiltration LID Swale with Amended or Imported Soil -- Lowest Elevation Cell with Area Drain	BMP 3.08
Unlined Filtration LID Swale – Lowest Elevation Cell with Area Drain	BMP 3.02
Infiltration LID Swale with Amended or Imported Soil and Rock Trench	BMP 3.05
Infiltration LID Swale with Amended or Imported Soil and Rock Trench– Lowest Elevation Cell with Area Drain	BMP 3.06
LID Swale Planting Schematic	BMP 3.09
Additional Details	
Pavement Undercut Protection for Infiltration Facilities	BMP 8.02
Curb Cut / Curb Opening	BMP 8.03
Inlet Pretreatment & Energy Dissipater	BMP 8.04
*Area drain rim or alternative overflow structure elevation must be set to a height that allows the chosen ponding depth (either 6 inches, 9 inches, or 12 inches) to accumulate in ponding area. ** Since the check dams in LID swales create a series of small ponded areas that cascade from one LID swale cell to the next, only the last cell needs an overflow structure.	

There are a variety of approaches to managing runoff in depressions in the ground. This section provides detailed guidance on three approaches – **rain gardens**, **stormwater planters**, and **LID swale BMPs**– which function in similar ways to reduce runoff volume and pollution in stormwater runoff.

These BMPs collect stormwater runoff in a depression to first settle and filter out sediment and pollutants. As stormwater comes into contact with soil and plants, pollutants are reduced further through chemical and biological means. Stormwater quantity is reduced through evaporation, infiltration, and evapotranspiration.

Terminology. For convenience, when this guidance refers to this family of BMPs that includes rain gardens, stormwater planters, or LID swales, the term "vegetated stormwater facility" or, in this section, sometimes simply "facility" is used.

Choosing Between Rain Gardens, Stormwater Planters and LID Swales. While rain gardens, stormwater planters, and LID swales are very similar in the high quality of treatment achieved through ponding (*i.e.* holding water in pond until it can infiltrate and evaporate), the volume of water ponded differs, which affects how large they are (*i.e.* sizing). Stormwater planters have the smallest footprint, while rain gardens and LID swales have larger footprints.
Differences between the three vegetated stormwater facilities are described next.

A rain garden:

- Has gentle side slopes and may be any shape (*e.g.* round, kidney, *etc.*).
- Should be installed on flat ground (finish grade slopes generally less than 1% or where no more than a difference of 0.5 inch of ponded water would occur)
- Has a single area where water is ponded before it infiltrates or, in large storms, overflows.

Figure 4-55. Rain garden in a church parking lot.

An LID swale:

- Has gentle side slopes but is linear in shape.
- Is installed on sloping areas, using check dams that allow water to back up, which makes LID swales function in a similar way to rain gardens. Each cell created by the check dam ponds up before water cascades over the check dam and into the next cell, infiltrating and evaporating along the way. At the last cell at the bottom of the LID swale, stormwater finally may overflow.
- The centerline of an LID swale cell should slope 1% or less.

Figure 4-56. An LID swale. Dense plantings of grasses, shrubs, and trees are ideal.

A stormwater planter:

- May be either above- or in-ground (***Figures 4-57*** and ***4-58***).
- Has vertical sides created by deep curbs (in ground) or walls or a container (free-standing/above ground) instead of gentle side slopes.
- Stormwater planters can be any shape. Those above-ground tend to be square or rectangular.
- A single stormwater planter cell may be installed on flat areas (finish grade slopes generally less than 1% or where no more than a difference of 0.5 inch of ponded water would occur). On sloping ground, a stormwater planter may incorporate check dams to create a series of cells where overflow may occur in the lowest elevation cell (***Figure 4-58***).

Figure 4-57. A residential above-ground stormwater planter. This facility is lined to prevent infiltration too close to the basement.

Figure 4-58. An in-ground stormwater planter with concrete check dams in a public street, right before planting. The centerline (looking straight up the center of this photo) slopes at less than 1%. Concrete check dams were needed because the street slopes more than 1%. Grades parallel to the check dam are flat.

Infiltration versus Filtration. Vegetated stormwater facilities may either be designed to infiltrate into the site's native soils (*i.e*. infiltration facility) or they may be lined or partially lined to prevent infiltration (*i.e.* filtration facility, also sometimes referred to as "flow-through facility").

Infiltration Facilities Provide Better Watershed Protection. The purpose of treating water is to protect water resources downstream of development. The following are reasons why using other BMPs in this guidance instead of a lined filtration facility might be more appropriate in many cases:

- While infiltration and filtration facilities both treat stormwater, the water quality of the receiving stream will be higher when there is more infiltration than filtration facilities in the watershed. Since even slow draining clayey soils can infiltrate at least some runoff[54], infiltration facilities divert water into the on-site soils. Reducing runoff not only prevents polluted water from being delivered to downstream waterways in pipes, it also protects stream banks from excess erosion, instead of polluting the waterway. (See **Chapter 1**, "*Why Use LID*", "*Protecting Water Quality by Addressing Water Quantity*".)
- Lined filtration facilities, which must have an underdrain can export nutrients (nitrogen and phosphorus), which can be pollutants.

More information on when a facility with an underdrain should be used is provided in "*Underdrains*" under the "*Design*" section below.

Siting

Both infiltration and lined filtration facilities can be used on private property, public property, and within the public right-of-way. Vegetated stormwater facilities may be built in new construction, re-developments, and retrofits.

Unsuitable Locations for All Facilities. Vegetated stormwater facilities should **NOT** be installed in the following locations:

- In floodways, defined by the Federal Emergency Management Agency as "the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the

[54] *Sharkey, L.J. (2006). The Performance of Bioretention Areas in North Carolina: A Study of Water Quality, Water Quantity, and Soil Media. Master's Thesis, North Carolina State University. Retrieved from: http://www.bae.ncsu.edu/stormwater/PublicationFiles/SHARKEYthesis2006.pdf*

base flood without cumulatively increasing the water surface elevation more than a designated height."[55]

- In other sensitive areas (*i.e.* wetlands, riparian areas or buffers, designated native habitat areas.
- Over septic systems.
- In seasonally wet areas.

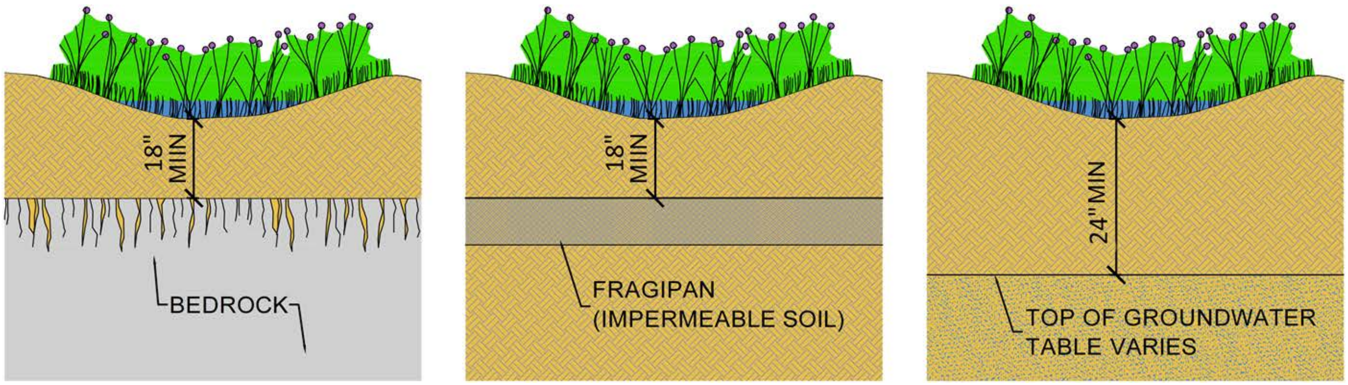


Figure 4-59. Vertical separations needed for infiltration are illustrated here. Fragipans are common in Southern Oregon. When Mount Mazama exploded and became Crater Lake, ash was spread far and wide. Over time, it was compressed under dirt and plants and became so dense that it prevents infiltration. If the fragipan is shallower than 18 inches and a permeable soil sits below the fragipan, then the fragipan can be removed and replaced with treatment soil (more info provided in later sections).

Suitable Locations for Infiltration Facilities Vegetated stormwater facilities that infiltrate can be located:

- Where the seasonal high groundwater table is greater than 24 inches from the bottom of a vegetated stormwater facility.
- Where the bedrock or other impermeable layer is greater than 18 inches from the bottom of a vegetated stormwater facility.
- In soils that infiltrate at least 0.5 inches/hour for the Simplified Sizing Approach provided in Chapter 5. Soils with lower infiltration rates may be acceptable but must be designed by a licensed engineer.
- Where they are at least 10 feet away from an existing building foundation (including slab foundations unless designed by a licensed engineer).
- Where they are least 10 feet away from a possible future building foundation (including slab foundations unless designed by a licensed engineer). Check setback requirements in the zoning code for the proposed development site and all neighboring properties to ensure that a vegetated stormwater facility will be 10 feet from a building foundation in the future.
- Where they are at least 10 feet from an underground tank or a site wall.
- Where they are at least 5 feet from underground utilities.
- On retrofits, where they will be directly over existing electrical lines that can be easily and cost-effectively relocated to be outside of the new facility.
- Directly adjacent to pier footings.
- Where they are at least 100 feet away from down-gradient slopes of 10 percent. Add 5 feet of setback for each additional percent up to 30 percent and avoid installing an infiltration vegetated stormwater facility where the down-gradient slope exceeds 30 percent.

[55] *Federal Emergency Management Agency website. Floodway definition. Retrieved from: https://www.fema.gov/floodplain-management/floodway*

- For runoff from vehicular areas, within a horizontal distance of 2x the depth of any nearby wells. Groundwater can move twice as fast horizontally as vertically, so infiltrating too close to private drinking wells can contaminate them. Locate these wells in relation to your site using the DEQ well log database[56] and infiltrate runoff no closer than 2 times the completed depth. For instance, for a well with a completed depth of 200 feet, an infiltration facility should be at least 400 feet away.
- In any location approved by a licensed engineer or geologist who has signed and stamped a geotechnical investigation report or letter clearly designating the location in narrative and/or by graphical means (i.e. site plan).

Lined filtration facilities should be used instead of infiltration facilities:

- Where the seasonal high groundwater table, bedrock is less than 24 inches from the bottom of a vegetated stormwater facility.
- Where the bedrock or other impermeable layer is less than 18 inches from the bottom of a vegetated stormwater facility.
- In landscape areas that are wet during the rainy season but dry out during the summer.
- In contaminated soils or groundwater.
- On slopes exceeding 10% or in landslide areas.
- Within 10 feet of an existing building.
- Within 10 feet of a future/possible building. Check setback requirements in the zoning code for all neighboring properties to the site to determine this.
- For vehicular runoff, in wellhead protection areas.
- For runoff from vehicular areas, within a horizontal distance of 2 times the depth of any nearby wells.

Design

Design of vegetated stormwater facilities is described generally in the following sections and applies to rain gardens, stormwater planters, and LID swales, unless otherwise stated. Information on specific configurations – for example, when to use an overflow structure or when to amend or replace soils – is described in a later section, “*Choose the Best Vegetated Stormwater Facility Configuration*”.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, “*Design*”, “*BMP Design Criteria*”.
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Sizing and Hydrologic Design. The size of a facility must be determined through hydrologic modeling (**Appendix B**: BMP Implementation Criteria, “*Design*”) based on the infiltration rate found by infiltration testing per **Appendix C**: Infiltration Testing. For vegetated stormwater facilities meeting the criteria above in “*Siting*”, “*Suitable Locations for Infiltration Facilities*” and designed in accordance with this guidance, size the facility using the LID Implementation Form (see Chapter **5**: LID Implementation, Step-by-Step).

A licensed engineer should sign, and stamp design drawings and drawings should be based on a hydrologic model using the criteria in **Appendix B**: BMP Implementation Criteria, “*Design*”, when the Simplified Sizing Approach is not applicable. The Simplified Sizing Approach is not applicable when any of the following conditions exist:

- A vegetated stormwater facility cannot be sized using the Simplified Sizing Approach according to Table 4-6.
- The tested infiltration rate per **Appendix C**: Infiltration Testing is less than 0.5 inches/hour.

[56] *Oregon Water Resources Department website. Retrieved from: http://apps.wrd.state.or.us/apps/gw/well_log/*

- The facility incorporates a rock trench (described in later sections below) beneath the vegetated stormwater facility.

Surface Geometry and Water Quality Function. Surface geometry affects the health of plants and soil, which affects water quality. Design criteria for surface geometry are as follows:

- The depth of water allowed to accumulate in a vegetated stormwater facility, known as the ponding depth, should be between 6 to 12 inches. Plants suitable for vegetated stormwater facilities are often healthier when not inundated beyond 12 inches.
- For rain gardens and LID swales, side slopes should be less than 33% (3 horizontal:1 vertical). Steeper soil slopes require mechanical compaction, which will impact the infiltration capacity of soil. This reduces the effective infiltration and/or treatment area, which can be measured from the top of the facility, and also makes it much more difficult to establish plantings (see **Chapter 2** "*The LID Construction Process*", "*Avoid Site Disturbance Impacts to Water Quality*").
- Stormwater planters have vertical sides made of structural material like concrete, not soil.
- Vegetated stormwater facilities may be any shape that meets the sizing criteria for vegetated stormwater facilities (see **Chapter 5**). Shape is more often dictated by the available space and budget.
- "Corners" made of soil should be designed with a rounded radius of at least 5 feet.

Table 4-5. Using the above guidance, minimum geometry for rain gardens and LID swales are as follows below.

Ponding Depth [inches]	Minimum Width[ft]	Min Area [sf]
6	3	9
9	4.5	20.3
12	6	36

Vegetation. Plants and the beneficial microbes that concentrate on plant roots remove pollutants through biological breakdown and/or uptake – the more plants, the more treatment. Plants also promote infiltration and evaporation.

<u>Design criteria for vegetation is as follows:</u>

- Vegetation should cover a minimum of 95% of the facility within three years. The better the plant coverage, the less effort needed for weeding.
- Avoid the dry creek bed look where rocks line the bottom and plants are sparse or located only around the top edges of the slopes. This approach doesn't provide adequate treatment for the small, frequent storms with ponding depths that may never reach the plants on the side slopes. This strategy also creates a lot of maintenance (weeding and cleaning rock).
- Vegetation should be selected based on its tolerance to flooding and drought cycles and other criteria listed in **Appendix E:** Plant Specifications.

Figure 4-60. A wide palette of vegetation can be used in rain gardens. Here, we can see sedges, rushes, shrubs and trees at a commercial property.

Mulch. Mulch is often the top layer of a newly installed vegetated stormwater facility. In non-stormwater landscape areas, mulch is used to control soil temperature for seed germination, to control weeds, to feed the plants, and to reduce the erosion of soil that would be otherwise bare; however, in a vegetated stormwater facility, routine inundation can turn mulch into a pollutant. During small storms, mulch floats and leaves soil bare as it is redistributed around the facility. During large storms, mulch is conveyed through the overflow structure. As with any organic material, as mulch breaks down in a waterway, it reduces the amount of available oxygen, which is one measure of water quality. Also, many pollutants, especially metal, attach easily to mulch.
Design criteria for mulch is as follows:

- Use mulch meeting the specifications in **Appendix D**: Specifications, "*Mulch*".
- Apply mulch for only the first three years of a vegetated stormwater facility. After that, vegetation should have adequate structure to hold soil, cover it, and shade out most weeds. (Additional information is provided in the following sections on how to implement vegetated stormwater facility to slow flows and reduce soil erosion.)

Soil. Directly below the temporary mulch is soil, which may be:

- Imported (Native soil is removed and replaced with a blended soil mix purchased from a supplier.)
- Amended (Amendments are folded into existing native soil.)
- Native and free-draining (Infiltration vegetated stormwater facilities allow water to flow down into the native soil.)

For design criteria for soil, see **Appendix D**: Specifications, "*Treatment Soil*".

Infiltration testing. Perform an infiltration test to determine the soil's capacity to absorb and percolate water down into the lower layers. See Appendix C for detailed guidance on field testing to find the rate that water can pass through the soil and how to interpret that data.

Infiltration rates impact geometry and sizing. If infiltration rates are high, the vegetated stormwater facility will have a smaller footprint, be less expensive to build, and will be able to accommodate ponding depths up to 12 inches, because water will drain through the soil within the required 30 hours.
If infiltration rates are low, a very shallow ponding depth will be desired to ensure that the plants will not have "wet feet" for excessive periods. In this case, expect to spread stormwater out in a shallow depth of just a few inches rather than trying to store the excess runoff volumes in a smaller footprint facility with a deeper ponding depth. This is the only way to ensure that the facility will be empty and ready for the next storm in 30 hours.

Imported Soil considerations. When purchasing soil to import to the site, the infiltration rate of both the imported soil and the native soil underlying it must be known. Investigate the site and decide if imported soil is needed. As described below in "*Choosing the Best Vegetated Stormwater Facility*", this may be done for a number of reasons:

- The soils are compacted and instead of restoring the soil with compost per the Restored Soil BMP, a designer or contractor would prefer to import and place a purchased product.
- The existing topsoil or surface material (*e.g.* gravel) does not have adequate nutrition to adequately support plant life.
- The existing soils drain faster than the recommended 12 inches/hour. (Faster than this could pollute groundwater by reducing the time that pollutants are in contact with soil.)

<u>To determine the infiltration rates of the different soils:</u>

1. Perform an infiltration test on the native soil per **Appendix C**: Infiltration Testing.
2. Determine the imported soil infiltration rate. Infiltration rates (referred to in laboratories as the "long-term hydraulic conductivity") for imported soils may be found from laboratory testing:
   a. **Infiltration rate testing (more difficult and costly).** Ensure the imported soil meets the infiltration rate range described above using ASTM D2434 at 85% compaction per ASTM D2668.
   b. **Gradation testing (less difficult and less costly).** Ensure the imported soil meets the infiltration rate range described above based on sieve analysis testing.
   Washington State Department of Ecology has developed charts that correlate grain size distribution to infiltration rates[57]. To determine the infiltration rate of a soil using this method, ask the soil supplier for the D10 specification on their imported soil mix, which is the volume of the soil's smallest 10% of particles.
   If the soil supplier cannot provide the D10 of their mix, collect a representative sample (i.e. the sample is expected to have the same grain size distribution as the soil left in the rest of the pile). Different soils may require different volumes to gather a representative sample. Send the sample to a soil testing lab and request an ASTM D422 procedure. The lab will dry the soil and run a series of tests, including a sieve analysis to assess the volume of the soil's smallest 10% particles, D10.
   For soils with a D10 greater than 0.05 mm, the following graph may be used to assign a design (i.e. long-term) infiltration rate:

[57] *Washington Department of Ecology. Stormwater Management Manual for Western Washington. Hydrologic Analysis and Flow Control Design/BMPs. Volume 3. (Amended Dec. 2014). Retrieved from: http://www.ecy.wa.gov/programs/wq/stormwater/manual.html*

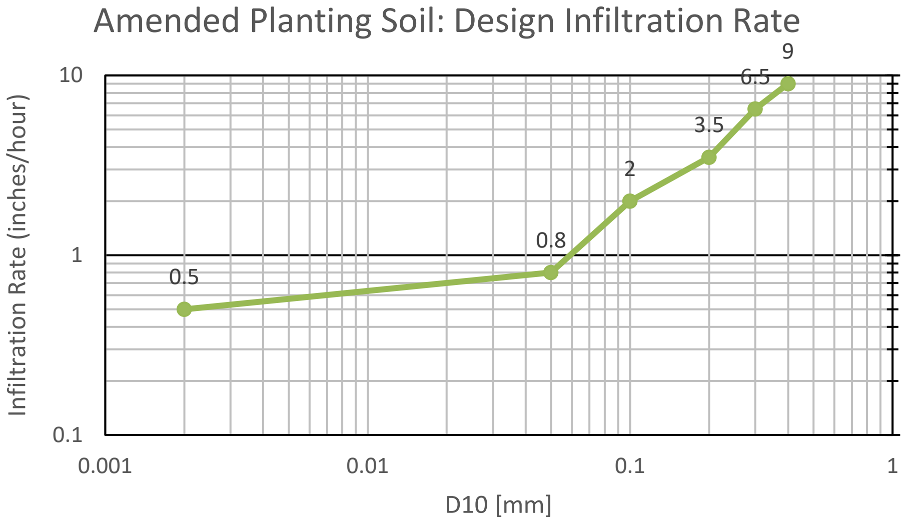


Figure 4-61. Infiltration Rate as a function of the D10 size of the soil for ponds in Western Washington.

Since these infiltration recommendations represent long-term design infiltration rates and not field-tested infiltration rates, no factor of safety is needed unless there is no pre-treatment system for sediments, less than average maintenance is expected, or soil horizons are finely layered (i.e. there are many types of soil in shallow layers).

3. Determine the design infiltration rate by comparing the infiltration rates of the different soil horizons per ***Figures 4-62*** below.

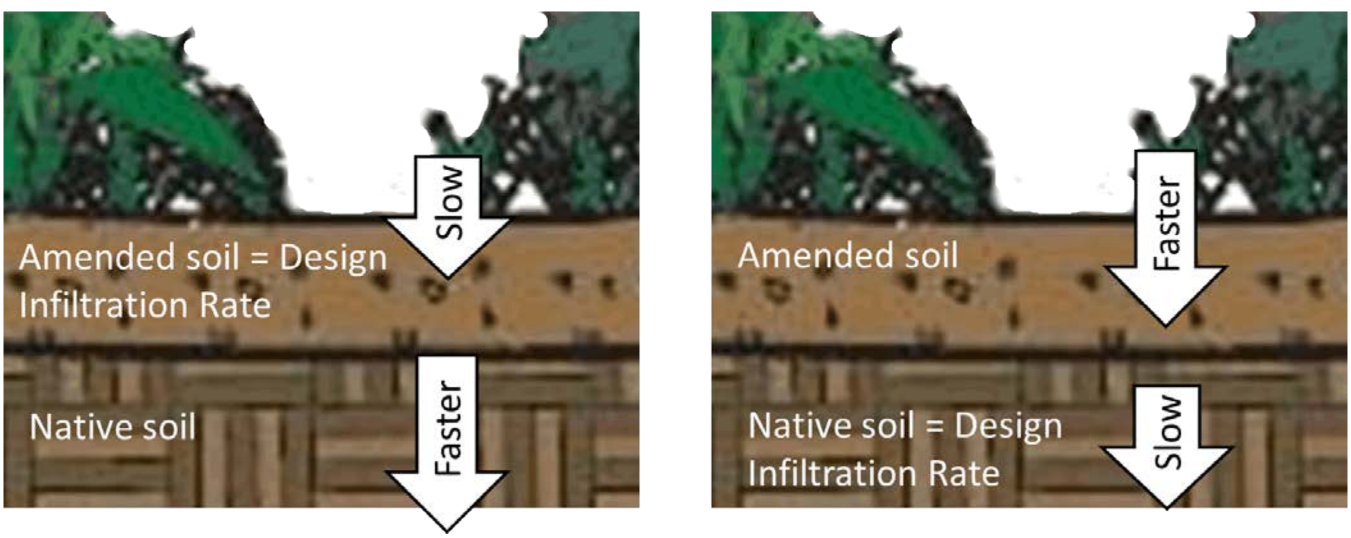


Figure 4-62. These images show the bottom of an infiltration vegetated stormwater facility, where more than one soil will infiltrate stormwater runoff. The design infiltration rate is always the slowest infiltration rate of the different soil horizons (imported or native), as shown.

4. Size the facility based on the design infiltration rate (i.e. the slowest infiltration rate within the rain garden footprint) using the appropriate worksheets when completing the LID Implementation Form (see **Chapter 5**).

Where stormwater enters a facility in a concentrated fashion (i.e. piped or flow from a gutter), a structure to settle out sediment and trap trash improves water quality treatment, extends the life of the facility and reduces maintenance times by concentrating potential clogging agents in one place, making them easier to remove. (See "*Maintenance*" below for additional information on sediment disposal.)

A number of different pretreatment strategies are shown below. Choose one that is appropriate for the level of sediment expected for the surface draining to the facility and one that can be maintained by the landowner. Strategies pictured below are characterized as:

- "High sediment loads" may come from roads with greater than 7,000 cars per day (*i.e.* average daily traffic or ADT).
- "Low sediment loads" come from roofs.
- All other surfaces may be considered to be "medium sediment loads".

Figure 4-63. This sump settles sediment making it easy to remove and also serves as a headwall to protect pipe integrity. This pretreatment strategy is suitable for high sediment loads but is more difficult to access than other pretreatment strategies presented below.

Figure 4-64. When runoff is piped to a facility and there is adequate fall, a sediment manhole can be used in settings with high sediment loads to pretreat runoff before it enters an infiltration vegetated stormwater facility. This facility is a proprietary system that provides advanced treatment for drainage from a gas station's parking lot and driveways. (The area where gas is pumped is covered and hydraulically isolated and does not drain to this facility.)

Figure 4-65. This concrete pad is tipped slightly away from the vegetated stormwater facility in the background and shaped with a slight off-center dip. As evidenced by the sediment, this pad works relatively well as a pretreatment strategy, but some dirt can be seen washing into the planted area, which is not ideal. This pretreatment strategy is suitable for medium sediment loads.

Design criteria for pretreatment is as follows:

- Allow water to pool in a sump (as shown in ***Figure 4-63*** above or ***Figure 4-70*** below) or equivalent structure such as a carefully shaped concrete pad (as shown in ***Figure 4-64*** above).
- Avoid rip rap placed at the entrance of the facility, especially in high traffic roads or other areas with high sediment loads. If designed properly, many solids will settle out as runoff passes over the rip rap but the primary purpose of rip rap is to slow flows to prevent erosion. Cleaning dirt between rip rap is a time consuming and expensive maintenance task and once the rip rap is full of dirt, it doesn't slow the flows much and erosion happens anyway. If rip rap is used, a licensed engineer should provide calculations for the length, width, depth, and rock diameter to account for the predicted velocity per the Oregon Department of Transportation 2014 Hydraulics Manual, Section 11.11 "Design of Rip Rap Pads"[58].
- Dense vegetation at the inlet may also slow flows but removing sediment from around the plants can be time consuming. Vegetation shouldn't be so dense that it will impede flow into the facility.
- Consider creating rough surfaces to slow flows. Avoid smooth concrete channels unless designed to tip back slightly towards the inlet, since they will simply transfer erosive flows from the entrance to the end of the channel.

Inlets. Careful inlet design will ensure that runoff enters the facility as expected.

<u>Design criteria for inlets is as follows:</u>

- Avoid curb cuts where water must make a 90-degree turn into an adjacent facility, since very small amounts of sediment will build up at the entrance, which can prevent the shallow flowing, frequent water quality flows from entering the facility. Curb cuts should be used where the pavement forms a V-shape draining towards it (***Figure 4-66***) or for "bump-out" type facilities (***Figure 4-68***).

[58] *Oregon Department of Transportation Hydraulics Manual. Chapter 11: Energy Dissipaters. (April 2014). Retrieved from: http://www.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/docs/Hydraulics/Hydraulics%20Manual/CHAPTER_11.pdf*

Figure 4-66. Curb cuts are effective where pavement forms a valley gutter that drains toward them. Here, the driveway slopes away from the sidewalk and away from the house making the curb cut the lowest point of the driveway.

Figure 4-67. For curb cuts on a slope, one effective means of turning the water 90-degrees into the facility is to pour an extruded speed bump-type structure onto existing pavement just downstream of the curb cut. Decorating this structure with fish is not necessary, but certainly raises awareness of the facility behind it.

Figure 4-68. A "bumpout" style rain garden where the curb drains directly into the facility without having to change the direction of its flow is a good application for a curb cut. A metal bar across the opening provides a mild warning, approximately equivalent to a curb, to alert drivers who might pull forward into the facility.

Figure 4-69. The front (left) and back (right) of this inlet is pictured. This is one way to avoid using curb cuts when flows along a curb need to be captured and redirected. Add a sump to the catch basin inlet to capture sediments, seen on the right, for a lower maintenance strategy for settings with medium and high sediment loads.

- Design the facility so that high flows, generated by storms larger than the design storm, can bypass the system. This will reduce erosion, the re-suspension of sediment, and maintenance. One method for incorporating a bypass is to develop a grading plan that will automatically block excess flows from entering the ponding area. (See **Appendix B**: BMP Implementation Criteria, "*Design*", "*High Flow Bypass*".)
- For inlets to vegetated stormwater facilities in the public right-of-way, the curb inlet should be a standard Grants Pass curb inlet modified to drain from the back into the vegetated stormwater facility at an elevation equal to the bottom of the vegetated stormwater facility (***Figure 4-96***).

Figure 4-70. This Curb Inlet is ideal to serve as an inlet, pretreatment, and high flow bypass for high sediment areas. A sump in the bottom allows sediment to collect and be easily removed with standard vacuum truck equipment. A slot cut in the back just a bit lower than the gutter line allows water to enter the facility cleaner and with less erosive power than a conventional curb cut. If the bottom of the weir/slot is located at the same elevation as the desired maximum ponding depth, then this will also serve as high flow bypass during large storms, allowing relatively clean water to bypass the facility instead of entering it and causing erosion.

Vegetated Stormwater Facility on Slopes: Check Dams. Check dams are structures usually used in linear shaped vegetated stormwater facilities to pond water and prevent erosion on slopes.

<u>Design criteria for check dams is as follows:</u>

- Horizontal spacing should be based on the ponding depth and centerline slope of the vegetated stormwater facility (see example for a rock check dam in ***Figure 4-71***)
- The top elevation of the check dam should not be so high that water cannot crest and flow into the next cell and not so low that the desired ponding depth is not achieved.

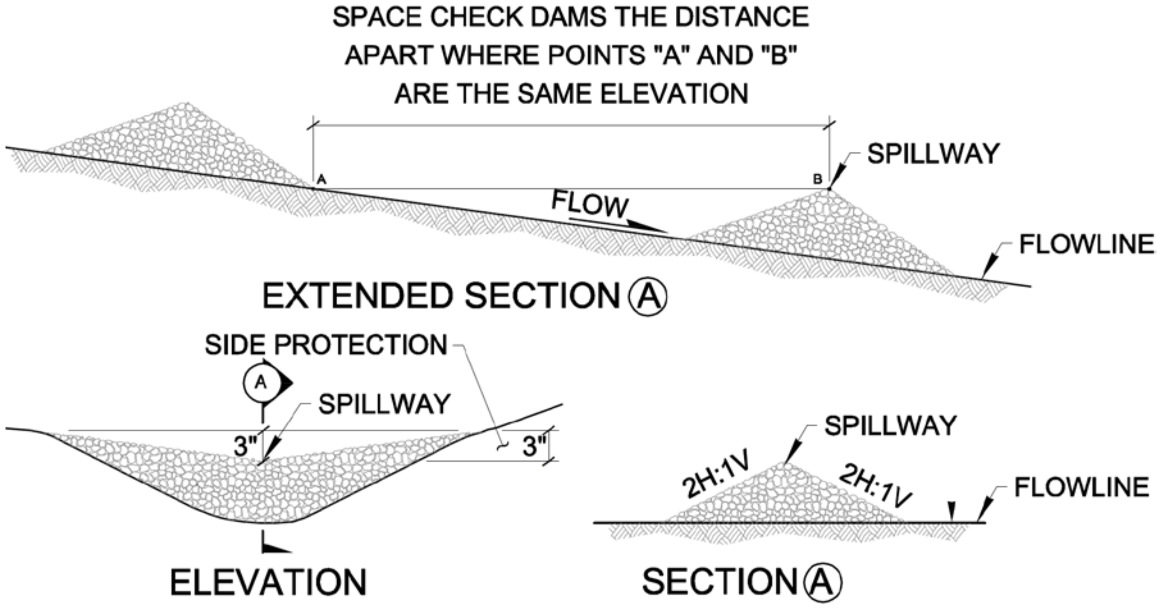


Figure 4-71. Check dam spacing depends on ponding depth and the facility's centerline slope, as shown in "Extended Section A" above. Adapted from City of Portland standard detail.

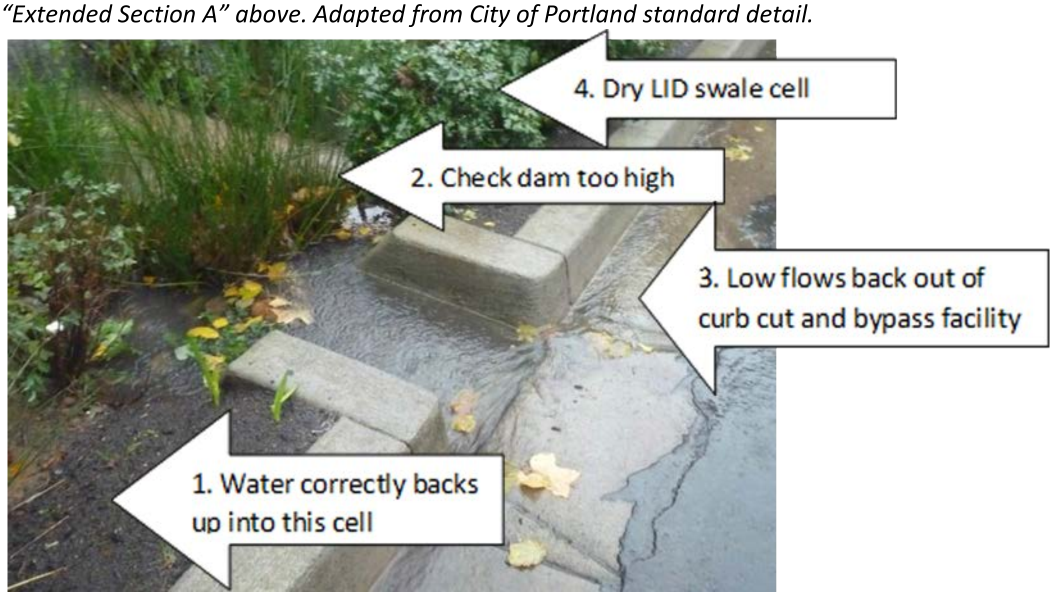


Figure 4-72. Water flows along the gutterline from bottom left to the top right. The top of this check dam is too high, which causes water to back out of the facility, instead of crest the check dam to be managed in the next lowest cell/section of the facility.

On slopes exceeding 5%, install check dams made of:

- Concrete
- Stone
- Untreated, rot resistant wood such as juniper

- Stainless steel

Because they contribute a variety of pollutants to stormwater, avoid using the following materials for check dams:

- Treated wood. Even wood treated with environmentally friendly products, like copper, is not suitable for stormwater facilities. Copper has very high impacts to endangered fish at very low levels.
- Any metal other than stainless steel. Copper, zinc (from galvanized materials), and iron are all water quality pollutants.
- Crushed concrete. This can raise the pH of water flowing through it.
- Bare compacted clay or soil. These will easily erode, and soil and sediment are both pollutants.

Underdrains. Underdrains are perforated pipes usually located at the bottom of a facility surrounded by gravel that ensure drainage within a reasonable time to keep the plants alive and/or to be ready for the next storm. In most cases, they should be avoided.
They are best used:

- In a lined filtration vegetated stormwater facility.
- Where soils are slow draining.

Avoid using underdrains in infiltration facilities just because the soils drain slowly. Reducing runoff is the most effective way to reduce pollution downstream (see **Chapter 1**, "*Why Use Low Impact Development*") and some infiltration occurs in slow draining soils[59]. An underdrain can cause the water to shortcut and can reduce the infiltration capacity of a facility. Follow the design guidance provided above in "*Infiltration versus Filtration*".
Design criteria for underdrains are as follows:

- Underdrains in infiltration facilities must be pre-approved since water will take the easiest path out of the system and not infiltrate if an underdrain is improperly designed.
- Underdrains in infiltration facilities should be either set at an elevation allowing the required design storm to be infiltrated in the aggregate rock beneath the pipe or connected to a control structure designed to back water up behind it (see Detail BMP 8.01).
- Underdrains are required in lined filtration facilities. These should be located on the bottom of the facility above the impermeable liner (as shown in the standard detail in Appendix F). Avoid connecting underdrains to a control structure in such a way that water might back up at an elevation greater than the pipe, which would create a permanent pool that could waterlog plants.
- Underdrains should not be wrapped in geotextile fabric; instead, the pipe should be surrounded by a 12-inch thick coarse aggregate layer (see Appendix "*Specifications*", "*Coarse Aggregate*") as shown on the details with underdrains in **Appendix F**.
- Access to underdrains should be provided via a cleanout or outlet structure such as an area drain or catch basin.

Overflow structures. Overflow structures such as a catch basin within a vegetated stormwater facility should be incorporated when storm events could cause damage to a structure (by backing up into it or flowing down into it) or create a dangerous condition (*e.g.* excess stormwater flowing over a public sidewalk) (***Figure 4-73***). Overflow structures cannot be relied upon during a storm larger than the design storm; instead, a safe overland route per **Appendix B**: BMP Implementation Criteria, "*Design*", "*BMP*

[59] *Sharkey, L.J. (2006). The Performance Of Bioretention Areas In North Carolina: A Study Of Water Quality, Water Quantity, And Soil Media. Masters Thesis, North Carolina State University. Retrieved from: http://www.bae.ncsu.edu/stormwater/PublicationFiles/SHARKEYthesis2006.pdf*

Design Criteria", "*Safe Overland Route*" must be provided.

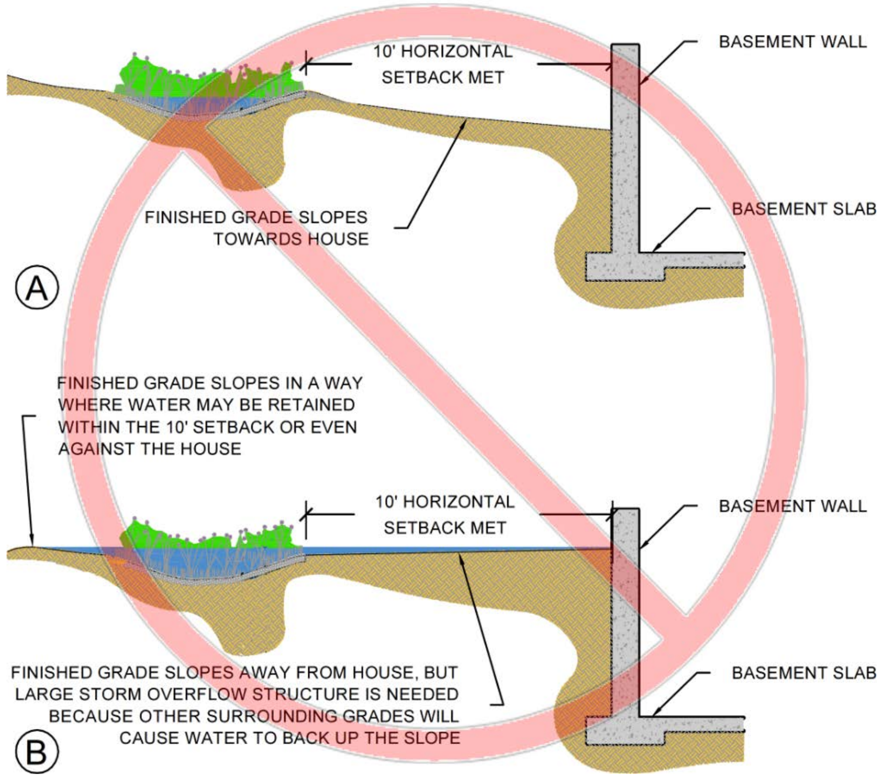


Figure 4-73. Examples of when an area drain or equivalent overflow structure is needed. Even when horizontal setback and vertical separation criteria are met, a rain garden could be placed in such a way that damage to a house or other structure is possible. "A" in the graphic above illustrates how water may flow downhill to damage a structure. "B" illustrates how, without an area drain or equivalent large storm overflow structure, finish grades could cause water to back up against a structure and cause damage. These are just two examples of when a large storm overflow is required to protect damage to structures and good examples that illustrate the importance of a safe overland route for large, infrequent storms.

Overflow structures must drain to an approved discharge point and may include:

- A berm. To build a berm, establish a minimum of 2 inches of freeboard above the ponding depth (6 to 12 inches) controlled by the outlet[60]. Earthen berms should be stabilized with vegetation or otherwise designed to reduce erosion. Berms should not be designed to be compacted bare soil.
- An overflow channel such as a water quality conveyance swale (see Chapter 4 "*Water Quality Conveyance BMP*") or a hard channel such as runnel. The centerline elevation of the channel should be set at an elevation for maximum ponding depth.
- Catch basin and pipe. Set the rim elevation of the catch basin equal to the desired ponding depth to store and infiltrate the full design storm.

Storage Rock. Storage rock is rock that provides adequate voids (per **Appendix D**: Specifications, "*Coarse Aggregate*") placed underneath the ponding area and soil of a vegetated stormwater facility, used to store large storm volumes until runoff can infiltrated. A licensed engineer is required for designs that incorporate rock storage beneath a vegetated stormwater facility to size the depth of rock using hydrologic modeling (per criteria provided **Appendix B**: BMP Implementation Criteria, "*Design*", "*Engineered Design Approach*").

[60] *Barr Engineering Company. (2001.). Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates. Metropolitan Council Environmental Services, St. Paul, Minnesota.*

In slow draining soils (generally less than 1.0 inch/hour but it depends on the design storm size), storage rock will not reduce the footprint of the vegetated stormwater facility. Since a facility must empty in 30 hours, shallow ponding depths (usually less than 6 inches) control the size of the facility. In this case, water must be spread out. Increasing the depth of water (either by increasing the ponding depth or by employing a rock trench below the pond) is more likely to cause the emptying time to exceed 30 hours.

For this reason, storage rock is best used in faster draining soils on projects with constrained infiltration area where the requirement to empty in 30 hours is easily met, even if additional ponded water is added to the same vegetated stormwater facility footprint.

Rock separation. A strategy to prevent the soil above and below the rock trench from migrating into the voids meant to store water is required when employing a rock trench. Avoid geotextile fabrics on the top and bottom, which have been found to clog in numerous studies[61]. Instead a 4-inch thick layer of separation rock (see **Appendix D**: Specifications for information for infill and separation rock under "*Aggregates*") should be installed between the facility soil and the rock trench. In the case of fine graded soils (*i.e.* clayey or silty soils), this separation rock layer should also be installed at the bottom of the rock trench. As shown in the standard detail (see **Appendix F**), geotextile fabric may be used on the sides of the rock.

Careful subsurface grading of rock trenches on slopes must be implemented to ensure that rock will be available to store runoff for subsequent infiltration (***Figure 4-74***).

[61] *Two Rouhi, A. and D. Schwartz. (2007). Physical Assessment of Selected Rain Gardens in Fairfax County, Virginia. The Northern Virginia Soil and Water Conservation District. Fairfax, VA. Retrieved from: http://www.fairfaxcounty.gov/nvswcd/raingardenstudy.pdf and the University of New Hampshire Stormwater Center. 2009 Biannual Report. Retrieved from: http://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/2009_unhsc_report.pdf*

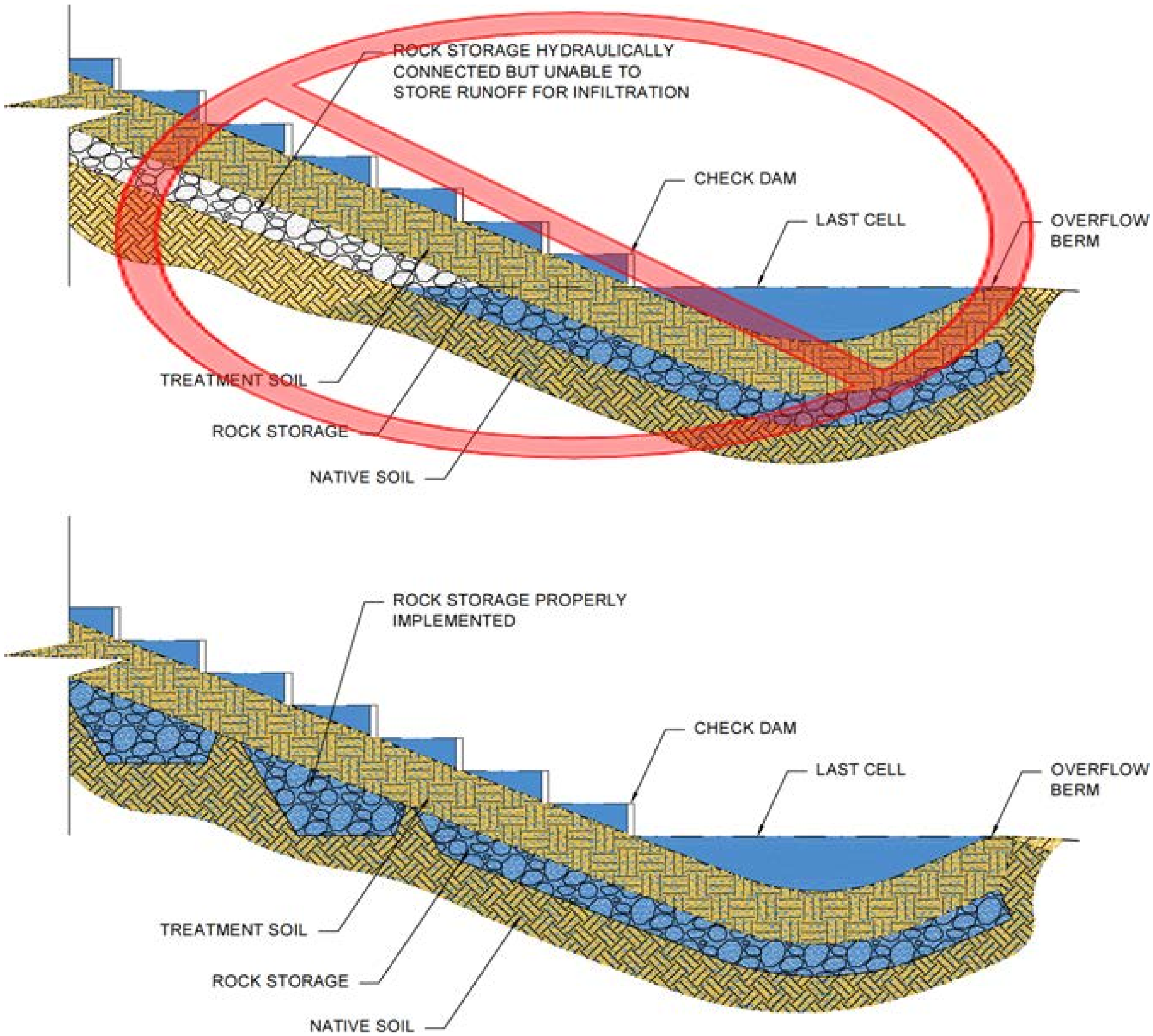


Figure 4-74. In the top figure, the desired rock trench depth has been installed with the same depth along the entire length of the facility; however, the overflow berm of the lowest cell will overflow before rock above that elevation can store and infiltrate water. Per the bottom figure, rock trenches are stepped down the hill with existing contours to ensure storage availability. In this case, a subsurface grading plan may be useful to include in the permit/construction drawing set.

Impermeable Liner. Impermeable liners are required in lined filtration facilities. Impermeable liners are sometimes used in infiltration facilities to limit horizontal flow. (See **Appendix D**: Specifications, "*Impermeable Liner*".)

Vertical installations in infiltration vegetated stormwater facilities. Because water moves through soil twice as fast horizontally as it does vertically, when installing vegetated stormwater facilities next to conventional roadways, it is prudent to block flows from entering the conventional pavement sections. Along public roads, this is often done by pouring continuous concrete curbs around the vegetated stormwater facility. Concrete curbs do pass moisture through them and some designers wish to block this as well, so an impermeable liner is mechanically attached to the curb as an extra precaution against moisture. The liner is only as deep as the curb and does not cover the bottom.

Partial infiltration vegetated stormwater facilities. Where site areas are constrained, one strategy for infiltrating at least some runoff is to partially line a vegetated stormwater facility (***Figure 4-75***). Some infiltration is better than none, where feasible. For new and re-development projects, a partially infiltrating vegetated stormwater facility must be designed and hydrologically modeled by a licensed engineer using the hydrologic criteria in Appendix B: BMP Implementation Criteria, "*Design*", "*Hydrologic Modeling*", "*Engineered Design Approach*".

Figure 4-75. This recently installed rain garden retrofit includes a partial liner on the right side and for a distance of about 5 feet out horizontally from the sidewalk. The sidewalk is 5 feet wide, so the 5-foot liner ensures that water cannot infiltrate closer than the recommended 10 feet from the building. The rest of the facility area is able to infiltrate. The vertical portion of this liner runs at least 12 inches deep so that adequate soil volume can be placed on top to grow the chosen grasses. A deeper liner would be needed to plant tall grasses, shrubs, or trees in this zone. The horizontal portion of the liner is installed tipped with 1% slope away from the building/sidewalk, so water can drain out of this area as the rain garden empties. No perforated pipe is needed to ensure proper drainage when the liner is tipped toward a column of soil that can infiltrate.

Standard Details and Sizing. A variety of standard details for rain gardens, stormwater planters, and LID swales are included in Appendix F and can be downloaded at the City website. Designs range from simple facilities with no formal overflow structure or amended soils to complex lined facilities that require an underdrain, a large storm overflow structure, and imported, engineered soil. The table below summarizes which standard details include which components and whether this facility configuration can be sized using the simplified sizing approach, described in **Chapter 4**.

Table 4-6. Summary of Standard BMP Details.

Summary of Standard BMP Details		
Detail #	Title	Sizing Factor on LID Implementation Form Applies? Yes or No
Rain Gardens		
BMP 1.01	Simple Infiltration Rain Garden	Yes
BMP 1.02	Infiltration Rain Garden with Area Drain	Yes*
BMP 1.06	Infiltration Rain Garden with Amended or Imported Soil	Yes
BMP 1.03	Infiltration Rain Garden with Amended or Imported Soil and Area Drain	Yes*
BMP 1.04	Lined Filtration Rain Garden	Yes (only for water quality sizing factor)
BMP 1.05	Infiltration Rain Garden with Rock Trench	No
Stormwater Planters		
BMP 2.06	Simple Infiltration Stormwater Planter	Yes
BMP 2.01	Infiltration Stormwater Planter with Area Drain	Yes*
BMP 2.05	Infiltration Stormwater Planter with Amended or Imported Soil	Yes
BMP 2.02	Infiltration Stormwater Planter with Amended or Imported Soil and Area Drain	Yes*
BMP 2.03	Lined Filtration Stormwater Planter	Yes (only for water quality sizing factor)
BMP 2.04	Infiltration Stormwater Planter with Rock Trench	No
LID Swales		
BMP 3.03	Simple Infiltration LID Swale	Yes
BMP 3.04	Infiltration LID Swale with Amended Native or Imported Soil	Yes
BMP 3.01	Lined Filtration LID Swale	Yes (only for water quality sizing factor)
BMP 3.07	Simple Infiltration LID Swale – Lowest Elevation Cell with Area Drain	Use this detail with BMP 3.03 (area in last cell can be included to meet sizing requirements)**
BMP 3.08	Infiltration LID Swale with Amended or Imported Soil -- Lowest Elevation Cell with Area Drain	Use this detail with BMP 3.04 (area in last cell can be included to meet sizing requirements)**
BMP 3.02	Unlined Filtration LID Swale – Lowest Elevation Cell with Area Drain	Use this detail with BMP 3.01 (area in last cell can be included to meet sizing requirements)**
BMP 3.05	Infiltration LID Swale with Amended or Imported Soil and Rock Trench	No
BMP 3.06	Infiltration LID Swale with Amended or Imported Soil and Rock Trench– Lowest Elevation Cell with Area Drain	Use this detail with BMP 3.05 (area in last cell can be included to meet sizing requirements)**
*Area drain rim or alternative overflow structure elevation must be set to a height that allows the chosen ponding depth (either 6 inches, 9 inches, or 12 inches) to accumulate in ponding area. ** Since the check dams in LID swales create a series of small ponded areas that cascade from one LID swale cell to the next, only the last cell needs an overflow structure.		

Choosing the Best Vegetated Stormwater Facility Configuration

Vegetated stormwater facilities have a range of complexity. This section provides information so that the level of complexity can be properly assessed, since well designed, simple facilities are less costly to build and easier to maintain than overly complicated systems and can perform just as well, or sometimes better, to protect watershed health.

Simple Infiltration Vegetated Stormwater Facility. A simple infiltration facility (detail BMP 1.01 (rain garden), BMP 2.06 (stormwater planter), or BMP 3.03 (LID swale)) may be used when the following criteria are met:

- The native soil infiltrates between 0.5 and 12 inches/hour
  AND
- The native soil meets applicable criteria of **Appendix D**: Specifications, "*Treatment Soil*"
  AND
- In a large storm or in the case of a clogging failure, when water flows over the berm and/or low point of the facility, it will not cause damage to any structures downhill (**Figure 4-73**)
  AND
- In a large storm or in the case of a clogging failure, water will not back up to flood any nearby structures uphill (***Figure 4-73***).

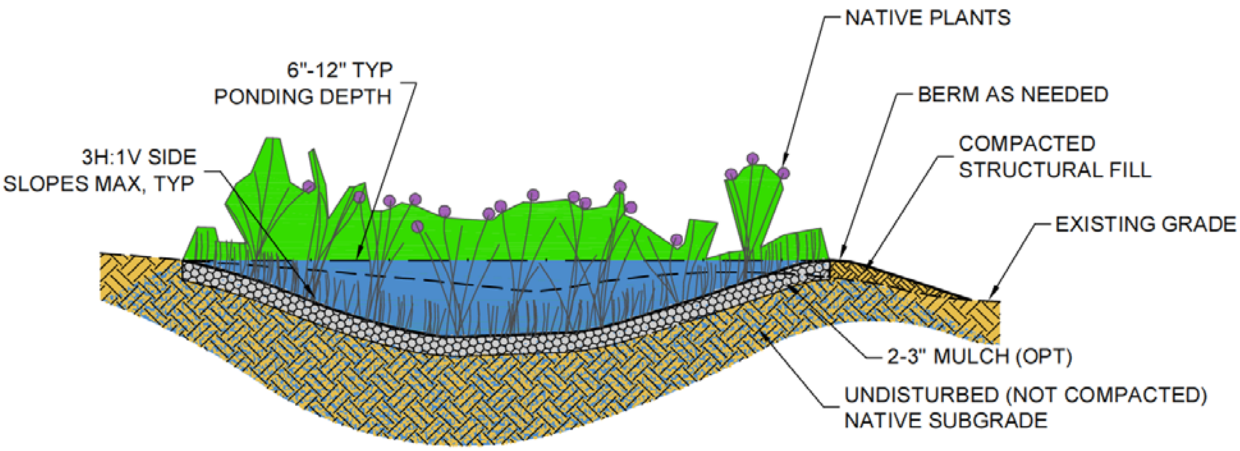


Figure 4-76. Example of a "Simple Infiltration Rain Garden". Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Infiltration Vegetated Stormwater Facility with Area Drain. Using detail BMP 1.02 (rain garden), BMP 2.01 (stormwater planter), or BMP 3.03 with BMP 3.07 (LID swale details), an area drain or equivalent large storm overflow structure should be added to the facility whenever:

- The native soil infiltrates between 0.5 and 12 inches/hour
  AND
- The native soil meets applicable criteria of Appendix D: Specifications, "*Treatment Soil*"
  AND
- In a large storm or in the case of a clogging failure, when water flows over the berm and/or low point of the facility, it WILL cause damage to any structures downhill (***Figure 4-73***)
  OR
- In a large storm or in the case of a clogging failure, water WILL back up to flood any nearby structures uphill (***Figure 4-73***)
  OR
- The facility is the last, lowest elevation cell of an LID swale.

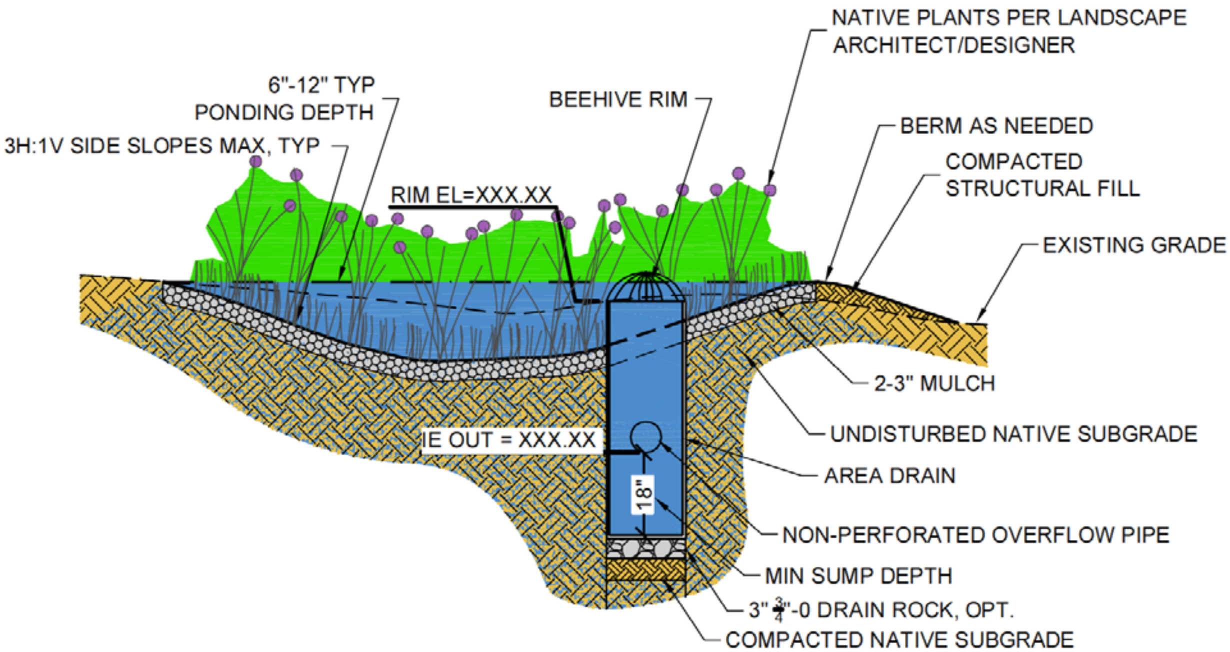


Figure 4-77. Example of an "Infiltration Rain Garden with Area Drain". In this case, the water level is above the rim elevation of the outlet because a storm larger than the design storm is overwhelming the downstream system (i.e. the non-perforated overflow pipe, which would be connected to an approved discharge point) with either intensity or volume or both. During the water quality design storm, water depth should be less than the rim elevation. Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Infiltration Vegetated Stormwater Facility with Amended Planting Soil. Using detail BMP 1.06 (rain garden), BMP 2.05 (stormwater planter), or BMP 3.04 (LID swale), soil should be amended to a minimum depth of 18 inches when:

- Native soils infiltrate 1 inch/hour or slower and will be kept in place but amended (see **Appendix D**: Specifications, "*Treatment Soil*"). Soil amendments can increase the facility's storage capacity (and therefore the infiltration capacity). This approach is most often used in tight clay soils to provide more voids in the soil for storage and restore permeability, but it does not necessarily increase the rate that water will infiltrate. (***Figure 4-62***)
  OR
- Native soils infiltrate at 12 inches/hour or faster and should be replaced with "*Imported Soil*" (see Appendix D: Specifications, "*Treatment Soil*"). Soil amendments are needed to slow flow to achieve adequate retention time in the soil for water quality treatment
  OR
- A simple infiltration vegetated stormwater facility was designed, but during construction, the soil was not protected from compaction (*i.e.* durable fencing and signage).

Soil may be optionally amended when:

- You believe that the plants will be healthier with amendments or imported soil (*e.g.* replacing rocky fill)
  OR
- A faster draining soil is beneath a slower draining surface soil and you wish to decrease the footprint of your facility, accessing the faster draining soil by replacing the native soil with an imported soil mix (see **Appendix D**: Specifications, "*Treatment Soil*").

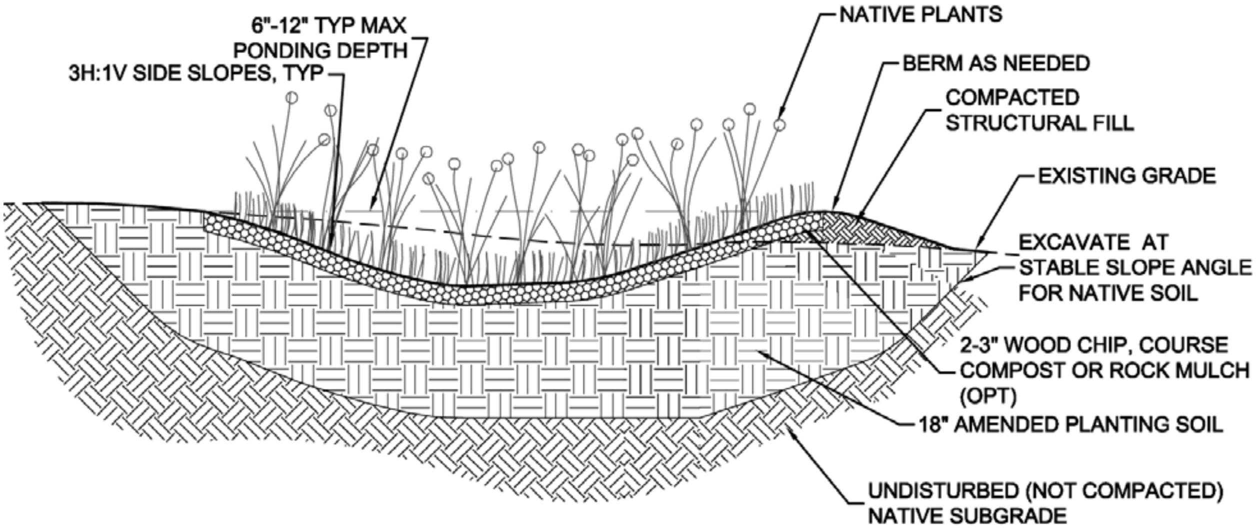


Figure 4-78. An example of an "Infiltration Rain Garden with Amended Planting Soil". Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Infiltration Vegetated Stormwater Facility with Amended Planting Soil and Area Drain. Use this configuration when:

- Soils are amended for the same reasons as "Infiltration Vegetated Stormwater Facility with Amended Planting Soil" above
  AND
- When overflows must be carefully directed for the same reasons listed in "*Infiltration Vegetated Stormwater Facility with Area Drain*" above.

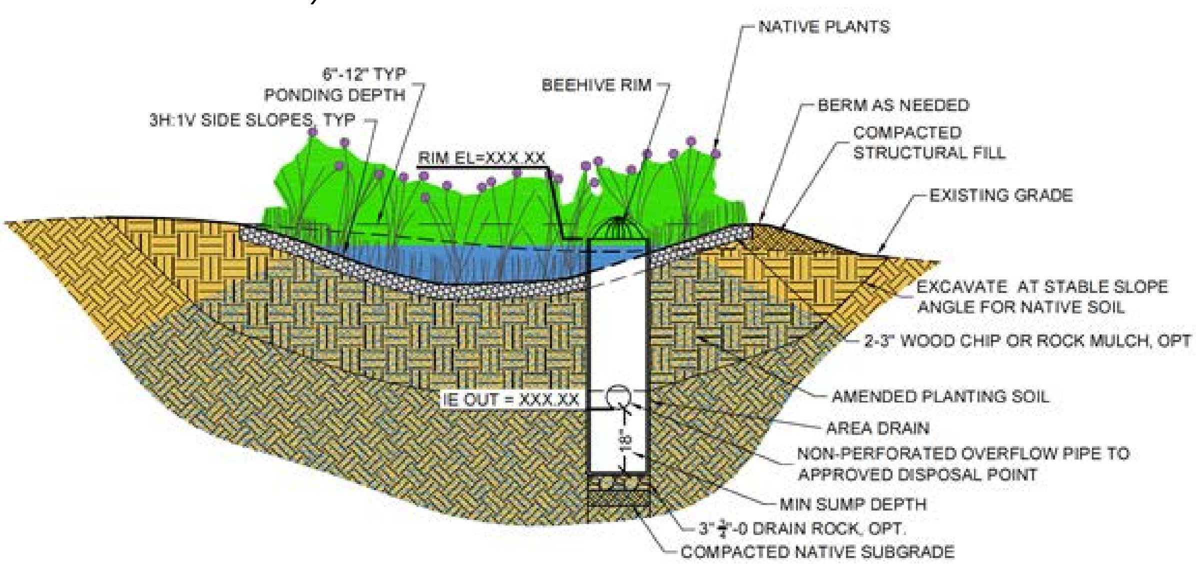


Figure 4-79. An example of an "Infiltration Rain Garden with Planting Soil and Area Drain". Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Infiltration Vegetated Stormwater Facility with Rock Storage. Using detail BMP 1.05 (rain garden), BMP 2.04 (stormwater planter), or BMP 3.06 (LID swale), include rock storage when:

- Space for infiltration is limited, but retention of larger volumes of stormwater runoff is desired or required
  AND
- The infiltration rate is at least 1.5 inches/hour.

This facility configuration is usually not cost-effective unless the remaining drainage area (described in **Chapter 5**) is large and stormwater management is required.

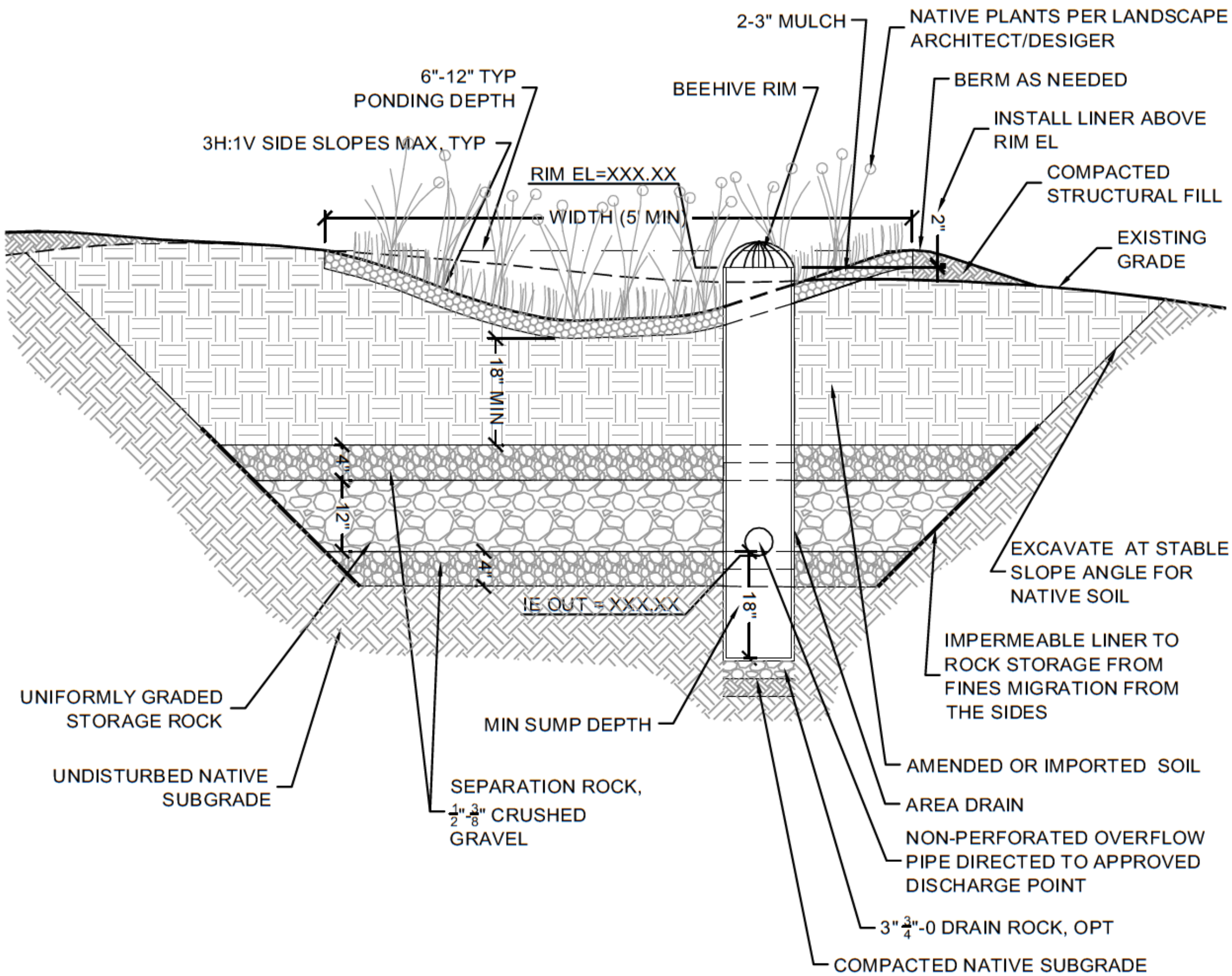


Figure 4-80. An example of an “Infiltration Rain Garden with Rock Trench”. Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Lined Filtration Vegetated Stormwater Facility. Using detail BMP 1.04 (rain garden), BMP 2.03 (stormwater planter), or BMP 3.01 (LID swale), a lined filtration facility may only be chosen in the event that siting criteria for infiltration cannot be met if it has been preapproved for use.

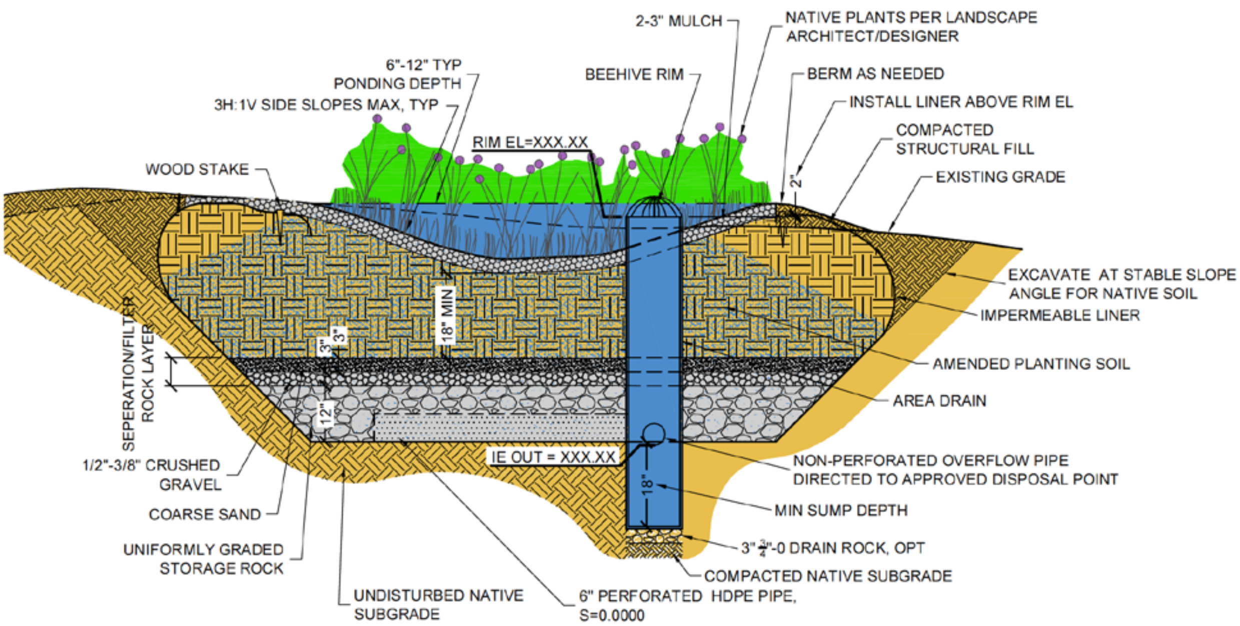


Figure 4-81. Example of a "Lined Filtration Rain Garden". Not pictured, but also applicable to the above criteria are versions of a stormwater planter or LID swale (see Appendix F Standard Details).

Construction

Like all stormwater management facilities, special care must be taken to properly construct BMPs. Protecting the infiltration capacity of the soil is crucial to the long-term functioning of any infiltration facility. See **Appendix B**, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project. Mistakes in construction can lead to unintentional damage to the facility (*i.e*. clogging) or to long-term maintenance challenges (*i.e.* plant replacement).

Infiltration Vegetated Stormwater Facilities. Protecting the infiltration capacity of the native soils is crucial to the long-term functioning of any infiltration facility. See **Appendix B**: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project. The following guidance is provided to inform the contractor about the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP, so its long-term function is achieved.

<u>To construct an infiltration vegetated stormwater facility:</u>

1. Install temporary erosion prevention and sediment control measures upstream from the infiltration facility, as needed per **Chapter 3**, "*The LID Construction Process*", "*Erosion Prevention and Sediment Control*".
2. Excavate to the depth shown on plans, which may vary from 6 to 48 inches, depending on the facility configuration.

For in-ground stormwater planters, at first, excavate only the area where the deep curbs and poured concrete check dams (if included) will be installed. Frame and pour curbs and check dams. After the concrete is cured, excavate to the elevation shown on plans.

(If vegetated stormwater facility is a simple infiltration facility with no structures or amendments, skip to step 6.)

3. Install area drains, perforated pipe, non-perforated piping, and/or cleanouts per plans and details.

4. If coarse aggregate rock trench, separation rock, and treatment soil are included in design, install layers as shown on plans according to guidance provided in **Appendix D**: Specifications.
5. If plans and details call for native amended soil, amend soil per the Restored Soils BMP or specifications provided on the plans. If plans call for treatment soil to be imported, place per guidance provided in Appendix D: Specifications, “Imported Soil Mix” under “Treatment Soil”. Place the amended planting soil in two lifts, to lightly compact it (i.e. 85% compaction). Boot packing or light tamping may also be used but never apply vibratory compaction.
6. If facility is a rain garden or LID swale, shape the side slopes to match plans and details but do not exceed a slope of 3:1 (horizontal: vertical). Water must be able to pass through the sides, so do not compact side slopes.
7. Rake (sandy soils) or compost amend (clayey, more compactable soils) using the Restored Soils BMP in any facility dug by hand, since foot traffic in the facility area is probably unavoidable.
8. If facility incorporates check dams that sit on the surface (*i.e*. rock, wood), install per details and plans. In theory, check dams should be placed so when water backs up behind them, it covers the entire cell with at least a few inches of water (per plans). Check dams that are too close together can reduce storage in the ponding area. If field conditions do not appear to match the conditions assumed during the design phase, contact the designer for guidance on appropriate check dam placement.
9. Install erosion prevention and **sediment** control to stabilize the surface of the facility.

Figure 4-82. This image shows a great example of erosion prevention and sediment control for an LID swale in the public right-of-way after construction but before planting.

10. Remove protection fencing.
11. Plant facility and protect it from stormwater flows for 3 months after planting using sand bags to block flows or piping around the facility. This will help plants establish and prevent erosion. Make sure that wherever the water is flowing for this 3-month period that it will not cause a dangerous condition (*e.g.* water flowing over a sidewalk, trip hazard, *etc.*), flooding, or erosion.
12. Mulch the facility per plans.
13. Remove temporary erosion prevention and sediment control.
14. Unblock inlets to allow stormwater flows to enter facility 3 months after planting.
15. Remove temporary erosion control if soil is stabilized.
16. Water plants as needed through dry months for a minimum establishment period of 2 years. See **Appendix E**: Plant Specifications “*Watering techniques*” under “*Establishment Maintenance*”.

Lined Filtration Vegetated Stormwater Facilities. The infiltration capacity of soils beneath lined filtration facilities does not need to be protected. As with all soil, unnecessary compaction should be avoided since soil below ground conveys groundwater to waterways. A loss of voids in the soil impacts watershed health.

To properly construct a lined filtration facility:

1. Install temporary erosion prevention and sediment control measures upstream of the facility, as needed per **Chapter 3** "*The LID Construction Process*", "*Erosion Prevention and Sediment Control*".
2. Over excavate between 40 and 48 inches depending on the ponding depth. If stockpiling soil for another use, cover with a breathable fabric to prevent erosion and protect the permeability of the soil.
3. Install the outlet structure (e.g. area drain, catch basin, berm) or cleanout and non-perforated piping using standard construction techniques.
4. Install impermeable liner of either 30 to 60-mil low density polyethylene (LDPE) or bentonite clay mat per manufacturer guidance. Make sure the liner is installed at a height equal to the depth of water that may be ponded in any storm, not just the design storm. Attach the liner to the outlet structure with the appropriate adhesive or mechanically. If a plastic liner is used, make sure that it's a single, solid piece of plastic big enough to be installed underneath the entire facility area. Overlapping plastic sheets will not adequately prevent infiltration. If the design calls for a bentonite clay mat, follow the manufacturer's guidance for installation.
5. Place a perforated underdrain pipe atop the liner and connect it to the outlet structure.
6. Place 12 inches of coarse aggregate that meets or exceeds specifications in **Appendix D**: Specifications, "*Coarse Aggregate*".
7. Place 4 inches of separation rock that meets or exceeds specifications in **Appendix D**: Specifications, "*Separation Rock*".
8. Place imported treatment soil per guidance provided in **Appendix D**: Specifications, "*Imported Soil Mix*" under "*Treatment Soil*".
9. Place the amended planting soil in two lifts, to lightly compact it (i.e. 85% compaction). Boot packing or light tamping may also be used but never apply vibratory compaction.
10. Place a final lift as needed to reach desired elevations.
11. Plant facility and protect it from stormwater flows for 3 months after planting using sand bags to block flows or piping around the facility. This will help plants establish and prevent erosion. Make sure that wherever the water is flowing for this three-month period it will not cause a dangerous condition (e.g. water flowing over a sidewalk, trip hazard, etc.), flooding, or erosion.
12. Mulch the facility per plans.
13. Remove temporary erosion prevention and sediment control.
14. Unblock inlets to allow stormwater flows to enter facility 3 months after planting.
15. Remove temporary erosion control if soil is stabilized.
16. Water plants as needed through dry months for a minimum establishment period of 2 years. See **Appendix E**: Plant Specifications "*Watering*" under "*Establishment Maintenance*".

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 2** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Proper maintenance of vegetated stormwater facilities will ensure that water can enter the facility at all times of the year. Observing the facility during a variety of rain events will help you see where water is flowing. Maintenance requirements for the landscape are typical of vegetated areas. Maintenance of structures like sumped catch basins is typical of conventional infrastructure maintenance. Watering and weeding may be needed frequently in the first 1 to 3 years during the very dry summers, but this should taper off dramatically if plants are chosen according to the guidance provided in **Appendix E**: Plant Specifications. Remember, the more you water, the more weeds you can expect.

Inspect the facility at least 4 times a year and perform needed maintenance as follows:

- Maintain a calm flow of water entering the facility via downspout pipes or other inlets.
  - Identify erosion sources and control them when soil is exposed, or erosion channels are forming. A settling basin or other effective means shall be placed around the point where water is discharged into the facility to slow the water and prevent erosion. Fill erosion channels with approved soil mix, not mulch, compost, or rock, and replant using a species of plant in the facility adjacent to the eroded channel.
  - Identify and correct sources of sediment and debris.
- Remove sediment and debris from:
  - The pretreatment sump
  - The facility surface with minimum damage to vegetation. Remove accumulated if it is more than 1 inch thick or damaging vegetation.
  - The facility outlet, such as overflow drain or conveyance swale.
  - Curb cuts when depth exceeds ¼ inch.
- Stabilize slopes with plants and appropriate erosion control measures when soil is exposed, or erosion channels are forming. Fill eroded channels with approved soil and replant. If flows can be redirected temporarily, redirect flows until plants establish. Check for erosion as a result of redirected flows on the next site visit.
- Maintain the design ponding depth by:
  - Repairing any structural elements that may leak from cracks or worn sealant
  - Maintaining the design elevation of check dams
- Soil should allow storm water to percolate uniformly through the rain garden.
  - If the facility does not drain within 48 hours, scrape 1 inch of soil out of the facility and replace with imported soil meeting the specifications provided in Appendix D: Specifications, "*Treatment Soil*". Infiltration test the facility to confirm drainage by either soaking the entire facility with water or by observing the facility during the next rain event.
  - If facility does not drain after scraping 1 inch, try another 1-inch depth.
  - If facility does not drain after scraping 2 inches, salvage plants, till and replant the facility.
  - Debris in quantities that inhibit infiltration shall be removed routinely (e.g., no less than quarterly), or upon discovery.
- Vegetation should be healthy and dense enough to provide filtering while protecting underlying soils from erosion with at least 90% coverage of bare soil in three years.
  - Replenish mulch until vegetation is established and shading the bottom of the facility.
  - Remove fallen leaves and debris from deciduous plant foliage, especially if the facility is in a roadway with trees located upstream from a curb.
  - Density of vegetation must be maintained for the facility to be effective.
    - Don't string trim ornamental grasses, sedges or rushes. These may be raked.
    - Don't prune shrubs into balls, natural growth will more effectively treat stormwater.
  - Remove nuisance (i.e. plants blocking the inlet) and non-native and invasive vegetation (i.e. weeds such as Himalayan blackberries and English Ivy) when discovered.

  - Remove dead vegetation and woody material before it covers 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.
  - Irrigate per guidance provided in **Appendix E**: Plant Specifications "*Establishment Maintenance*".
  - Maintain vegetation using integrated pest management per Appendix E: Plant Specifications "*Integrated Pest Management*".
- Exercise spill prevention measures when handling substances that can contaminate stormwater. Correct releases of pollutants as soon as identified:
  - Make sure the area is safe to enter
  - Block the outflow of the BMP
  - Block the inflow of the BMP
  - Stop the release of the hazardous materials
  - Clean up the flow path to the BMP
  - Clean out the BMP, replacing soil, amended soil and vegetation as necessary

SOAKAGE TRENCH BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			■
Water Quality Management†	■		
Flow Control Management†	■		
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach	■		
Engineered Design Approach	■		
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required	■		
Design Information			
Title	**Form/Worksheet**		
LID Form	Form F		
Worksheet	Worksheet F3		
Drawings			
Title	**Detail**		
Soakage Trench in Landscape Area	BMP 6.01		
Soakage Trench under Impervious Pavement Surface	BMP 6.02		
Soakage Trench at Surface	BMP 6.03		

* This BMP does not offer this type of management
† Applies when meeting requirements in Chapter 2

Soakage trenches (*i.e.* infiltration trenches, recharge beds) are excavated trenches filled with coarse stone (*i.e.* storage rock) and wrapped in geotextile that receive runoff via a pipe and store it in the rock voids until it is able to infiltrate into surrounding soils. The EPA defines soakage trenches as an assemblage of perforated pipes, drain tiles or other similar mechanisms that distribute fluids below the ground surface.

The space occupied by soakage trenches is often available for another use at the surface, such as parking on porous or impervious/conventional pavement or as lawn or a perennial groundcover or shrub area. Soakage trenches are often preferred because they are an invisible way to manage stormwater. However, because of their poor accessibility, they are costlier to maintain[62].

The primary difference between a soakage trench and a vegetated stormwater facility is that water is injected underground via a pipe, rather than infiltrating through the soil surface.

Figure 4-83. Soakage trench at a multi-family residential project (photo courtesy of Lower Columbia River Estuary Partnership).

UIC Authorization

Soakage trenches are relatively shallow facilities and are not automatically considered an Underground Injection Control (UIC, see **Chapter 1** "*Underground Injection Controls Overview*"). Even though the trench may inject stormwater into the subsurface, it is not generally considered a UIC unless injection occurs via a perforated pipe. If runoff other than from roofs is directed to a trench, pretreatment for sediment and debris should be included in the design and is expected to extend the life of the design by reducing the amount of fine sediments that reach the facility and could contribute to clogging. If incorporated perforated pipe discharges water to the subsurface, then the soakage trench IS considered a UIC and requires authorization, unless it accepts only single-family residential or duplex roof runoff. For more information, see **Chapter 4** "*Drywells*", "*UIC Authorization*".

[62] *Field, R., Tafuri, T.N., Muthukrishnan, S., Acquisto, R.A., and A. Selvakumar, (2006). The Use of Best Management Practices (BMPs) in Urban Watersheds,. DEStech Publications, Inc. Lancaster, PA,*

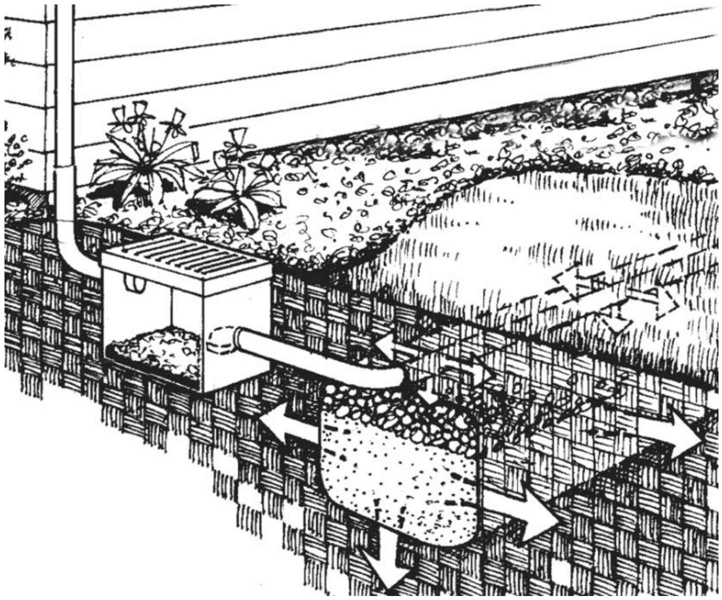


Figure 4-84. A soakage trench with a perforated pipe (right) and a sumped catch basin (left) that catches debris and sediment. A down turned pipe, as shown on the outlet side of the sumped catch basin improves sediment removal. For high sediment areas, such as roadways, two catch basins with down-turned pipe outlets may be used in series. Image adapted from City of Portland, Bureau of Environmental Services[63].

Siting

Runoff from any surface may be directed to a soakage trench, as long as hazardous materials, toxic substances, or petroleum products are not used, stored, or handled in the area drained by the soakage trench. See "*UIC Authorization*" section above for more information.

Soakage trenches may be located:

- In soils infiltrating at least 0.5 inches/hour.
- On land slopes with less than 10% grade.
- Where the bedrock or other impermeable layer is lower than 24 inches from the bottom of the soakage trench.
- At least 100 feet uphill from a steep slope. (But, locating a soakage trench at the bottom of a hill is encouraged.)

The following restrictions apply to soakage trenches that DEQ authorizes by rule[64]:

- Cannot be located within 500 feet of a water supply well,
- Cannot be located within the two-year time of travel for a public supply well,
- Cannot intersect the groundwater table. DEQ recommends that soakage trenches have at least five feet of vertical separation from the seasonal high groundwater table.

Other areas where soakage trenches may **NOT** be located:

- Where the bedrock is higher than 24 inches from the bottom of the soakage trench
- Within 10 feet of a building foundation or within 10 feet of where a neighboring building foundation could be allowed by zoning code in the future. Consider the setback requirements of

[63] https://www.portlandoregon.gov/bes/article/127481

[64] *There are two options for soakage trench authorization: authorization by rule and authorization by permit. Soakage trenches authorized by rule are subject to default horizontal setbacks between the soakage trench and water wells, and default vertical setbacks between the soakage trench and groundwater. The default setbacks may be modified if a soakage trench is authorized by permit, as long as the permittee can demonstrate that the soakage trench is protective of groundwater resources. Authorization by permit is relatively rare, and is more expensive than authorization by rule. Additional information about authorization by rule and authorization by permit is available on DEQ's UIC webpage:* http://www.deq.state.or.us/wq/uic/uic.htm

the zoning codes of your property and the neighboring property or properties. For shallow soakage trenches draining a small area, this setback may be reduced if a licensed engineer deems it appropriate. For buildings downhill from the facility, the setback of 10 feet increases to 20 feet.

- Within 10 feet of the public right-of-way
- In slow draining soils less than 0.5 inches/hour.
- On slopes exceeding 10%.
- Over karst bedrock.
- In septic fields.
- In contaminated soils.
- In landslide areas.
- Under the canopy of existing trees.

Siting soakage trenches near newly planted trees. Tree roots will often seek out water in pipes, damaging them. Soakage trenches without perforated pipes may be located within the projected mature canopy area of a newly planted tree; however, soakage trenches with perforated pipes should be located at a distance of 1.5 times the projected mature canopy spread (*i.e.* how big the canopy will be when the tree is fully grown) from the trunk to the perforated pipe to avoid root damage to the pipe.

Design

Several variations of soakage trenches are briefly described below.

Soakage Trench at the Surface. This variation incorporates rock all the way to the existing or proposed grades and usually receives runoff from an adjacent surface (***Figure 4-85***).

Figure 4-85. Soakage trenches receiving flows directly from the surface (photo courtesy of Lower Columbia River Estuary Partnership)

Soakage Trench beneath Landscape Areas. These facilities have a cover of soil and vegetation.

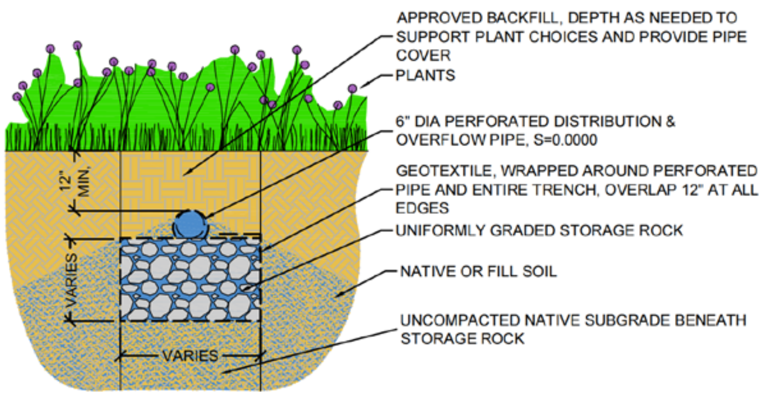


Figure 4-86. A typical soakage trench cross section beneath landscaped areas. A perforated distribution pipe at the top may also be connected to a non-perforated pipe to handle overflows during larger storms without the use of a control structure (which is needed when the distribution pipe is located inside or at the bottom of the trench, as discussed in more detail below).

Soakage Trench beneath Porous Pavement. This variation adds additional rock underneath porous pavements and directs concentrated runoff from other areas to the bottom of the rock with perforated pipes laid out along the bottom[65]. This variation is covered in more detail in **Chapter 4**, "*Porous Pavement BMP*", "*Underdrains for Inflow*", "Additional Routing Considerations for Porous Pavements that Manage Runoff".

Soakage Trench beneath Impervious Pavement. Soakage trenches may be installed beneath impervious pavement; however, the rest of the pavement section (base rock, geotextile fabric, and subgrade) must be installed as if it were porous pavement. Since conventional pavements compact the subgrade, a soakage trench underneath this construction assembly would not be capable of infiltrating into the subgrade. To ensure that infiltration can occur, implement the pavement section according to all the guidance provided in **Chapter 4** "*Porous Pavement BMP*". In particular, follow the guidance under "*Design*" as follows:

[65] *More information about this approach can be found at:,Stormh2o.com website. Porous Asphalt Pavement with Recharge Beds, 20 Years and Still Working. Retrieved from: http://www.stormh2o.com/SW/Articles/Porous_Asphalt_Pavement_With_Recharge_Beds_20_Year_228.aspx*

"*Structural Design for Porous Pavements Required*", "*Base Rock Depth*", "*Hydrologic Design for Managing Runoff*", "*Geotextile*", "*Design Specific to Sloping Sites*", "*Routing for All Porous Pavements*".

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Hydrologic Modeling and Sizing. The size of a facility must be determined through hydrologic modeling (Appendix B: BMP Implementation Criteria, "*Design*", "*Engineered Design Approach*") based on the infiltration rate found by infiltration testing per Appendix C: Infiltration Testing. For soakage trenches meeting the criteria above in "*Siting*" and designed in accordance with this guidance, size the BMP using the LID Implementation Form (see Chapter 5: LID Implementation, Step-by-Step).

Preventing Clogging During Design. For soakage trenches collecting roof runoff, incorporate gutter screens to filter debris. Pretreatment for sediment is suggested to prolong the life of the soakage trench. This could be as simple as directing runoff to a catch basin with a sump (a settling basin below the lowest elevation of the outflow pipe) before conveying runoff to the facility, such as the sumped catch basin shown in ***Figure 4-84***. This structure should be 12-inch square minimum for small drainage areas. An open grated top will help ensure that the structure is not buried by mulching activities in landscape areas. Proprietary treatment facilities with a filtering media are a common pretreatment strategy. A lined rain garden or stormwater planter (see **Chapter 4**, "*Rain Garden, Stormwater Planter and LID Swale BMPs*") could also serve this pre-treatment need.

Routing and Piping. For soakage trenches adjacent to a drainage area that is graded towards the soakage trench, no piping is needed.
To distribute runoff concentrated in a conveyance system such as a pipe or swale, a rigid (*i.e.* not corrugated) perforated pipe, embedded in the trench, is usually used. Refer to the 2017 Oregon Plumbing Specialty Code[66] for specifications on piping materials and cleanout sizing and spacing requirements. For maintenance purposes, a minimum diameter of 6 inches is recommended to ensure that a variety of maintenance activities (*e.g.* inspecting the pipe with video or removing sediment if it can't be pressurized out the end of the pipe) are possible to perform. Pipes installed too shallow can be crushed by loads at the surface such as cars or riding mowers. All pipes need adequate cover (*i.e.* soil, rock, and/or pavement above the top of the pipe) to ensure that they will remain structurally sound. Refer to manufacturer requirements to determine adequate cover for the piping material specified on construction documents.

If perforated pipes placed at the bottom of the facility are used to both spread in-flows over the trench and will also serve as a large storm overflow connected to a downstream conveyance system (*e.g*. outlets to a ditch or connects to a non-perforated pipe), the soakage trench should incorporate a control structure (see "*Catch Basin Control Structure*" in **Appendix F** "*Standard Details*"). Otherwise, runoff will be conveyed off-site before it can infiltrate. An overflow structure is not needed if:

- Adequate cover exists, and a perforated pipe placed at the top of the facility can double as the underdrain and overflow pipe because it will only overflow when it reaches this higher elevation.
- A perforated pipe is placed at the bottom and is not connected to any other structure.

Non-perforated overflow pipes that direct runoff to an approved discharge point may be needed to ensure that during an intense storm, water will not flood a building or other critical structure. Even when the system is designed to infiltrate "all" of the stormwater, a larger storm than the maximum design storm will

[66] *IAPMO. 2011 Oregon Plumbing Specialty Code website. Retrieved from: http://www.iapmo.org/pages/2011oregonplumbingspecialtycode.aspx*

overwhelm the system. Alternatively, water may back up out of the system and overflow overland as long as on-site finished grades are such that no critical structures are flooded by this configuration. For more information, see **Appendix B**, "*Design*", "*BMP Design Criteria*", "*Safe Overland Route*".

Standard Details. See standard details BMP 6.01, 6.02, 6.03 to include applicable details in construction documents. These are available in pdf, jpg, and AutoCAD dwg format.

Dimensions. A soakage trench in a landscape area may be any dimension, although a minimum width of 2 feet is often recommended. (Many excavation equipment buckets are 2 feet wide.)
For soakage trenches beneath porous or impervious pavements, the width is likely to equal the pavement area, unless a building or other critical piece of infrastructure drives a setback requirement for the trench.

Sub-surface and Ground Slopes. The facility bottom should be sloped between 0 and 0.5%. Design the bottom elevation of the trenches to match existing contours to achieve this desirable flat bottom, reduce excavation, and allow for the maximum effective storage volume as water infiltrates.

Soakage trenches running across contours that exceed 0.5% slope should be stepped down the slope by creating underground berms. This will ensure that the soakage trench infiltrates intended runoff volumes instead of just conveying it to the lowest elevation. Excess runoff cascades over berm after berm. (See **Chapter 4** "*Porous Pavement BMP*", ***Figure 4-46***, Cross section example on sloping sites.)

Figure 4-87. Soakage trenches below pavement are shown here. Stepping along existing contours reduces excavation and increases infiltration capacity. Graphic courtesy of Cahill & Associates.

Slopes at the ground surface may exceed 0.5% without impacting facility function; however, for soakage trenches at the surface, additional rock will be needed to backfill to surface grades.

Coarse aggregate (*i.e.* storage rock). Coarse aggregate provides structure to support surfaces above the soakage trench and stores runoff in the voids between the rocks until it infiltrates. This material should meet the coarse aggregate specifications provided in **Appendix D**: Specifications under "*Aggregates*". In place of this uniformly graded aggregate, concrete or plastic vaults with open bottoms can be used. These chambers may be useful in areas with high water tables or shallow impermeable layers (typically bedrock or fragipan) where the facility needs to be shallower to be installed high enough above these barriers. Lightweight plastic vaults are also useful in difficult-to-access areas, such as backyards where transporting and placing aggregate is difficult, expensive, or damaging to existing landscaping and hardscaping.

Vegetation. Since runoff doesn't pass through a ground surface (as in a vegetated stormwater facility, for instance) but is delivered to the facility underground via a pipe, vegetation doesn't play a direct role in improving water quality. For this reason, soakage trenches have more flexible finish grade elevations and landscape choices than other BMPs. Vegetation planted over trenches should tolerate drier conditions since the rock below will tend to drain the area. Deep rooting systems can ruin piping systems, so avoid planting shrubs and trees over soakage trenches with piping.

If larger vegetation is desired, and conditions will allow for the bottom of the soakage trench to be deeper, then additional soil can be provided to accommodate the roots of shrubs (24 inches minimum soil depth) and trees (36 inches minimum soil depth). The presence of the larger vegetation and the greater depth of the rock trench will make initial construction and future replacement costlier.

If the soakage trench does not have a pipe, experience with trees in porous pavement has shown that they do not impact the ability of those facilities to infiltrate. The roots of shrubs and trees enhance infiltration, so some roots growing into the gravel of a soakage trench is acceptable, just not the piping.

Geotextile Fabric (aka Filter fabric). Geotextile fabrics should line the trench. This provides separation between the soil and the coarse aggregate and prevents clogging. Geotextile segments should overlap a minimum of 12 inches. Alternatively, because geotextiles tend to clog if the coarse aggregate isn't clean enough when installed, the bottom layer of filter fabric can be replaced with 6 inches of separation rock (see Appendix D: Specifications for information for infill and separation rock under "*Aggregates*").
For soakage trenches where pretreatment settles out debris and sediment and runoff is conveyed via a perforated pipe, clogging should not pose much of a problem. For soakage trenches at the surface, the geotextile IS likely to clog so a means of removing and replacing this is shown on the detail BMP 6.03 Soakage Trench at Surface.

Observation Wells/Cleanout Pipes. An observation well is vertical piping installed to observe whether the facility is infiltrating. This is especially important for facilities with overflow pipes. If the soakage trench stopped infiltrating, then it would always be full and subsequent runoff would bypass the system with no water quantity or flow management.

Design criteria for observation wells/cleanout pipes are as follows:

- Install at least one observation well near the center of the facility or in its lowest point and every 50 feet.
- Observation well piping should be a 6-inch diameter non-perforated pipe. Properly attach this to the horizontal perforated pipe in the soakage trench using a tee-connection.
- Equip the end above ground with an operable cap, which may need to be a locking cap depending on whether tampering is likely to occur (*e.g.* at schools).

Even with a minimum 6-inch diameter perforated pipe in the soakage trench, conventional cleanouts with many bends may not provide adequate access for maintenance if the pipe becomes clogged. A catch basin is recommended as pretreatment for the soakage trench. If incorporated, this will also serve as an additional, more accommodating pipe access point.

Construction

Protecting the infiltration capacity of the native soils is crucial to the long-term functioning of any infiltration facility. See **Appendix B**: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project.

Figure 4-88. Soakage trench during construction. Photo courtesy of Howard's Excavating, New Buffalo, MI.

The following guidance is provided to inform the contractor about the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP so its long-term function is achieved.

To construct a soakage trench:

1. Install temporary erosion prevention and sediment control measures upstream from the infiltration facility, as needed per **Chapter 3** "*The LID Construction Process*", "*Erosion Prevention and Sediment Control*".
2. Excavate to the depth or depths (in the case of facilities that step down a hill), as shown on plans.
3. Install control structures (only needed if perforated pipe is placed at bottom of trench), non-perforated piping, and/or cleanouts as called for on details and plans.
4. Install geotextile fabric on bottom and sides per guidance provided in **Appendix D**: Specifications "*Geotextile Fabric*". (Separation rock installed per guidance provided in **Appendix D**: Specifications "*Aggregates*" may be substituted for geotextile fabric on the bottom of the soakage trench.)
5. Place coarse aggregate per guidance provided in **Appendix D**: Specifications "*Aggregates*" and details and plans.
6. Install perforated pipe as shown on plans and detail. (Or, if perforated pipes are to be placed at the bottom, this will be done as step 5.)
7. Place geotextile fabric over the top of the soakage trench per **Appendix D**: Specifications "*Geotextile Fabric*".
8. Backfill with approved backfill (mostly likely native soil, imported topsoil, or aggregate). If native soil or imported soil is placed, install in 12-inch lifts (*i.e.* depths) and lightly compact with water compaction or boot compaction. Do not compact with vibratory equipment.
9. Install finish surface, such as lawn, garden, or pavement per plans.
10. Backfill with approved backfill (mostly likely native soil, imported topsoil, or aggregate). If native soil or imported soil is placed, install in 12-inch lifts (*i.e.* depths) and lightly compact with water compaction or boot compaction. Do not compact with vibratory equipment.
11. Install finish surface, such as lawn, garden, or pavement per plans.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Durability and longevity of a soakage trench is highly influenced by proper design, but ultimately, careful maintenance to prevent clogging will have the greatest impact on the longevity of a properly designed and installed soakage trench. Maintenance demands range from medium to high.

Inspect the facility a minimum of 4 times per year during each season and after major storms and perform needed maintenance as follows:

- Maintain manufactured structures like silt basins and water quality manholes per manufacturer's operations and maintenance guidelines.
- Confirm via the observation port that the facility is emptying out/infiltrating. Clogged facilities must be completely reconstructed or relocated.
- Remove debris from pipes and other conveyance.
- Repair or replace damaged pipes.
- For soakage trenches that receive runoff from adjacent surfaces, sediment and debris will tend to clog the surface of the facility. Vacuum sediment from rocks. If water can no longer drain into the facility, clogging of the top geotextile has occurred. Using sediment control techniques such as compost berms and biobags, remove and clean rock on the surface. Replace the geotextile fabric on the top, being careful not to damage the fabric on the sides. Place the cleaned rock back over the geotextile fabric. Dispose of sediment in trash destined for the landfill. Sweeping regularly will reduce the likelihood of clogging. High traffic areas will clog faster than low traffic areas.

DRYWELL BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form F		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

A drywell is a well, assemblage of perforated pipes, or drain tiles that receive runoff from impervious surfaces and infiltrates that runoff underground[67]. Drywells reduce runoff flow rates and volumes, infiltrating it into the surrounding soils. Drywells have limited storage capacity, so they are generally installed in fast draining soils, such as buried gravelly and sandy flood deposits.

Drywells are underground injection control (UIC) devices and require authorization from DEQ (see "UIC Authorization" section below), which, in all but residential roof drainage areas, requires pretreatment before discharge can be directed to a drywell. These systems provide fewer benefits than other low impact development measures, which is why this guidance encourages the use of other LID techniques such as rain gardens, planters, and porous pavements before implementing drywells.

[67] *Oregon Department of Environmental Quality website. Water Quality: Underground Injection Control Program: Identifying an Underground Injection Control. AvailableRetrieved from: https://www.epa.gov/uic*

Figure 4-89. Drywells are commonly made of perforated (shown) and sometimes non-perforated (not shown) concrete rings. Photo credit: Howard's Excavating, New Buffalo, MI

UIC Authorization

Drywells are considered a Class V Injection Well and must be authorized by the Oregon Department of Environmental Quality (ODEQ) through the Underground Injection Control (UIC) permitting process. These systems are regulated throughout the state to protect groundwater, which many communities rely on for drinking and irrigation uses.

Rule Authorization. Most UICs are authorized by rule. Single family residential drywells are not required to register and get DEQ approval as UICs.

If the drywell serves a non-single family residential parking area, driveway, street or other impervious surface, then it needs to be registered and approved with the DEQ.

Pretreatment. Treatment of runoff from vehicular traffic is required with any one of the applicable treatment technologies in DEQ's *Industrial Stormwater Best Management Practices Manual*. This manual is available online at: http://www.deq.state.or.us/wq/wqpermit/docs/IndBMP021413.pdf.

Long term Stormwater Management Plan. In addition to the rule authorization or permit application, a long-term stormwater management plan must be developed, which includes a description of the best management practices for the entire site, spill prevention and response, a maintenance plan and schedule, and an employee training record. The plan must be re-visited every 5 years or immediately after a spill, when the drywell itself must be re-evaluated.

Decommissioning. DEQ must approve drywell decommissioning[68].

Siting

Runoff from any kind of surface may be directed to a drywell, as long as hazardous materials, toxic substances, or petroleum products are not used, stored, or handled in the area drained by the drywell. See "UIC Authorization" section above for more information.

[68] *Oregon Department of Environmental Quality website. Water Quality: Underground Injection Control Program: Closure of an Injection System. Retrieved from: https://www.epa.gov/uic*

Drywells may be located:

- In native soils infiltrating at least 2 inches/hour
- On a variety of land slopes; however, engage a licensed engineer to investigate the stability and suitability of slopes greater than 20%.
- 5 feet from the property line, measured from the center of the drywell. Drywells may be located closer to the public right-of-way as approved on a case-by-case basis by the City Engineer.

The following restrictions apply to drywells that DEQ authorizes by rule[69]:

- Drywells cannot be located within 500 feet of a water supply well,
- Drywells cannot be located within the two-year time of travel for a public supply well,
- Drywells cannot intersect the groundwater table. DEQ recommends that drywells have at least five feet of vertical separation from the seasonal high groundwater table.

Other areas where drywells may **NOT** be located:

- Within 10 feet of a building foundation (measured from the center of the drywell) or within 10 feet of where a neighboring building foundation could allowably be constructed in the future. Consider the setback requirements of the zoning codes of your property and the neighboring property or properties. For shallow drywells, draining less area, this setback may be reduced if a licensed engineer deems it appropriate.
- In soils infiltrating at a rate of less than 2 inches/hour.
- In fast draining soils that are a mix of sand and clay and will not hold the shape of the hole (*i.e.* will slump) when excavated. These soils are likely to cement together over time and clog.
- In septic fields.
- In contaminated soils, except where the depth of the contaminated soils is shallow enough that non-perforated manhole rings can be installed in the contaminated soil and an adequate depth of perforated rings can be installed below the depth of contamination.
- In landslide areas.
- In areas exposed to potential spills (*i.e.* vehicle fueling areas, industrial loading, unloading, material storage areas, *etc*.).

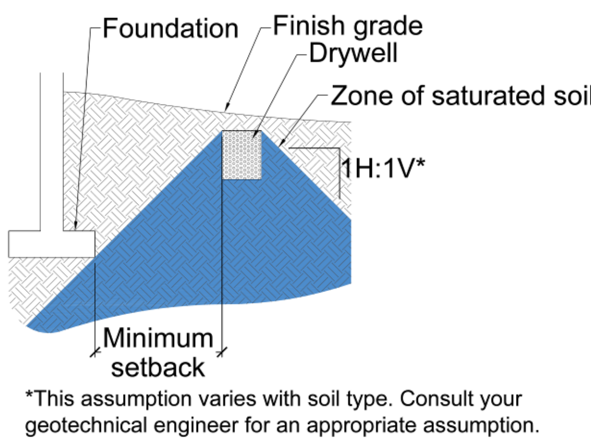


Figure 4-90. Setbacks are needed to ensure that water flows under foundation walls. A common assumption for the slope of the zone of saturation is shown, but the true zone of saturation varies with soil type.

[69] *There are two options for drywell authorization: authorization by rule and authorization by permit. Drywells authorized by rule are subject to default horizontal setbacks between the drywell and water wells, and default vertical setbacks between the drywell and groundwater. Default setbacks may be modified if a drywell is authorized by permit, as long as the permittee can demonstrate that the drywell is protective of groundwater resources. Authorization by permit is relatively rare, and is more expensive than authorization by rule. Additional information about authorization by rule and authorization by permit is available on DEQ's UIC webpage at: Oregon Department of Environmental Quality website. Water Quality: Underground Injection Control Program. Retrieved from: https://www.epa.gov/uic*

Design

DEQ's UIC rules do not prescribe design criteria for drywells. Drywells and any other associated piping and pretreatment systems should be designed by a licensed engineer.

Drywells are usually made from vertically installed perforated concrete manhole rings or vertically installed perforated pipe. They may be as shallow as 2 feet. The maximum depth constructible with common construction equipment is usually 30 feet. Provide maintenance and inspection access via a traffic rated manhole cover. When slower draining soils overlay faster draining soils or when contaminated soils overlay uncontaminated soils, a ring or multiple non-perforated manhole rings may be installed in the top portion of the drywell. Then, at the proper depth, perforated manhole rings are installed to allow runoff to infiltrate into the faster draining or uncontaminated soils. Usually, the excavation hole is a minimum of 2 feet greater than the drywell's outside diameter. Since backfill is needed anyway, an additional 2 feet of coarse aggregate per **Appendix D**: Specifications, "*Course Aggregates*" can be counted, around the outside of the drywell, as storage for runoff. This coarse aggregate also increases the infiltration area. Most pre-cast drywells come with a plastic mesh "fishnet wrapped around them to keep drain rock from rolling into the drywell and causing settlement and voids around the outside of the rings".

Additional Design Criteria. In addition to the design guidance provided in this section:

- Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Hydrologic Modeling. Drywells cannot be sized using the simplified procedures offered for other BMPs using the LID Implementation Form in **Chapter 4**. Design criteria are as follows:

- All criteria listed in **Appendix B**: BMP Implementation Criteria, "*Design*", "*Hydrologic Modeling*", "*Engineered Design Approach*"
- The area of infiltration may be calculated based on the depth of the perforated rings and the diameter of the drywell plus 1 foot of course aggregate that surrounds it.
- The void ratio of the rock is usually 40%. This information can be provided by the aggregate supplier/quarry.
- If adequate infiltration volumes cannot be achieved by building the maximum depth of perforated rings, there are two common options:
    - Drywells can be linked together in series by piping, spaced at least 10 feet apart from each other.
    - The diameter of the hole could be increased to increase the infiltration area. Open-graded coarse aggregate per **Appendix D**: Specifications, "*Course Aggregates*" should still be used to fill this entire hole.

Preventing Clogging During Design. Pretreatment for sediment is suggested to prolong the life of the drywell. This may be as simple as directing runoff to a catch basin with a sump (a settling basin below the lowest elevation of the outflow pipe) before conveying runoff to the drywell. Proprietary treatment facilities with a filtering media are a common pretreatment strategy but a lined rain garden or stormwater planter (see **Chapter 4** "*Rain Garden*, *Stormwater Planter, and LID Swale BMP*") could also serve this pre-treatment need. For drywells collecting roof runoff, incorporate gutter screens to filter debris.

Figure 4-91. Drywell with a catch basin with a sump for pretreatment of sediment from roof runoff. Courtesy of BES.

Infiltration Testing. Infiltration testing should always be performed to size drywells. It should be performed by a qualified professional, likely a “geotechnical engineer” or a “licensed geologist”. Soils may vary with depth and must be tested in the location of the facility and in the different soil horizons to ensure the facility will function as designed.

Some tips to test infiltration for drywells installed at depths greater than 4 feet (whose depth exceeds the Occupational Safety and Health Administration (OSHA) guidelines for working in unreinforced open pits):

1. Follow guidance provided in **Appendix C**: Infiltration Testing on “*Timing and Location*” and “*Safety*”.
2. First, excavate the first few feet.
3. Then, hand auger, machine drill, or use a backhoe with a clamshell to excavate to the proposed bottom of the drywell.
4. Choose a suitable depth of water to test and excavate down to it.

Pressure head, created by water that accumulates in the drywell and pushes water out the sides, plays a more prominent role in dictating infiltration rates than for other facilities such as rain gardens, which are designed with a shallow pond. Some consultants choose to test conservatively by using floats to maintain no more than 12 inches of water; others use a depth of water convenient for them to test while they stand at the surface, but that depth should never exceed the depth of water that will be accumulating in the drywell during large storms.

If soils vary with depth, then multiple infiltration tests in these different soil horizons will be needed. To predict whether the soil horizon will vary with the depth of the planned drywell, refer to the Natural Resources Conservation Service (NRCS) soil surveys, which are available in print or online[70]. NOTE: While the NRCS provides data on hydraulic conductivity in inches per hour, this information is not accurate at the site scale, as discussed in **Appendix C**: Infiltration Testing. This will not be an adequate substitute for infiltration testing the site where the drywell will be installed.

Test the shallowest soil column first.

5. Seat a non-perforated pipe in the bottom.
6. Fill the pipe with water to the chosen testing depth.

---

[70] http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

7. Record the exact time you stop filling the hole (if soils are fast draining, measure time down to the second) and the time it takes to drain completely or at any interval of interest. Professionals will often record water drops at 10 minutes or less for fast draining soils and 30 minutes for slower draining soils.
8. If testing during the rainy season and soils are saturated, one test is enough. If testing during the dry season and soils are dry, refill the hole again and repeat steps 6 and 7 two more times. The third test will give you the best measure of how quickly your soil absorbs water when it is fully saturated. The average infiltration rate should generally decrease with each round.
9. Divide the distance that the water dropped by the amount of time it took for it to drop. This is the infiltration rate for this particular soil horizon
10. If soil horizons vary, continue excavation into the next soil horizon and repeat steps 5 to 9.
11. Repeat step 10 until all the soil horizons where the drywell may infiltrate into have been tested.

Routing. A bypass system is recommended when the drywell reaches saturation. In this case, an overflow pipe at the surface can deposit runoff onto a splash block or to a secondary facility. As is the case with all stormwater management strategies, excess runoff should never be directed to a neighboring private property without a utility easement. Runoff maybe allowed to back up into the system and daylight at the surface via a structure as long as that daylight point is at least 10 feet away from building foundations and the ground slopes away from the building.

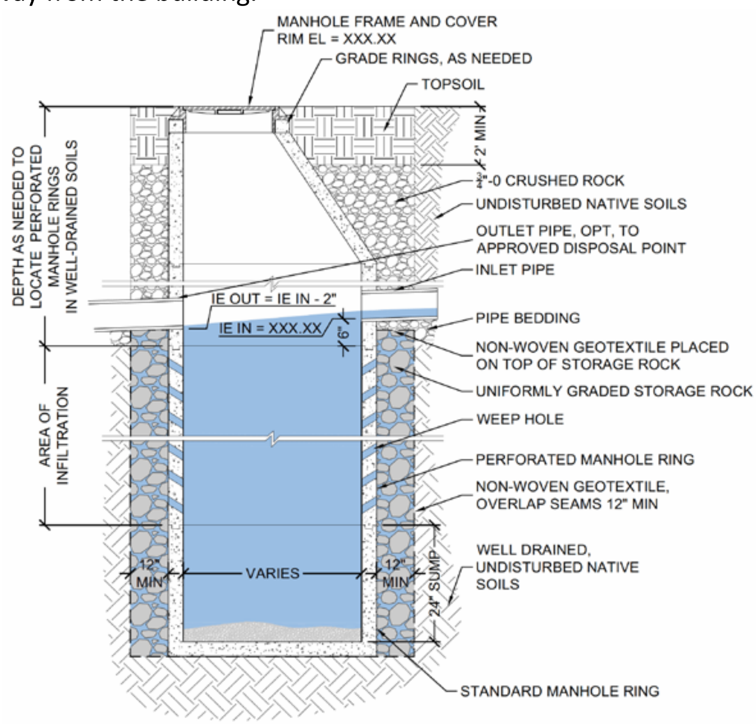


Figure 3-92. Typical drywell detail in landscape area. This includes an optional sub-surface outlet pipe for large storms when excess runoff volumes could impact nearby infrastructure if water backed up to the ground level. This assembly, with a manhole lid at the surface and piping into the sides is recommended to improve and ease maintenance access. Note that this recommendation conflicts with the requirements of the 2014 Oregon Plumbing Specialty Code, "Chapter 11 Storm Drainage"[71]; however," Section 301.4 Alternative Engineered Design" in Chapter 3[72] allows for alternative designs that meet the intention and function of the code when signed and stamped by an Oregon registered Professional Engineer (P.E.) and approved by a Building Official.

[71] IAPMO. 2014 Oregon Plumbing Specialty Code. Chapter 11: Storm Drainage". Retrieved from: http://goo.gl/xwrO2K
[72] IAPMO. 2011 Oregon Plumbing Specialty Code. Chapter 3: General Regulations. Retrieved from: http://www.iapmo.org/2011%20Oregon%20Plumbing%20Specialty%20Code/2011OregonPlumbingSpecialty_Ch03_General%20Regulations.pdf

Due to pipe cover requirements, often the overflow pipe will be too deep to daylight (*i.e.* convey water in the pipe to the top of the ground) with these options and is connected to another pipe. An overflow pipe at the top of the facility or some other system should be used to convey water to an approved discharge point. An approved discharge point is a public or private storm pipe or an outfall to somewhere that will not impact structures and other property.

Standard Details. See standard details BMP 7.01 and 7.02 to include in construction documents. These are available in pdf, jpg, and AutoCAD dwg format.

Construction

Protecting the infiltration capacity of the native soils is crucial to the long-term functioning of any infiltration facility. See **Appendix B**: BMP Implementation Criteria, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project.

Construction Approaches to Prevent Clogging.

- Install adequate erosion control measures such as a compost sock and diversion methods to prevent clogging the sides during construction. Consider staging construction so that the surrounding land has been stabilized to prevent clogging.
- Construct the drywell, disturbing as little of the surrounding soil as possible.
- Do not direct runoff from other areas to the drywell until those areas have been stabilized or completely constructed.
- Install geotextile carefully, as described below.

The following guidance is provided for discussion with the contractor regarding the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP so its long-term function is achieved.

Construction of a drywell may be performed as follows:

1. Excavate a hole that is at least 2 feet larger in diameter than the outside diameter of the proposed manhole rings. A clamshell is often used to excavate deep, narrow holes greater than 15 to 20 feet deep.
2. Over-excavate by 12 inches to 18 inches and place a leveling course of drain rock (3/4 inch-minus) on the bottom.
3. Place non-woven geotextile fabric per **Appendix D**: Specifications, "*Geotextile Fabric*" so that a continuous piece reaches the bottom and all pieces overlap a minimum of 12 inches at vertical edges. Drape it on all sides and the bottom of the drywell. This will prevent fine sediments in the native soils from migrating into the surrounding drainage rock and will help protect against long-term clogging.
4. Place the non-perforated 3-foot deep sump in the bottom and re-arrange the geotextile if it has been pulled out of place. Place the rest of the specified number and depths of perforated and non-perforated rings that will set the ring at the correct finish grade.
5. Install the coarse aggregates (see **Appendix D**: Specifications, "*Coarse Aggregates*") drain rock between the outside walls of the drywell and the geotextile to the depth specified on plans.
6. After placing rock a few inches above the highest perforated ring, trim the geotextile and lay over the rock and up the sides of the geotextile a few inches more, then trim it.
7. Remove any debris that may have entered the drywell during construction.
8. Install the access rings and lid per manufacturer guidelines.
9. Install inlet and outlet pipes with the same technique used to connect pipes to standard

manholes per the 2017 Oregon Plumbing Specialty Code[73]. Surface backfill construction should follow project specifications.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in Appendix B: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Properly cared for drywells in Oregon are still functioning after 80 years. It is unlikely that a facility can be repaired when it becomes clogged, so proper maintenance is critical.

Maintenance activities include:

- Remove excess debris.
- Control erosion from areas draining to drywell.
- Pick up and remove trash.
- Maintain piping to and from drywell using industry standard best practices. Remove any vegetation that might clog these.
- Inspections should occur frequently and decline in frequency with larger facilities (NRCS 2008).
- Remove excess sediment from the pretreatment sump and the sump installed on the bottom of the drywell itself on an annual basis in the fall or more often as dictated by site conditions.

[73] *IAPMO. 2011 Oregon Plumbing Specialty Code. Retrieved from:* http://www.iapmo.org/pages/2011oregonplumbingspecialtycode.aspx

WATER QUALITY CONVEYANCE SWALE BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			■
Water Quality Management†	■		
Flow Control Management†	■		
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach		■	
Engineered Design Approach	■		
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required	■		
Design Information			
Title	**Form/Worksheet**		
LID Form	Form F		
Worksheet	N/A		
Drawings			
Title	**Detail**		
Water Quality Conveyance Swale	BMP 9.01		
Water Quality Conveyance Swale with Amended Soil	BMP 9.02		
Partially Lined Water Quality Conveyance Swale	BMP 9.03		
Fully Lined Water Quality Conveyance Swale	BMP 9.04		
Simple Infiltration LID Swale – Lowest Elevation Cell with Area Drain	BMP 3.07		

* This BMP does not offer this type of management
† Applies when meeting requirements in Chapter 2

Water quality (WQ) conveyance swales are linear vegetated channeled depressions that convey and treat runoff from a variety of surfaces. Runoff may be piped, channeled, or flow overland to a swale. These might be used instead of the more preferred ponding facilities where ponded water might be considered a hazard (*i.e* ODOT highways).

Swales and bioswales are widely used throughout western Oregon; however, as with all stormwater facilities, how they are designed and implemented influences the degree of water quality treatment and watershed protection provided; therefore, this guidance breaks swales into three different categories:

LID Swales BMP (high degree of water quality treatment and watershed protection). LID Swales are linear facilities able to pond water using flat bottoms or structures that pond water (*e.g.* check dams) before water cascades to the next cell. The ponding achieved by LID swales improves water quality through biological and chemical means as well as settling and provides a high degree of on-site stormwater treatment and runoff reduction to protect downstream systems. They also tend to have the smallest footprint of any other swale configurations. See **Chapter 4** "*Rain Garden*, *Stormwater Planter*, and *LID Swale BMP*" to implement this type of swale, which is preferred.

Figure 4-93. Of the three types of swales discussed here, LID swales pond water and provide a higher quality of treatment in a smaller footprint. See Chapter 4 "Rain Garden, Stormwater Planter, and LID Swale BMP". They tend to be smaller, distributed BMPs compared with other swale types.

Water quality conveyance swales BMP (medium degree of water quality treatment and much lower watershed protection). Water quality conveyance swales treat stormwater by conveying it – not ponding it --through the facility overtop of the plants. Water quality treatment is mainly achieved by filtration and settling of solids provided by the plant structure. Because water does not pond, runoff reduction via infiltration and evaporation is less than in an LID swale, so this BMP provides less protection of downstream watersheds.

Water quality conveyance swales may be unlined, partially lined, or fully lined depending on where they are located. Water quality benefits from an unlined or partially lined facility will not be significantly different; however, the use of an underdrain, required in lined facilities, can significantly reduce water quality treatment benefits. Costs can be significantly different and are described in "Cost Considerations" below.

Figure 4-94. Water quality conveyance swales are long, linear facilities that treat stormwater primarily by settling sediments, and the pollutants that attach to them, along their length. Runoff reduction is usually not considered in the design. These facilities are usually less desirable "end of pipe" type solutions, located at the bottom of a project site.

Conveyance swales (very low to no water quality treatment or watershed protection). Conveyance swales are open channels that carry water from a high point to a low point without regard to water quality treatment. They are often used as a cost effective substitute for pipes, such as ditches alongside roads, and may be very narrow, have no vegetation, and quickly convey runoff from one place to another.

Conveyance swales are not covered in this guidance. One significant difference between water quality conveyance swales and conveyance swales is that they are not densely vegetated with tall flow-resistant plants, so designing a conveyance swale in a conventional way but vegetating per this guidance can turn a potentially harmful conveyance system into a higher performing facility. For roadside projects, Kitsap County, WA has recommendations to convert a ditch to a higher functioning LID BMP[74].

Figure 4-95. Roadside ditches (left) and grassy mowed swales (right) are common ways to convey stormwater; however, without tall, densely planted vegetation and a design to protect against erosion, these swales are more likely to pollute water, not treat it. These facilities are even more undesirable when relied upon as an "end-of-pipe" solution, located at the bottom of the site, which is generally not considered LID because BMPs should be distributed around the site. Ideally the high side of a site will have as many BMPs as the low elevations.

[74] *Kitsap County, Washington. (Dec. 2012). Roadside Ditch and Shoulder Water Quality Enhancement Plan. Retrieved from:* ftp://kcwppub3.co.kitsap.wa.us/pw/sswm/Kitsap_Roadside_Ditch_WQ_Enhancement_Plan.pdf

Siting

Suitable Locations for Lined WQ Conveyance Swales. Other than locations listed under "Unsuitable Locations for all WQ Conveyance Swales" below, lined facilities do not have any specific setbacks.

Lined WQ Conveyance Swales should be avoided to the extent possible through good site design (see **Chapter 3** "*The LID Planning Process*"). Where lined facilities cannot be avoided, they may be located:

- Within 10 feet of an existing building foundation (including slab foundations).
- Within 10 feet of a possible future building foundation (including slab foundations).
- Within 10 feet of an underground tank or a site wall
- Within 5 feet of utilities
- Directly adjacent to pier footings
- Within 100 feet from down-gradient slopes of 10%. Add 5 feet of setback for each additional percent up to 30%, and use a lined WQ conveyance swale where the down-gradient slope exceeds 30%.
- For runoff from vehicular areas, within a horizontal distance of 2x the depth of any nearby wells. Groundwater can move twice as fast horizontally as vertically, so infiltrating too close to private drinking wells can contaminate them. Locate these wells in relation to your site using the DEQ well log database[75] and infiltrate runoff no closer than 2 times the completed depth.
- Over contaminated soils

Figure 4-96. Partially or fully lined facilities may be located next to buildings; however, they will be more costly to construct (see "Cost Considerations" below).

Suitable Locations for Unlined WQ Conveyance Swales. Even though WQ conveyance swales are not specifically designed to infiltrate, the soils are not compacted (see "*Design*" below for more information), so where facilities are unlined, and infiltration is a possibility, these facilities should be located:

- Where they are at least 10 feet away from an existing building foundation (including slab foundations).
- Where they are least 10 feet away from a possible future building foundation (including slab foundations). Check setbacks requirements in the zoning code for the proposed development site and all neighboring properties to ensure that a vegetated stormwater facility will be 10 feet from a building foundation, should any of the neighboring properties redevelop or add buildings to their properties.
- Where they are at least 10 feet from an underground tank or a site wall

[75] Oregon Water Resources Department. Well Log Query. Retrieved from: http://apps.wrd.state.or.us/apps/gw/well_log/

- Where they are at least 5 feet from utilities
- Directly adjacent to pier footings
- Where slopes along the centerline are or can be constructed to be up to 6%
- Where they are at least 100 feet away from down-gradient slopes of 10%. Add 5 feet of setback for each additional percent up to 30%, and avoid installing a WQ conveyance swale where the down-gradient slope exceeds 30%.
- For runoff from vehicular areas, greater than a horizontal distance of 2x the depth of any nearby wells. Groundwater can move twice as fast horizontally as vertically, so infiltrating too close to private drinking wells can contaminate them. Locate these wells in relation to your site using the DEQ well log database[76] and infiltrate runoff no closer than 2 times the completed depth.
- In any location approved by a licensed engineer who has signed and stamped a geotechnical investigation report or letter clearly designating the location in narrative and/or by graphical means (i.e. site plan).

Figure 4-97. This ideal unlined WQ conveyance swale is located away from buildings and other critical infrastructure. Mowing has been performed up to the swale (left); however, the swale itself (unmowed center) is allowed to grow tall and dense. See "Design" below for more information.

Unsuitable Locations for All WQ Conveyance Swales. WQ conveyance swales of any type should never be installed in the following locations:

- In floodways, defined by the Federal Emergency Management Agency as "the channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height."[77]
- In other sensitive areas (*i.e.* wetlands, riparian areas or buffers, designated native habitat areas, beneath existing tree canopy)
- Over septic systems

Design

Generally, the slower the water flows through the facility, the higher the water quality treatment achieved.

[76] *Oregon Water Resources Department. Well Log Query. Retrieved from: http://apps.wrd.state.or.us/apps/gw/well_log/*
[77] *Federal Emergency Management Agency website. Floodway definition. Retrieved from: https://www.fema.gov/floodplain-management/floodway*

Additional Design Criteria. In addition to the design guidance provided in this section:

- Water quality conveyance swales, compared with other BMPs in this guidance, are generally much less effective at reducing runoff volumes, so flows from them may be significant. Refer and incorporate design elements per **Appendix B**, "*Design*", "*BMP Design Criteria*".
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Hydrologic Modeling and Sizing. Multiple design aspects such as shape, width, slope, and channel roughness are related to flow velocity. These variables also define the depth of water flow during the design storms. For these reasons, a WQ conveyance swale must be designed by a licensed engineer using criteria provided in **Appendix B**: BMP Implementation Criteria, "*Design*", "*Hydrologic Modeling*", "*Engineered Design Approach"*.

An additional design criterion specific to WQ conveyance swales is a residence time (*i.e.* the time water spends flowing through the swale) of 9 minutes, which determines the minimum length of the swale. This means that polluted water must flow through a WQ conveyance swale for a minimum of 9 minutes before it can be considered treated. When designing swales with multiple places for stormwater to enter, take care to account for the shortened length and accumulating volumes when calculating residence time. To size the facility, perform hydrologic modeling to determine the peak flow from the drainage area during the water quality design storm and the flood storm. Then, incorporate the design aspects listed above, using Manning's equation to determine the average velocity and depth of flow. From this, calculate the required length adequate to treat the water quality design storm and convey the flood storm.

Shape. The recommended cross-sectional shape of a swale is trapezoidal mainly because it is the easiest to maintain, causes the least scouring and creates the least runoff[78]; however, this shape is the most difficult to build, because soil doesn't tend to conform to hard angles, even with compaction. The wider the facility the more surface area runoff will be in contact with and therefore pollutant removal levels will be higher.

Dimensions. Bottom width is generally between 1 to 8 feet wide. The wider the facility, the shallower and slow the flow will be, which will improve the water quality treatment capacity of the swale.

Side Slopes. Side slopes for the facility should be 3 feet horizontal to 1 foot vertical (often seen written as 3H:1V), which is the angle at which most soils will stand on their own without compaction. Avoid compacting the side slopes, which removes voids in the soil and impacts or even prevents healthy plant establishment.

[78] *Field, R., Tafuri, T.N., Muthukrishnan, S., Acquisto, R.A., and A. Selvakumar,. (2006). The Use of Best Management Practices (BMPs) in Urban Watersheds,. DEStech Publications, Inc.,., Lancaster, PA,.*

Figure 4-98. This WQ conveyance swale was squeezed into a constrained space by snaking it through available space and compacting the sides to create slopes that exceed 3H:1V. While many plants were successfully established, many steep slopes remain bare (foreground right and background left).

Longitudinal Slope. The longitudinal slope of the facility should be whatever is necessary to control erosive flow velocities considering the other design elements that will influence erosion. The maximum longitudinal slope is 10%. Slopes greater than 6% shall include check dams spaced along the swale such that the toe of one check dam to the top of the downstream check dam does not exceed 6%. Limit flows to 2 feet per second or less during the 25-year storm. For lined WQ conveyance swales, the minimum longitudinal slope is 0.5%.

Depth and Freeboard. The minimum depth of a swale is impacted by the method of conveyance to it. For instance, if the swale receives overland or concentrated flow through an open-ended trench drain at the surface, it may be shallower than a swale that has runoff piped to it, since pipes need a minimum of 12 inches of cover.

If no high-flow bypass is provided (see **Appendix B**, "*Design*", "*BMP Design Criteria*", "*High-Flow Bypass*") the swale depth must be capable of safely conveying the 25-year frequency flood storm, which adds to the overall depth of the swale.

- Provide freeboard (the depth from the maximum flow depth to the top of the facility) of 12 inches, to convey the very large storm.
- The maximum flow depth for water quality treatment is 6 inches.

Pretreatment and Energy Dissipation to Reduce Erosion. Runoff at inlets can be erosive, especially when concentrated to enter the swale at a particular place. See **Chapter 4** "*Rain Garden*, *Stormwater Planter*, and *LID Swale BMP*", "*Design*", "*Pretreatment*" for detailed guidance on low- maintenance methods to reduce erosion at inlets.

Vegetation. Vegetation plays a key role in slowing water and allowing sediment to drop out before reaching the end of the swale. If a facility is not vegetated, then it is considered a ditch or simply a conveyance swale and does not provide adequate water quality.

Figure 4-99. Vegetation density down the swale centerline at this industrial warehouse site is ideal. Grasses, shrubs, trees, and groundcover are all suitable for vegetated swales.

Design criteria for vegetation is as follows:

- Vegetation should cover a minimum of 95% of the facility within three years per planting density guidance provided in **Appendix E**: Plant Specifications. The better the plant coverage, the less effort needed for weeding during the maintenance phase.
- Avoid the dry creek bed look where rocks line the bottom and plants are sparse or located only around the top edges of the slopes. This approach doesn't provide adequate treatment for the small, frequent storms with flow depths that may never reach the plants on the side slopes and significantly increases maintenance (weeding and cleaning rock).
- Choose vegetation with a sturdy above ground structure able to withstand and slow flowing water. The mature height of this vegetation should be at least the height of the flow depth. Avoid sod, lawn, and weakly structured grasses.
- Vegetation should be selected based on its tolerance of flooding and drought cycles and other criteria listed in **Appendix E**: Plant Specifications.

Figure 4-100. Vegetation is tall and sturdy enough to withstand flows during this rain event. A variety of plant species including lupines and grasses are included in this swale and add beauty. If mowing is required by ODOT, include a geogrid on the bottom to stabilize the surface for mowing.

Soils. Swales are appropriate for any soil type. Soils may be native or imported topsoil. Do not compact soil, which will not prevent erosion, as flowing water is very good at carving canyons out of soil or bedrock. Instead, planting per "*Vegetation*" section above will be more effective at holding soil.
To support plant health, soils may be optionally amended with compost following the same guidance in the footprint of the swale as provided in **Chapter 4** "*Restored Soils BMP*". ODOT has found this also improves removal of dissolved metals.

Mulch. Mulch is used in landscape areas to make weeding easier and to reduce watering demands. When compost is used as mulch, it replaces chemical fertilizers.

Mulch of any kind – even rock mulch – will be carried around, if not out of, the facility. If this mulch is made of organic matter such as compost, then it also carries attached pollutants out of the facility, polluting the downstream waterway.

To provide the benefits of mulch without having to constantly mulch, the designer, construction contractor, and maintenance staff should work together to perform the following tasks:

- Designer:
  - Specify compost mulch per in **Appendix D**: Specifications, "*Compost*" on plans and/or specifications to provide nutritional support to plants. Avoid rock mulch, which will not feed new plants and is difficult to pull weeds from.
  - Specify mycorrhizae on plans and/or specifications to reduce irrigation demand.
- Construction Contractor:
  - A dense fibrous erosion control mat-like coir fabric will protect open areas from erosion and weed seeds blowing in, but will allow soil to breathe, protecting critical life in the soil. Avoid impermeable membranes like plastic.
  - Apply mycorrhizae and compost carefully per specifications provided by designer (**Appendix E**: Plant Specifications).
  - Do not compact the soil. Uncompacted soil helps plant establishment.
  - Remove the dense erosion control mat right before planting.
- Maintenance Staff:
  - During 2-year establishment period: Apply compost mulch meeting the standards in **Appendix D**: Specifications, "*Compost*".
  - After the establishment period, allow vegetation to fully cover swale bottom instead of maintaining an English Garden look with individual plants. Full cover shades out many weeds (see **Appendix E**: Plant Specifications).
  - Remove weeds using integrated pest management (see **Appendix E**: Plant Specifications)
  - Unhealthy plants should be removed and replaced, possibly with another species if replacing for the second time.

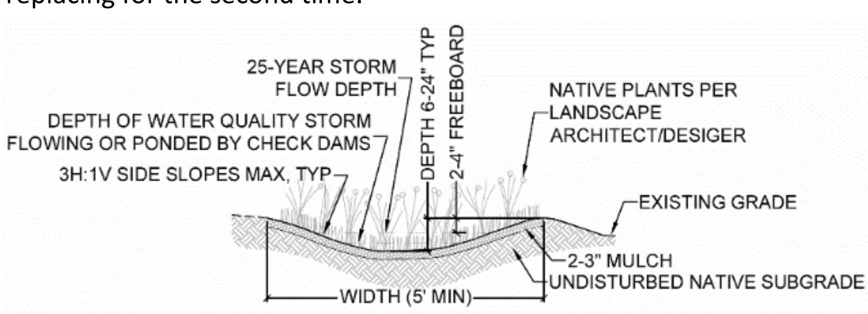


Figure 4-101. Infiltration swale detail for soils that don't need amendment.

Impermeable Liners. Impermeable liners such as plastic, rubber, or bentonite clay are required when facilities are within 10 feet of a building foundation or other critical infrastructure. Use minimum 45 millimeter plastic or rubber sheeting or bentonite clay. Avoid petroleum sealants, which are digested by microbes in the soil and can leach pollutants.

There are two different configurations, which have important water quality differences:

- Partially lined. WQ Conveyance swales can be partially lined to convey runoff through an area where infiltration is not recommended (see "*Siting*", "*Suitable Locations for Infiltration WQ Conveyance Swales*"). Beyond these areas, the liner is no longer needed.
  When a liner is needed, partially lined facilities are less complicated to construct than fully lined facilities. Following the guidance provided in "*Construction*" below, they will not require an underdrain. Facilities without underdrains have not been shown to export excess nutrients the way facilities with underdrains have.
- Fully lined. WQ Conveyance swales that are fully lined must incorporate an underdrain to ensure that soil will drain out and plants will survive. Facilities with underdrains are likely to export excess nutrients, which pollute the downstream. Do not implement these in watersheds where algae growth is problematic or where streams are listed for dissolved oxygen.

Outlets. Since runoff volume will not be significantly reduced, all WQ conveyance swales require an outlet to direct treated stormwater to an approved discharge point, protected from erosion. This outlet structure is most often a ditch inlet.

If the bottom section of the WQ conveyance swale can be designed to infiltrate and pond water, essentially turning the lower length of swale into an infiltration rain garden, then an area drain (catch basin) may also serve to redirect excess volumes of runoff to an approved discharge point.

Standard Details. See standard details BMP 9.01 through 9.04 and related details BMP 3.02 and 3.07 available in pdf, jpg, and AutoCAD .dwg format to include in construction documents:

Table 4-7. Description of WQ Conveyance Swale Standard Details.

Detail #	Title	Additional Information
BMP 9.01	Water Quality Conveyance Swale	For conveyance across areas suitable for infiltration
BMP 9.02	Water Quality Conveyance Swale with Amended Soil	For conveyance across areas suitable for infiltration and soils are restored using the "Restored Soils BMP" to support plant health.
BMP 9.03	Partially Lined Water Quality Conveyance Swale	For conveyance across areas not suitable for infiltration to areas that are
BMP 9.04	Fully Lined Water Quality Conveyance Swale	For conveyance across areas not suitable for infiltration in watersheds not limited for nutrients
BMP 3.07	Simple Infiltration LID Swale – Lowest Elevation Cell with Area Drain	Optional outlet detail if site conditions allow: Use this detail with BMP 9.01, 9.02, and 9.03 to use the bottom (*i.e.* the last length of the facility) of the WQ conveyance swale to infiltrate. The area capable of ponding water and infiltrating water between 6 inches and 12 inches can be included to meet the sizing requirements on the LID Implementation Form (see Chapter 5) as if it were an LID Swale per Chapter 4 "*Rain Garden*, *Stormwater Planter*, and *LID Swale BMP*")

Construction

Like all stormwater management facilities, special care must be taken to properly construct BMPs. Protecting the infiltration capacity of the soil is crucial to the long-term functioning of any infiltration facility. See **Appendix B**, “Construction”, “Protecting Permeability” for specific steps that should be taken on every LID project. Mistakes in construction can lead to unintentional damage to the facility (*i.e*. clogging) or to long-term maintenance challenges (*i.e.* plant replacement).

Water Quality Conveyance Swale. Protecting the infiltration capacity of the native soils is crucial to the long-term functioning of any infiltration facility. See **Appendix B**: BMP Implementation Criteria, "*Construction*", “*Protecting Permeability*” for specific steps that should be taken on every LID project.

The following guidance is provided to inform the contractor about the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP so its long-term function is achieved.

To construct a WQ conveyance swale:

1. Install temporary erosion prevention and sediment control measures upstream from the WQ conveyance swale, as needed per **Chapter 3**, “*The LID Construction Process*”, “*Erosion Prevention and Sediment Control*”.
2. Excavate to the depth shown on plans, which may vary from 18 to 48 inches, depending on the facility configuration.
3. Install area drains, perforated pipe, non-perforated piping, and/or cleanouts as called for on details and plans.
4. If separation rock and treatment soil are included in design, install layers as shown on plans according to guidance provided in **Appendix D**: Specifications.
5. If plans and details call for native amended soil, amend soil per the Restored Soils BMP or specifications provided on the plans.
6. Shape the side slopes to match plans and details, but do not exceed a slope of 3:1 (horizontal: vertical) or compact the side slopes. Plant establishment is difficult to achieve on compacted slopes (Figure 4-98)
7. Rake (sandy soils) or compost amend (clayey, more compactable soils) per the Restored Soils BMP if facility is dug by hand, since foot traffic is probably unavoidable.
8. If facility incorporates check dams on the surface *(i.e.* rock, wood), install these per details and plans.
9. Install erosion prevention and sediment control to stabilize the surface of the facility.
10. Remove protection fencing.
11. Plant facility and protect it from stormwater flows for 3 months after planting using sand bags to block flows or piping around the facility. This will help plants establish and reduce erosion. Make sure that wherever the water is flowing for this three-month period that it will not cause a dangerous condition (*e.g.* water flowing over a sidewalk, tripping hazard, *etc.)*, flooding or erosion.
12. Mulch the facility per plans.
13. Remove temporary erosion prevention and sediment control.
14. Unblock inlets to allow stormwater flows to enter facility 3 months after planting.
15. Remove temporary erosion control if soil is stabilized.
16. Water plants through dry months for a minimum of 2-year establishment period per **Appendix E**: Plant Specifications, “*Establishment Maintenance*”, “*Watering*”.

Lined Water Quality Conveyance Swale. The infiltration capacity of soils beneath partially or fully lined facilities does not need to be protected. However, as with all soil, unnecessary compaction should be avoided since soil below ground conveys groundwater to waterways. A loss of voids in the soil still impacts watershed health.

<u>To construct a lined facility:</u>
Install temporary erosion prevention and sediment control measures upstream of the facility, as needed per **Chapter 3**, "*The LID Construction Process*", "*Erosion Prevention and Sediment Control*".

1. Excavate between 40 and 48 inches depending on the flow depth. If stockpiling soil for another use, cover stockpile with a breathable fabric to prevent erosion and protect the permeability of the soil.
2. Install the outlet structure (*i.e.* area drain, catch basin, ditch inlet) or cleanout and non-perforated piping using standard construction techniques.
3. Install impermeable liner per Appendix D: Specifications, "*Impermeable Liner*".
4. Place a perforated underdrain pipe on top of the liner and connect it to the outlet structure.
5. Place 12 inches of coarse aggregate that meets or exceeds specifications in **Appendix D**: Specifications "*Coarse Aggregate*".
6. Place 4 inches of separation rock that meets or exceeds specifications in **Appendix D**: Specifications "*Separation Rock*".
7. Place imported treatment soil or amended native soil per guidance provided in **Appendix D**: Specifications, "*Treatment Soil*".
8. Place the amended planting soil in two lifts, saturating each lift with water to lightly compact it (*i.e*. 85% compaction). Boot packing or light tamping may also be used but never apply vibratory compaction.
9. Place a final lift as needed to reach desired elevations and lightly compact as above.
10. Plant facility and protect it from stormwater flows for 3 months after planting using sand bags to block flows or piping around the facility. This will help plants establish and prevent erosion. Make sure that the water flow during this 3-month period will not cause a dangerous condition (*e.g.* water flowing over a sidewalk, tripping hazard, *etc.)*, flooding, or erosion.
11. Mulch the facility per plans.
12. Remove temporary erosion prevention and sediment control.
13. Unblock inlets to allow stormwater flows to enter facility 3 months after planting.
14. Remove temporary erosion control if soil is stabilized.
15. Water plants in dry months during minimum establishment period of 2 years. See **Appendix E**: Plant Specifications "*Watering*" under "*Establishment Maintenance*".

Maintenance

Specific maintenance is needed to ensure proper long-term function. In addition to detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*" and **Appendix B**: BMP Implementation Criteria, "*Maintenance*", review **Chapter 6** Operations and Maintenance Agreement to determine who is responsible for maintenance and confirm early stakeholder buy-in of maintenance practices before settling on the mix of BMPs.

Observing the facility during rain events and looking for erosion during dry weather will help you see where water is and isn't flowing. Maintenance requirements for the landscape are typical of non-lawn vegetated areas.
Maintenance of structures, like sumped catch basins, is typical of conventional infrastructure. Watering and weeding may be needed frequently within 2-year establishment period during the dry summers, but this should taper off dramatically if plants are chosen according to the guidance provided in **Appendix E**:

Plant Specifications. The more you water, the more weeds you can expect.

Inspect the facility a minimum of 4 times per year and perform needed maintenance as follows:

- Maintain a calm flow of water entering the facility via downspout pipes or other inlets.
    - Identify erosion sources and control them when soil is exposed, or erosion channels are forming. A settling basin or other effective means should be placed at the point where water is discharged into the facility to slow the water and prevent erosion. Fill erosion channels with approved soil mix, not mulch, compost, or rock, and replant using a plant species found in the facility adjacent to the eroded channel.
    - Identify and correct sources of sediment and debris.
- Remove sediment and debris from:
    - Pretreatment sump
    - Facility surface when more than 1 inch thick or damaging vegetation. Minimize damage to vegetation.
    - Facility outlet, such as overflow drain or conveyance swale.
    - Curb cuts when depth exceeds ¼ inch.
- Stabilize slopes with plants and appropriate erosion control measures when soil is exposed, or erosion channels are forming. Fill eroded channels with approved soil and replant. If flows can be redirected temporarily, redirect flows until plants establish. Check for erosion due to redirected flows on the next site visit.
- Maintain the design ponding depth by:
    - Repairing any structural elements that may leak from cracks or worn sealant
    - Maintaining the design elevation of check dams
- Vegetation should be healthy and dense enough to provide filtering while protecting underlying soils from erosion with at least 95% coverage of bare soil in three years.
    - Replenish mulch until vegetation in the bottom of the WQ conveyance swale is established and shading the bottom of the facility.
    - Remove fallen leaves and debris from deciduous plant foliage, especially if the facility is in a roadway with trees located upstream from a curb.
    - Don't string trim ornamental grasses, sedges or rushes. These may be raked.
    - Remove nuisance (*i.e.* plants blocking the inlet) and non-native and invasive vegetation (*i.e.* weeds such as Himalayan blackberries and English Ivy).
    - Remove dead vegetation and woody material before it covers 10% of the WQ conveyance swale surface area. Vegetation should be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
    - Maintain vegetation using integrated pest management such as hand pulling weeds. Avoid use of fertilizers, pesticides, and herbicides, as these are common pollutants found in waterways.
- Exercise spill prevention measures when handling substances that can contaminate stormwater. Correct releases of pollutants as soon as identified:
    - Make sure the area is safe to enter
    - Block the outflow of the BMP
    - Block the inflow of the BMP
    - Stop the release of the hazmat
    - Clean up the flow path to the BMP
    - Clean out the BMP, replacing soil, amended soil and vegetation as necessary.
- Mow if required by ODOT.

DISPERSION BMP

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form F		
Worksheet	Worksheet F4 Worksheet F5		
Drawings			
Title		**Detail**	
Vegetated Filter Strip		BMP 4.01	
Vegetated Filter Strip with Amended Planting Soil		BMP 4.02	
* This BMP does not offer this type of management † Applies when meeting requirements in Chapter 2			

Dispersion is a BMP that spreads runoff over a landscape area specifically to reduce pollution and runoff. Dispersion is suitable for a variety of roadside applications and development densities; however, due to setbacks, the volume of water that can be dispersed generally decreases with density, unless clustered (see **Chapter 4** "*Limit Disturbance: Cluster Development BMP*") where open space can be used for dispersion.

Siting

Dispersion relies on the soil's ability to absorb adequate volumes of runoff, which is related to the flow path or the distance runoff travels over a pervious or hard surface before entering the dispersion area. To function properly, dispersion areas should be located as follows:

- Over soils with a minimum infiltration rate of 2.0 inches/hour. (See **Appendix C**: Infiltration Testing.)
- In landscaped areas where the Restored Soils BMP is applied, or in protected natural areas through the Cluster Development BMP and/or the Tree Protection BMP. For existing forested areas, be aware of the species that will receive runoff. The health of most established trees, especially Oregon White Oak, are impacted by additional volumes of water. Some species of trees

that can tolerate additional water after establishing include willows, ashes, alders, poplars, and some maples. Since trees and forests are some of our most important stormwater management strategies, if in doubt, consult an International Society of Arboriculture certified arborist.

- In areas where the seasonal groundwater table is at least 2 feet from the surface.
- 10 feet from a building with a basement.
- 2 feet from a building without a basement (*i.e.* slab on grade, crawl space, pier, or post foundations).
- On slopes < 15%, except where that slope is a historical site that can be found on OregonMapper[79] and/or is found to be a landslide hazard by a licensed engineer.
- Downhill of pervious areas with a maximum flow path of 150 feet.
- Runoff volumes and flow from dispersion can be significant, so:
    - Not over or towards septic drain fields.
    - Not towards neighboring private properties.
- Dispersion areas must slope away from buildings.
- Not over contaminated groundwater plume (check with Regional DEQ Cleanup program).
- In any location approved by a licensed engineer who has signed and stamped a geotechnical investigation report or letter clearly designating the location in narrative and/or by graphical means (i.e. site plan).

Design

Dispersion design is driven by the type of impervious drainage area and whether the runoff is flowing in sheet or concentrated form. All runoff starts as sheet flow (*i.e.* overland flow), which can occur on any surface. Eventually, runoff becomes concentrated flow, either because it has flowed over the surface for a relatively long distance or because it has been captured and intentionally concentrated in a roof gutter and downspout, a catch basin and a pipe, and/or a curb.

Facilities that manage sheet flow are known as “vegetated filter strips”. Facilities that manage concentrated flow are called “disconnection”.

Additional Design Criteria. In addition to the design guidance provided in this section:

- Dispersion techniques, compared with other BMPs in this guidance, are generally much less effective at reducing runoff volumes, so flows from them may be significant. Refer and incorporate design elements per **Appendix B**, “*Design*”, “*BMP Design Criteria*”.
- Show information on plans and obtain permits as required by **Chapter 3** "*The LID Design Process*".

Temporary Mulch. Mulch is often the top layer of a newly installed dispersion technique. Mulch is used to control soil temperature for seed germination, control weeds, feed the plants, and reduce the erosion of soil that would be otherwise bare; however, in dispersion BMPs, routine flows across the facility redistribute mulch around and out of the BMP, which makes maintenance difficult.
Design criteria for mulch is as follows:

- Use mulch meeting the specifications in **Appendix D**: Specifications, “*Mulch*”. Avoid rock mulch, which is high maintenance (difficult to clean) and can be a barrier to achieving a desirable plant cover density as described below in “*Vegetation*”.
- Apply mulch during the establishment period of 2 years. After that, vegetation should have adequate structure to hold and cover soil, shading out most weeds.

Soil. Directly below the temporary mulch is soil, which may be:

[79] Oregon Department of Revenue. ORMAP website: Oregon Map GIS Viewer. Retrieved from: http://www.ormap.net/flexviewer/

- Imported. (Native soil is removed for a certain depth and replaced with a blended soil mix.)
- Amended. (Amendments are folded into existing native soil.)
- Native and uncompacted. (Infiltration vegetated stormwater facilities allow water to flow into the native soil.)

For design criteria for soil, see **Appendix D**: Specifications, "*Treatment Soil*".

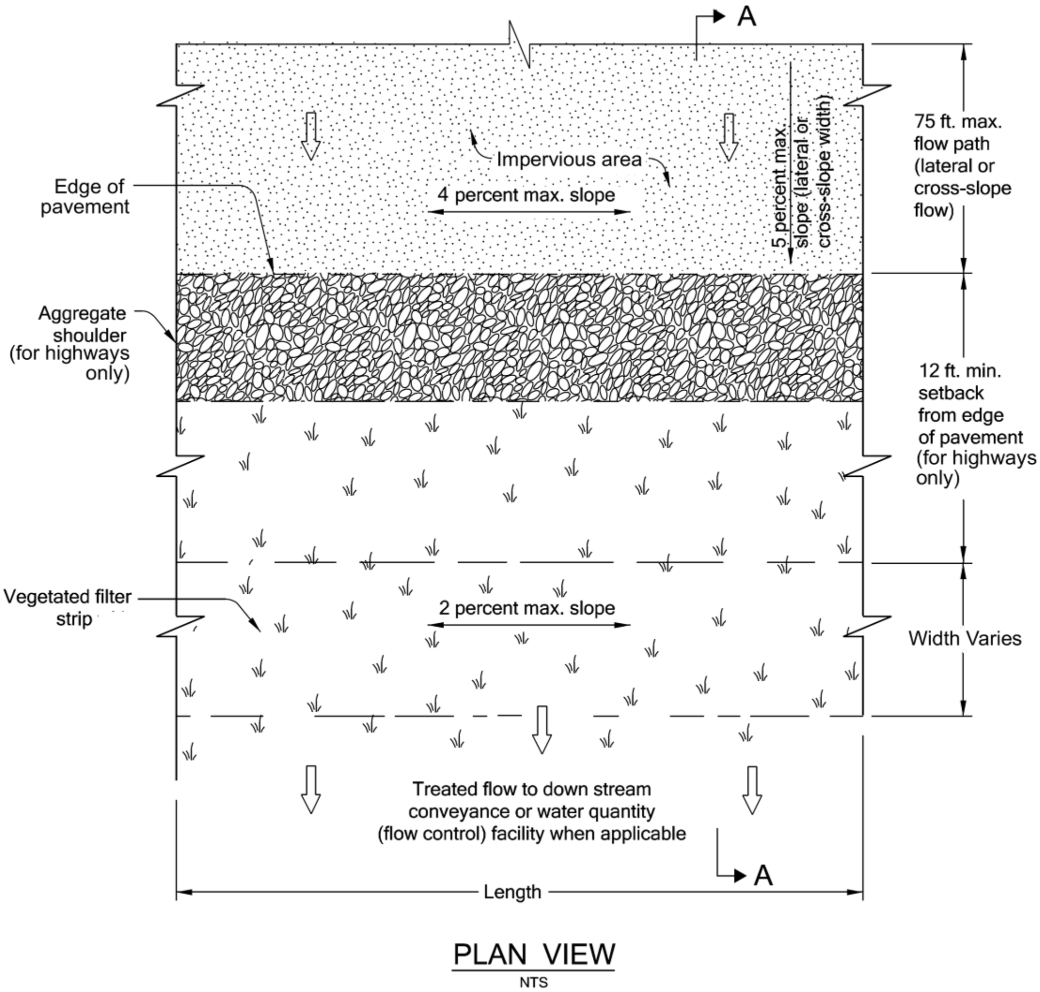
Infiltration testing. Perform an infiltration test to determine the soil's capacity to absorb and percolate water down into the lower layers. See Appendix C for detailed guidance on field testing to find the rate that water can pass through the soil and how to interpret that data.

Standard Details and Sizing. Standard details for vegetated filter strips (described below) in native and uncompacted soil (BMP 4.01) and in imported or amended soil (BMP 4.02) are included in Appendix. Sizing guidance for vegetated filter strips and downspout disconnection is provided in **Chapter 5** "*Step-by-step LID Implementation*".

If the site's soil meets the criteria in Appendix D: Specifications, "*Treatment Soil*" where the BMP will be installed, the more simple and less costly BMP 4.01 may be used. If the site's soils do not meet the criteria or amendment is desired for plant health, implement BMP 4.02.

Design Specific to Vegetated Filter Strips (Sheet flow). Design criteria for sheet flow dispersion areas (***Figure 4-102***) are as follows:

- Maximum impervious area flow paths of 75 feet.
- Maximum impervious lateral slope (*i.e.* slope parallel to centerline of a sidewalk or a road) of 2%.
- Maximum impervious longitudinal slope of 4%.
- Maximum vegetated filter strip lateral slope of 15%.
- Maximum vegetated filter strip longitudinal slope of 2%.
- The length of the vegetated filter strip should match the length of the impervious area draining to it.
- Incorporate a level spreader (described in next section).
- See Figure 4-102 for additional materials and widths for highways. For highways in the Oregon Department of Transportation jurisdiction, refer to the most recent ODOT Hydraulics Manual.



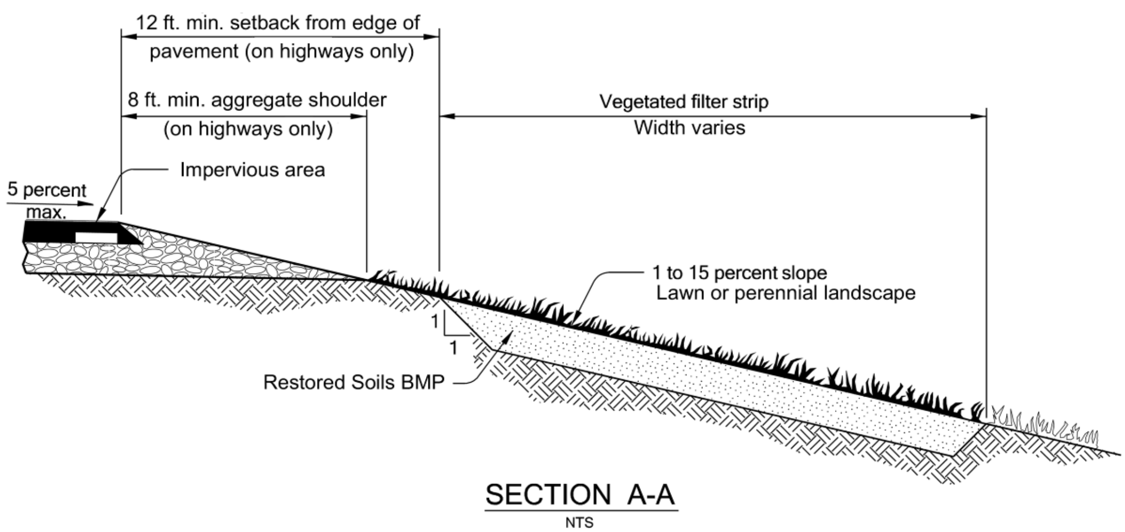


Figure 4-102. Design parameters for sheet flow dispersion (i.e. vegetated filter strip). Adapted from ODOT Hydraulics Manual 2014 (Chapter 14, Figure 7). The aggregate shoulder serves as a level spreader (see "Supporting Infrastructure: Level Spreader" section below).

Level Spreader. Pavement cannot be installed perfectly with no dips or bumps, especially asphalt pavement which is rolled into place with heavy machinery, so flows over the pavement tend to concentrate in some areas. Level spreaders, as described in detail below in "Supporting Infrastructure for Vegetated Filter Strips: Level Spreader" should be included in every vegetated filter strip to redistribute flows more evenly across the facility. This will reduce the need to fix areas damaged by erosion in addition to improving stormwater management function; however, maintenance to keep gravel clean may be moderate to high.

Design Specific to Downspout Disconnections. Disconnecting a downspout or pipe causes runoff to be directed to a landscape area in a concentrated form. Design criteria for disconnections are as follows:

- Maximum impervious area of 700 square feet/downspout
- Include a splash block or pad
- Include downspout extensions to protect against flooding the adjacent building (see "Siting" above). A 6-foot long downspout extension should be used for minimal excavation foundations (see **Chapter 4** "*Minimal Excavation Foundations BMP*") and 10-foot long extension should be used for buildings with full basements.
- Provide a minimum vegetated flow path of 50 feet sloping between 2% and 5% away from buildings. This may include natural areas or riparian buffers.

Design Specific to a Vegetated Filter Strip for Roofs. In many rural areas, where pipe infrastructure is limited, roofs with no gutters or downspouts are common. Specific architectural design must be incorporated into the overhang and the roofing and siding materials to ensure that water flowing over the edge doesn't run down the siding and cause damage to the building. This practice can be used in new and re-development projects when there is no basement adjacent to the roof area that overhangs (Figure 4-103).

Figure 4-103. There are no gutters on this office building roof. Runoff sheet flows directly over a carefully designed roof edge into a linear rock trench. The exposed concrete at the bottom where water could splash up is a better choice than wood or other materials, that won't rot and require replacement.

Figure 4-104. Roof runoff from this residential garage is dispersed via an open gutter system into the landscape below.

Design Specific to Vegetated Filter Strip for Sidewalks or Patios. Tip a sidewalk or patio towards a landscape area, not towards a curb or catch basin inlet.

Figure 4-105. Example of sheet flow from a patio to a newly installed vegetated filter strip.

Design Specific to Vegetated Filter Strips for Parking Lots and Driveways. To use dispersion on parking lots and driveways, avoid using curbs and gutters (***Figure 4-106***).

Figure 4-106. The parking lot sheds runoff to the left towards the grassy area. A lack of curb and flat area means almost all the annual runoff from the parking lot stays on-site.

While many people believe curbs control traffic and improve safety, curbs and gutters are most effective at channeling runoff and keeping pedestrians' feet dry. While curbs may be a handy way of letting a driver know when they have left the road, many people will still drive over them. Other elements in the landscape, such as shrubs, bollards, wheel stops (with raised feet to allow stormwater under them), and rumble strips may be just as good, if not better, at delineating a parking space or road edge.

Since drivers must turn more to navigate parking lots and driveways than roads and highways, curbs may still be desired. If so, some specific guidance for minimizing curbs is as follows:

- Use curbs on radii for turning into or out of a parking lot or around landscape islands.
- Taper the curb ends from a height of 6 inches (typical) to flush with the pavement over a distance of 3 feet as soon as a driver is likely to stop their turning motions.
- Tip pavement towards a landscape area, not towards a valley in the drive aisle draining to a catch basin inlet.
- Since a level spreader should be included with a vegetated filter strip, curbs with cuts might be used as well and erosion that would result from concentrated flows at these points will be controlled by the level spreader.

Design Specific to Vegetated Filter Strips for Roads or Highways. Some roads and many highways already have no curbs and can be designed or may already meet most of the design criteria for vegetated filter strips.

Figure 4-107. Since most highways aren't greater than 75 feet wide from the crown to the road edge, they are well suited for dispersion (aka vegetated filter strips). In this area along a highway in Oregon, excess runoff is likely to flow to a ditch and finally an inlet after leaving the vegetated filter strip. Photo from ODOT Hydraulics Manual 2014, Chapter 14, Figure 6.

Vegetation. Plants and the beneficial microbes that concentrate on plant roots remove pollutants through biological breakdown and/or uptake and physically slow the water to filter it – the more plants, the more treatment.

Design criteria for vegetation is as follows:

- Place less dense vegetation directly at the inlet or front of the inlet strip. Flooding can occur when dense vegetation at the mouth of a downspout extension or the edge of a vegetated filter strip causes water to back up.

- To reduce erosion, choose plants with a robust above-ground structure, like tall grasses, to slow water when it flows overland. Some grass species lay over under flow conditions (Figure 4-108), so rushes, sedges, shrubs, and trees are all good choices.

Figure 4-108. If grasses are used, they should have some structure that can hold up to flowing conditions and not lay over as in the grasses shown here.

Vegetation in the dispersion area should be well established with at least 95% cover of lawn or perennial native landscape (groundcover, ornamental grasses, shrubs, and/or trees) within 3 years. The better the plant coverage, the less weeding needed.

See **Appendix E** for additional design considerations when choosing vegetation.

Figure 4-109. Vegetated filter strips can be as attractive as any landscape. Photo credit: US Army Corps of Engineers.

Construction

Like all stormwater management facilities, special care must be taken to properly construct BMPs. Protecting the infiltration capacity of the soil is crucial to the long-term functioning of any infiltration facility. See Appendix B, "*Construction*", "*Protecting Permeability*" for specific steps that should be taken on every LID project. Mistakes in construction can lead to unintentional damage to the facility (*i.e*. clogging) or to long-term maintenance challenges (*i.e.* plant replacement).

The following guidance is to inform the contractor about the differences between low impact development and conventional stormwater approaches. If guidance conflicts with standard industry practice, the contractor should consult with the design team and find acceptable means to implement the BMP so its long-term function is achieved.

To construct dispersion BMPs:

1. If included in the construction plan set, fence off the dispersion area with a durable fence (chain link, wood, *etc*.) at least 3 feet high to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of the existing soils.
2. Install temporary erosion control such as erosion control fabric, temporary seeding, biobags, wattles, and compost berms.
3. Make sure the erosion control method is weed seed free. Avoid plastic, especially plastic mesh, where possible; amphibians and other animals are harmed by it.
4. Amend soils per the Restored Soils BMP if organic matter is less than 10% or if the area was not fenced off.
5. Plant facility per Appendix E: Plant Specifications "*Planting Techniques*"
6. Protect plants from stormwater flows for 3 months after planting using sand bags to block flows or piping around the facility. This will help plants establish and prevent erosion. This practice may not be feasible along roads.
7. Apply 3 inches of mulch. See Appendix D: Specifications, "*Mulch*" for mulch specifications.
8. After 3 months, allow stormwater flows to enter dispersion area.
9. Remove temporary erosion control when soil is stabilized.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** "*The LID Operations and Maintenance Process*".
- Detailed guidance for BMPs in Appendix B: BMP Implementation Criteria, "*Maintenance*".
- **Chapter 6**: Operations and Maintenance Agreement.

Because vegetated filter strips look similar to a regular garden, permanent demarcation, such as fencing (even as simple and attractive as a 2-foot-tall post and chain fence) or road marking to prevent long-term compaction might be helpful.

Common maintenance tasks are as follows:

- Mow and trim grasses to lengths appropriate to the type and species of grass. Longer grass is generally better.
- Identify and correct sources of sediment and debris.
- Inspect for and remove excess sediment (maximum depth of 2 inches) that may affect vegetation growth in the dispersion area or the level spreader. Dispose of sediment in trash destined for the landfill.
- Replace vegetation as needed. If a plant did not do well, choose a different plant.

- Repair eroded areas where channels have formed by filling them with soil, lightly compacting them with tamping or boot compaction, and re-establish vegetation. Do not fill eroded channels with mulch. If possible, redirect flows around the establishing vegetation for 3 months. Inspect other areas around redirecting device (*i.e.* sandbag) to ensure that this redirection is not causing additional erosion. If plants receiving redirected flows are small or not very sturdy and erosion is or may occur, biobags (a sediment control measure, which is a bag with compost or shredded wood chips) will allow water to enter the vegetated filter strip slowly and may be a better way to prevent erosion than redirecting flows.

DISPERSION BMP: SUPPORTING INFRASTRUCTURE, LEVEL SPREADER

Pavement is often not as regular as it appears. Even very small dips and inconsistencies can concentrate sheet flow, forming channels and causing erosion. A level spreader will intercept runoff, slow it down, and spread it out. Level spreaders are most often used with vegetated filter strips but may be useful anywhere water flows overland into a landscape area to reduce erosion.

Siting

Install a level spreader between the contributing pavement area and the landscape area, such as the vegetated filter strip in Figure 4-110.

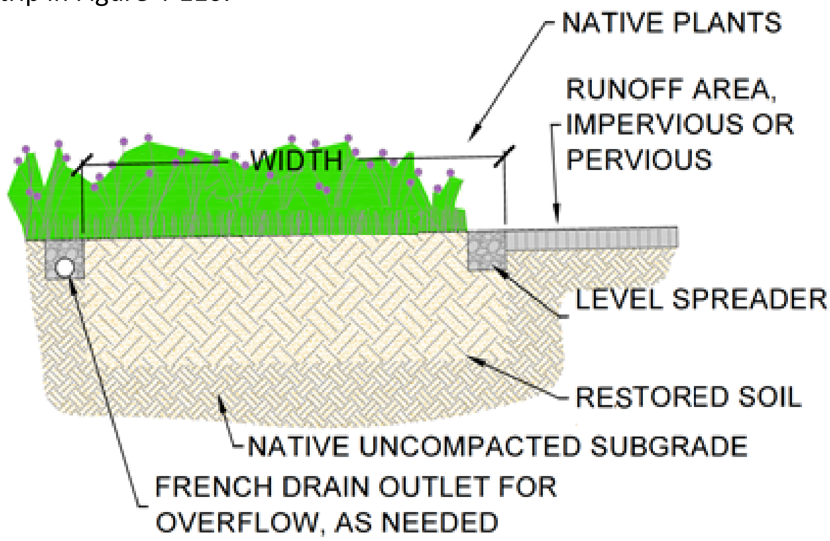


Figure 4-110. Cross section of a vegetated filter strip with level spreader.

Design

Design criteria for level spreaders are as follows:

- Include with all vegetated filter strips except on highways and roads where a gravel strip is proposed or already exists or on roads with gravel parking edges.
- Length = Match length of vegetated filter strip and impervious area.
- Width = 1 foot, Depth = 9 inches (This will ensure that the level spreader is wider than it is deep, avoiding a UIC.)
- Use crushed aggregate meeting the coarse aggregate specification in Appendix D: Specifications or any other open-graded (*i.e.* all the same or similar size) rock with a maximum diameter of 3 inches. Pea gravel or other rounded river rock is not recommended since it will not perform as well as angular rock in slowing flows.

- To encourage water to enter the level spreader and ensure that a mound of rock is not blocking inflows, set the elevation of the level spreader ¼ inch lower than the pavement, which meets ADA accessibility requirements.

Construction

Construction is as follows:

1. Excavate a 12-inch wide by 9-inch deep trench the entire length of the vegetated filter strip.
2. Lightly compact the soil in the area of the level spreader by tamping or boot compaction. Avoid mechanical compaction such as the use of a jumping jack or vibratory compactor, even small ones.
3. Place an impermeable liner vertically along the upstream side (pavement side, not landscape side) of the trench, overlapping the liner a few inches.
4. Place coarse aggregate in the trench.
5. Cut the excess liner to be level with finish (*i.e.* final) grade.

Maintenance

Specific maintenance activities are needed to ensure proper long-term function. Determine who is responsible for operations and maintenance and confirm early stakeholder buy-in of maintenance practices before determining the mix of BMPs. To do this, review and follow sections provided in this guidance:

- Detailed guidance provided for all LID sites in **Chapter 3** “*The LID Operations and Maintenance Process*”.
- Detailed guidance for BMPs in **Appendix B**: BMP Implementation Criteria, “*Maintenance*”.
- **Chapter 6**: Operations and Maintenance Agreement.

In high sediment areas, level spreaders will be high maintenance. Spreading water out so that it cascades over a level spreader instead of concentrating at a single point and causing erosion is difficult to achieve. While the level spreader design recommended here may be high maintenance, it will reduce problems with erosion and is an effective means of spreading out flows.

The main maintenance activity with a level spreader is keeping the rock clean, so that the rough edges of the angular rock remain exposed to the runoff and can slow and spread it. This slowing of runoff causes sediments to settle out and serves as pretreatment for the vegetated filter strip. To maintain a level spreader:

- Use a flat shovel, remove the rock to a depth of at least 6 inches. Install appropriate erosion control techniques (see the DEQ’s “Construction Stormwater Erosion and Sediment Control Manual[80]) such as biobags or wattles. Hose off the rock on a plastic tarp. Place the clean rock back and dispose of sediment and organic matter in trash destined for the landfill.
- Remove weeds twice a year if enough sediment accumulates to grow weeds but not enough accumulates to warrant cleaning the rock.
- Clean rock before the angular rock is completely buried in sediment. Frequency will depend on the type of pavement and if any uphill landscape areas draining across the pavement are stabilized. Roofs generally contribute the least amount of sediment, although roofs near highways will have more particulates deposited on their surface. Generally, for roads, sediment will increase with the number of cars on them. Lawns will contribute the highest volume of sediment, if they happen to be uphill of the pavement that drains to the vegetated filter strip.

[80] *Oregon Department of Environmental Quality. Water Quality Permit Program. Erosion and Sediment Control. Retrieved from: http://www.deq.state.or.us/wq/wqpermit/docs/general/npdes1200c/ErosionSedimentControl.pdf*

WET, EXTENDED WET, AND DRY DETENTION PONDS

BMP Overview			
Management Applications			
	YES	NO	N/A
Landscaped Area Management*			
Water Quality Management†			
Flow Control Management†			
Design Methods Possible			
	YES	NO	N/A
Simplified Sizing Approach			
Engineered Design Approach			
Infiltration Required			
	YES	NO	N/A
Is Infiltration Testing Required			
Design Information			
Title	**Form/Worksheet**		
LID Form	Form I		
Worksheet	N/A		
Drawings			
Title		**Detail**	
-		-	

* This BMP does not offer this type of management
† Applies when meeting requirements in Chapter 2

Ponds

Facility Description

Three types of ponds are described in this section: wet ponds, extended wet ponds, and dry ponds, all of which must be designed and submitted under the hydrologic modeling criteria in Appendix B and Chapter 2 to meet the site-specific stormwater requirements. The City encourages pond design to provide multipurpose benefits (e.g., parks, open space, or recreation facilities), provided that any alternative uses are compatible with the primary stormwater functions and maintenance standards.

Wet ponds are constructed with a permanent pool of water (commonly referred to as pool storage or dead storage). Stormwater enters the pond at one end and displaces water from the permanent pool. Pollutants are removed from stormwater through gravitational settling and biological processes. When criteria for the Engineered Design Approach (Chapter 2) are followed, water quality requirements are presumed to be met. Additional facilities may be required in order to meet flow control requirements, as applicable.

Extended wet ponds are also constructed with a permanent pool of water but have additional storage above that fills during storm events and releases water slowly over a number of hours. The permanent pool is sized to provide pollution reduction, and the additional storage above (extended detention area) is sized to meet flow control requirements. Pollutants are removed from stormwater through gravitational settling and biological processes. When criteria for the Engineered Design Approach (Chapter 2) are followed, water quality requirements are presumed to be met. The extended detention must be designed using acceptable hydrologic modeling techniques (see Appendix B and Chapter 2) to meet applicable flow control requirements**.**

Dry detention ponds are designed to fill during storm events and slowly release the water over a number of hours. Dry detention ponds must be designed using acceptable hydrologic modeling techniques (see Appendix B) to meet applicable flow control requirements. Additional facilities are required in order to meet water quality requirements, unless the bottom flow path of the pond is designed as a swale according to the swale sizing and design criteria.

Design, Siting, and Construction

Location and Ownership: All open ponds to be maintained by the City of Grants Pass must be located in a separate open space with storm drainage easements dedicated to the City. Open ponds serving more than one tax lot or designed to function as multiuse/ recreational facilities must be located in a separate, defined easement, or designated open space.

Instream ponds are not allowed.

Soil Suitability: Detention ponds are appropriate for sites with slow draining soils (less than 2”/hour tested) or for facilities that are fully lined. Sites with well-draining soils (at or over 2”/hour tested) should consider the use of other BMPs sized for water quality and quantity as shown in the BMP suitability matrix (Appendix G).

Setbacks: Ponds are typically constructed to maintain the following setback distances from structures and other facilities. (All distances are measured from the edge of the maximum water surface elevation.)

- Minimum distance from the edge of the pond water surface to property lines and structures: 20 feet, unless an easement with adjacent property owner is provided.
- Distance from the toe of the pond berm embankment to the nearest property line: one-half of the berm height (minimum distance of 5 feet).
- Minimum distance from the edge of the pond water surface to septic tank, distribution box, or septic tank drain field: 100 feet.
- Surrounding slopes must not exceed 10 percent. Minimum distance from the edge of the pond water surface to the top of a slope greater than 15 percent: 200 feet, unless a geotechnical report is submitted and approved by the City of Grants Pass.
- Minimum distance from the edge of the pond water surface to a well: 100 feet.

Access: Access routes to the pond for maintenance purposes must be shown on the plans. Public ponds must provide a minimum 12-footwide access route, not to exceed 10 percent in slope. An eight-foot wide access route is allowed with approval.

Sizing:

- Wet and extended wet detention ponds should be designed for large drainage areas (5 to 150 acres) to help avoid problems associated with long periods of stagnant water.

- For wet and extended wet detention ponds, a water budget must be submitted for review. The water budget must demonstrate that the base flow to the pond is sufficient such that water stagnation/algal matting will not become a problem.
- Wet and extended wet detention permanent pool sizing: The permanent pool (or dead) storage volume, V_{pond}, is equivalent to **twice** the runoff volume generated by a storm of 1.2-inches over 24-hours (NRCS Type 1A rainfall distribution).

Flow control for extended wet detention and dry detention ponds: To restrict flow rates exiting the pond to those required by Chapter 2, a control structure must be used. For extended wet detention ponds, this control structure must be located above the permanent pool elevation. The outlet orifice must be designed to minimize clogging.

Note: Because of minimum orifice size requirements (2 inches for public facilities, 1 inch for private facilities), detention facilities that rely on orifice structures to control flows for small projects (under 15,000 square feet of impervious development footprint area) are not allowed.

Control structure design: Weir and orifice structures must be enclosed in a catch basin, manhole, or vault and must be accessible for maintenance. The control structure must be designed to pass the 50-year storm event as overflow, without causing flooding of the contributing drainage area. The methods and equations for the design of flow-restricting control structures, for use with extended wet detention ponds, and dry detention ponds are below.

Orifices: Orifices may be constructed on a "tee" riser section. The minimum allowable diameter for an orifice used to control flows in a public improvement is 2 inches. Private facilities may use a 1-inch-diameter orifice if additional clogging prevention measures are implemented. The orifice diameter must always be greater than the thickness of the orifice plate.

Multiple orifices may be necessary to meet the 2- through 25-year design storm performance requirements for a detention system. However, extremely low flow rates may result in the need for small orifices (< 1 inch for private facilities, < 2 inches for public) that are prone to clogging. In these cases, retention facilities that do not rely on orifice structures must be used to the maximum extent practicable to meet the site-specific flow control requirements. Large projects may also result in high flow rates that necessitate excessively large orifice sizes that are impractical to construct. In such cases, several orifices may be located at the same elevation to reduce the size of each individual orifice.

Orifices must be protected within a manhole structure or by a minimum 18-inch thick layer of 1½- to 3-inch evenly graded, washed rock. Orifice holes must be externally protected by stainless steel wire screen (hardware cloth) with a mesh of ¾ inch or less. Chicken wire must not be used for this application.

Orifice diameter must be greater than or equal to the thickness of the orifice plate.

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

Orifice Sizing Equation:

$$Q = CA\sqrt{2gh}$$

where:
Q = Orifice discharge rate, cubic feet per second (cfs)

C = Coefficient of discharge, feet (suggested value = 0.60 for plate orifices)
A = Area of orifice, square feet
h = hydraulic head, feet
g = 32.2 ft/s^2

The diameter of plate orifices is typically calculated from the given flow. The orifice equation is often useful when expressed as an equivalent orifice diameter in inches.

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

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

Rectangular Notched Sharp Crested Weir:

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

where:
Q= Weir discharge, cfs
C = 3.27 + 0.40×H/P, feet
P = Height of weir bottom above downstream water surface, feet
H = Height from weir bottom to crest, feet
L = Length of weir, feet*
* For weirs notched out of circular risers, length is the portion of the riser circumference not to exceed 50 percent of the circumference.

V-Notched Sharp Crested Weir:

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

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

Dimensions and slopes: Slopes and depth should be kept as mild as possible to avoid safety risks. Slopes within the pond must not exceed 3 horizontal to 1 vertical. The maximum depth of the pond must not exceed 4 feet. The 0- to 2-foot depth must be distributed evenly around the perimeter of the pond.

The distance between all inlets and the outlet must be maximized to facilitate sedimentation. The minimum length-to-width ratio is 3:1, at the maximum water surface elevation. This ratio is critical to prevent “short-circuiting,” where water passes directly through the facility without being detained for any length of time. If area constraints make this ratio unworkable, baffles, islands, or peninsulas may be installed, with City approval, to increase the flow path and prevent short circuiting.

Minimum freeboard must be 1 foot above the highest potential water surface elevation (1 foot above the emergency overflow structure or spillway elevation).

Dry detention ponds must be divided into a minimum of two cells. The first cell (forebay) must contain approximately 10 percent of the design surface area and must provide at least 0.5 foot of dead storage for sediment accumulation.
Wet and extended wet detention ponds must be divided into a minimum of two cells. The first cell (forebay) must contain approximately 10 percent of the design surface area.

Outlet/overflow: If a riser pipe outlet is used, it must be protected by a trash rack and anti-vortex plate. If an orifice plate is used, it must be protected with a trash rack with at least 10 square feet of open surface area. In both cases, the rack must be hinged or easily removable to allow for cleaning. The rack must be adequately secured to prevent it from being removed or opened when maintenance is not occurring.

All ponds must have an emergency overflow spillway or structure designed to convey the 50-year, 24-hour design storm for post-development site conditions, assuming the pond is full to the overflow spillway or structure crest. The overflow must be designed to convey these extreme event peak flows around the berm structure for discharge into the downstream conveyance system. The overflow must be designed and sited to protect the structural integrity of the berm. This will ensure that catastrophic failure of the berm is avoided, property damage is avoided, and water quality of downstream receiving water bodies is protected. The subgrade of the spillway must be set at or above the 50-year overflow elevation of the control structure. The spillway must be located to direct overflows safely toward the downstream conveyance system and must be located in existing soil wherever feasible. The emergency overflow spillway must be armored with riprap or other flow-resistant material that will protect the embankment and minimize erosion. Riprap must extend to the toe of each face of the berm embankment. The emergency overflow spillway weir section must be designed for the maximum design storm event for post-development conditions, using the following formula:

$$L = \frac{Q_{50}}{3.21H^{1.5}} - 2.4H$$

where:
L = Length of bottom of weir, feet
Q_{50}= 50-year post-development flow rate, cfs
H = Height of emergency overflow water surface, feet

Berm embankment/soil stabilization: Pond berm embankments must be designed by a licensed engineer. Pond berm embankments must be constructed on native consolidated soil (or compacted and stable fill soil) that is free of loose surface soil materials, roots, and other organic debris. Topsoil is required over the consolidated soil to support required plantings. Pond berm embankments must be constructed by excavating a key equal to 50 percent of the berm embankment cross-sectional height and width, measured through the center of the berm. The berm must be keyed into the native soil by excavating a trench below the berm. This keys the berm into the native soil and prevents it from sliding. The berm embankment must be constructed of compacted soil (95 percent maximum dry density, Modified Proctor Method per ASTM D1557) placed in 6- to 8-inch lifts with hand-held equipment, or 10- to 12-inch lifts with heavy equipment. Anti-seepage collars must be placed on outflow pipes in berm embankments that impound water greater than the designed depth of the pond. During construction, exposed earth on the pond side slopes must be seeded with appropriate seed mixture. Establishment of protective vegetative cover must be ensured with appropriate surface-protection best management practices (BMPs) and reseeded as necessary.

Pond embankments must be constructed with a maximum slope of 3H: 1V on the upstream and downstream face. Side slopes within the pond must be sloped no steeper than 3H: 1V. The use of retaining walls in ponds requires preapproval from the City of Grants Pass. Retaining walls must not exceed one-third of the circumference of the pond.

Detailed structural design calculations must be submitted with every retaining wall proposal.

Pond berm embankments 6 feet or less in height (including freeboard), measured through the center of the berm, must have a minimum top width of 6 feet, or as recommended by a geotechnical engineer.

Where maintenance access is provided along the top of berm, the minimum width of the top of berm must be 15 feet.

Growing medium: Because pond grading generally requires the topsoil to be removed to form the basin shape of the pond, the resulting top layers of soil must to be amended, or topsoil must be brought back in to ready the soil for planting. Topsoil must be used within the top 12 inches of the facility, or the soil must be amended to support plant growth.

Vegetation: The planting design must minimize solar exposure of open water areas. Trees or other appropriate vegetation must be located around the east, south, and west sides of the facility to maximize shading. Reducing solar exposure has two benefits: it helps reduce heat gain in water before discharging to a receiving water, helping it maintain a healthy and aesthetic pond condition, reducing algae blooms and the potential for anaerobic conditions to develop. The facility area is equivalent to the area of the pond, including bottom and side slopes, plus the 10-foot buffer around the pond. The emergent plant zone must be at least 25 percent of the total pond water surface area. Minimum plant material quantities are shown in tables below.

Table 4-8. Pond Vegetation – Emergent Plants

Number of Plants	Vegetation Type	Per square feet	Size	Spacing Density (on center)
115	Wetland plants	100	6” plugs	1’
OR				
100	Wetland plants	100	6” plugs	1’
4	small shrubs	100	#1 container	3’
OR				
100% seed coverage				

Table 4-9. Pond Vegetation – Side Slopes and Buffers

Number of Plants	Vegetation Type	Per square feet	Size	Spacing Density (on center)
1	Evergreen tree	300	Min 6’ height	
OR				
1	Deciduous tree	300	1 ½“ caliper at 6” above base	
AND				
4	Large shrubs	100	#3 container	4’

Wildflowers, native grasses, and groundcovers used for City-maintained facilities must not require mowing. Where mowing cannot be avoided, facilities must be designed to require mowing no more than once or twice annually. Turf and lawn areas are not allowed for City-maintained facilities; any exceptions require City approval.

For plant specifications, see **Appendix E**.

Fencing: Fences are required for all City-maintained ponds with a permanent or temporary pool greater than 18 inches deep, interior side slopes steeper than 3H: 1V, or any walls/bulkheads greater than 24 inches high. The design must address screening requirements for fencing. Fencing for privately owned facilities is at the discretion of the owner. The owner may use the criteria for City-maintained facilities.

For both private and City-maintained facilities where fencing is used, fences must be at least 6 feet high. The six-foot height may not be required in situations where fences are not needed to prevent climbing (e.g., on steep slopes where they are needed to prevent slipping). For City-maintained facilities, a minimum of one vehicular locking access gate must be provided. It must be 12 feet wide, consisting of two swinging sections each six feet wide. At least one pedestrian gate must be provided, with a minimum four-foot width.

Fencing materials must be complementary to the site design.

CHAPTER 5: IMPLEMENTING LID, STEP-BY-STEP

TABLE OF CONTENTS

CHAPTER 5: IMPLEMENTING LID, STEP-BY-STEP

LID IMPLEMENTATION FORM OVERVIEW

The LID Implementation Form is a step-by-step method, for implementing LID by applying BMPs in a meaningful hierarchy across the site. This approach to managing stormwater reminds designers to blend a variety of practices in the order that they should be considered, since a single BMP will not achieve a key goal of LID implementation, which is to mimic predevelopment hydrology.

Requirements

- The LID Implementation Form should be completed at the very beginning of the project, during the site planning phase and re-visited by the designer(s) detailing the construction plan set.
- If the Simplified Sizing Approach is used to design BMPs, All LID Forms must be submitted for the permit application package which includes:
  - Project Summary Form.
  - LID Forms A through C once.
  - LID Forms D through J for each basin.
  - For each BMP, submit relevant Worksheet.
  - Refer to Chapter 3 "*Permit Application Package Requirements for All Projects*" for further requirements.
- If Engineered Design Approach is used to design BMPs, LID Forms and worksheets are not required, but the permit application package should include the following in addition to a drainage report:
  - Information on project summary form.
  - Any sizing factors used to design BMPs on site.
  - Refer to **Chapter 3** "*Permit Application Package Requirements for All Projects*" for further requirements.

Stormwater Management Hierarchy

Choose BMPs based on their ability to mimic pre-development hydrology following the preferred hierarchy:

1. Lay out the site to minimize impacts to natural resources and to minimize impervious areas.
2. Prevent runoff by intercepting, evaporating, and/or infiltrating rainfall.
3. Reduce runoff using BMPs with surface storage (*i.e.* ponding) that infiltrate and to a lesser extent, intercept and evaporate runoff and the rainfall they receive.
4. Reduce runoff using BMPs with underground storage that infiltrate runoff.
5. Reduce runoff using flow-based BMPs without storage (*i.e.* conveyance) that infiltrate lower volumes and to a lesser extent, intercept and evaporate runoff and the rainfall.
6. If the first five choices are not feasible, then the only remaining LID choice is to improve the water quality of runoff, without significantly reducing the volume, using a lined BMP or proprietary device. This is not preferred. (See **Chapter 1** "*Why Use Low Impact Development*", "*Protecting Water Quality by Addressing Water Quantity*").
7. To manage stormwater water quality and flow control on larger sites (**Chapter 4**, "*Wet, Extended Wet, and Dry Detention Ponds*"), a Wet Pond, Extended Wet Pond, and Dry Detention Pond can be used when LID facilities are not sufficient. It is recommended the designer considers steps 1-6 before using Ponds, especially in sites with higher infiltration rates.

This form assumes that:

- The LID process, as outlined in **Chapter 3**, has been or will be applied throughout the planning, design, construction, and maintenance phases.
- The detailed implementation information provided in **Chapter 4** and **Appendix B** has been used to determine site suitability, develop detailed designs, and guide construction and maintenance activities for each BMP.

“Managed Area” Approach

Start the LID Implementation Form by separately entering the proposed landscape and hardscape drainage areas. As BMPs are applied to either proposed landscape or hardscape drainage areas, those areas are considered “managed areas”. BMPs are applied for water quality and flow control until all drainage area is managed. The area for the runoff reduction facility itself is considered managed area for the rainfall it receives within its own footprint.

Cost Savings Approach

The LID Implementation Form encourages using runoff prevention BMPs first. When these opportunities are exhausted, the remaining drainage area to be managed will likely be smaller, making the site development more cost-effective by causing the remaining, costlier runoff reduction BMPs to be smaller.

Area Managed and Sizing Factors

A sizing factor simplifies the complex hydrologic modeling that is often needed to implement BMPs and is used to size a BMP relative to the area it manages.
IMPORTANT! Sizing factors are specific to The City of Grant Pass, because they were created based on hydrologic modeling that considers the appropriate storm type distribution, storm size, land cover, and more to determine these values or were adapted based on experience.

Runoff prevention BMPs. To calculate the area managed for runoff prevention BMPs, a multiplier may be applied to the BMP/drainage area to increase (*e.g.* 1.5), decrease (*e.g.* 0.5), or leave it unchanged (*e.g.* 1.0).

Figure 5-1. Example runoff prevention BMPs applied to a single-family home:

- *Minimize Building Footprint (with a two-story house, impervious area reduced)*
- *Minimize Front Setbacks (impervious area reduced)*
- *Vegetated Roof BMP (50% prevented, 50% runoff)*
- *Restored Soils to lawn BMP (100% managed)*
- *Porous Pavement (Rainfall) BMP (100% prevented)*

Runoff reduction BMPs. For runoff reduction BMPs, the area of the BMP is always smaller than the drainage area. Sizing factors may be used to size the area/footprints of rain gardens, stormwater planters, LID swales, and soakage trenches. Other runoff reduction BMPs use alternative methodologies, which may be sized through worksheets (vegetated filter strips, downspout disconnection) and via hydrologic modeling provided by a licensed engineer (See **Chapter 2**).

Figure 5-2. In this runoff reduction example, the vegetated roof is the only surface generating runoff, so this is directed to a rain garden. Other surfaces, per Figure 5-1, don't generate runoff (i.e. porous pavement) or are assumed to not generate runoff (i.e. restored soils). The approach for this site would satisfy the requirements of the LID Implementation Form.

Terminology

A few terms are used consistently throughout the form:

- A "basin" is a site-scale area that runoff flows over. It is defined by the site grading plan and may be influenced by the project boundary, building roof designs, and other elements that runoff flows over. A site may be designed to have more than one basin (***Figure 5-3***).
- A "drainage area" is the area that is either encompassed by a rainfall BMP or directed to a runoff BMP.
- "Landscape" drainage areas include protected forests or single trees and any type of proposed landscape surface (*e.g.* lawn, perennial, meadow, shrubs, forests, etc).
- "Hardscape" drainage areas include any pavement or roof and may include porous pavements.
- "Impervious" drainage areas include any pavement or roof but do not include porous pavements. Above ground pools are also considered impervious. The area of in-ground pools with an overflow to the sanitary sewer system need not be entered at all. These systems may generate runoff, but since it doesn't flow to the storm system, it does not have the potential to pollute downstream waterways.

Number of Forms per Project

The number of forms may vary by project (***Figure 5-4***).

LID Implementation Form, Sections A, B, and C. The BMPs in these sections apply to the entire site. Complete Sections A, B, & C only once per project.

LID Implementation Form, Sections D through J. BMPS in Sections D though H apply to basins. Complete Sections D through Section J as follows:

- For a site with multiple basins or where proposed grades slope to create multiple basins, include these sections from the LID Implementation Form for each basin.
- For other simpler sites, a single set of LID Implementation Forms may be all that's needed.

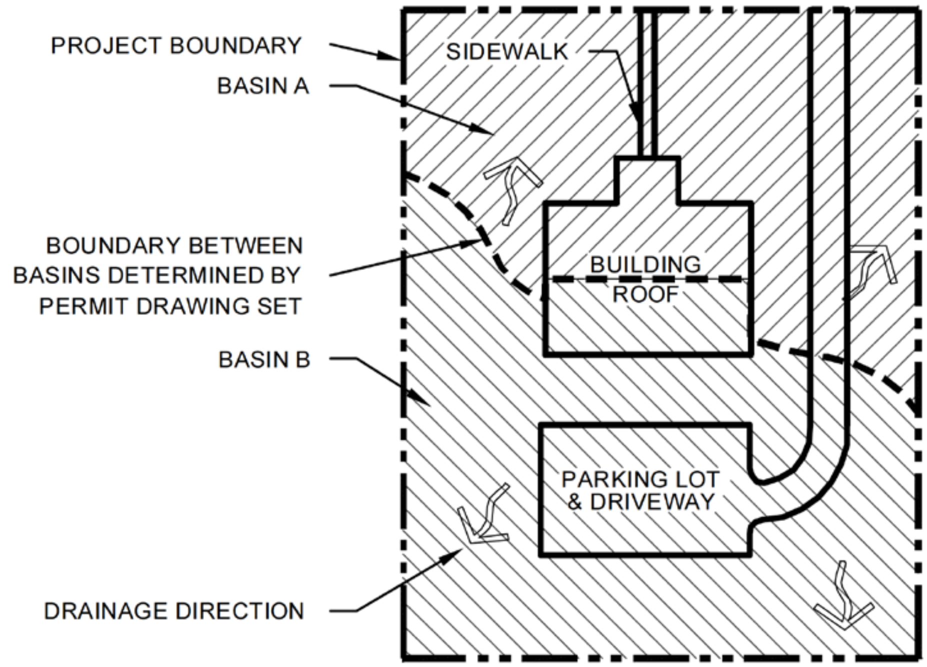


Figure 5-3. This is an example of a typical development with two basins, Basin A and Basin B, separated by a ridge created by the final grading plan and the roof slope and downspout design. (BMPs not shown.) This project would use two LID Implementation Forms (see "Completing the LID Implementation Form (Overview & Example)" below).

Worksheets. Some BMPs have additional worksheets to ensure that key steps have been performed, to help size facilities, and/or to determine the area managed. Complete the worksheets for each BMP at the site. For instance, if there are two infiltration rain gardens, then complete two versions of the "F1 Infiltration Rain Garden & LID Swale BMP Worksheet".

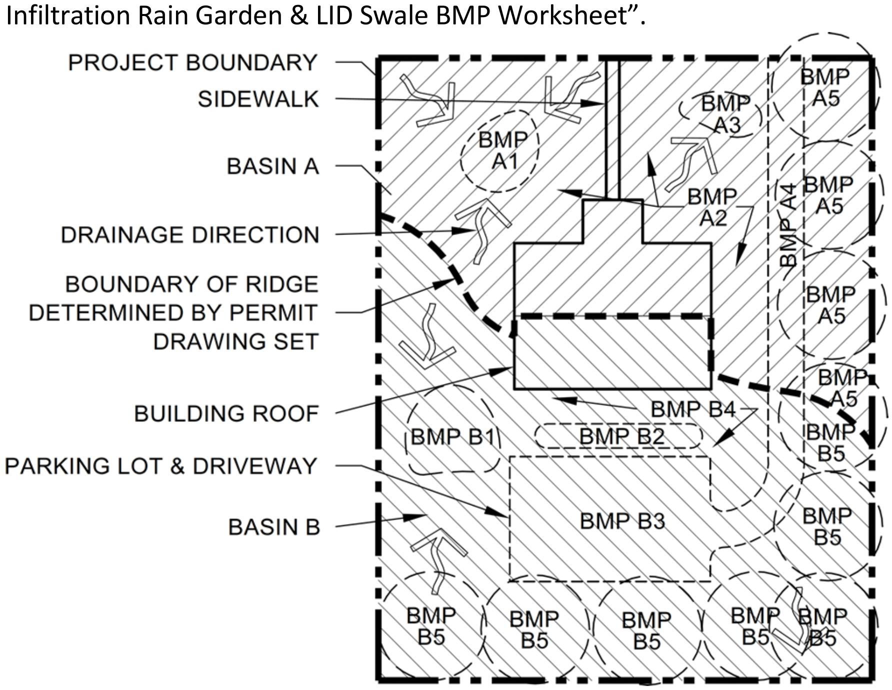


Figure 5-4. In this example, complete the worksheets as follows:

BMP:	Area Managed:	Assuming this BMP is a:	Complete Worksheet:	Worksheet Instructions:
Basin A (Complete Sections A – J of first LID Implementation Form.)				
BMP A1	Left, front portion of building roof and landscape	Rain Garden BMP	F1	Size the footprint of the rain garden and enter the area managed on the LID Implementation Form.
BMP A2	Landscape area	Restored Soil BMP to Lawn	N/A	
BMP A3	Right, front portion of building roof, sidewalk & landscape	Rain Garden BMP	F1	Size the footprint of the rain garden and enter the area managed on the LID Implementation Form.
BMP A4	Driveway	Porous Pavement (Rainfall) BMP	C1	Determine the depth of base rock needed to infiltrate the design storm.
BMP A5	Landscape area	Tree Planting (Landscape, Evergreen) BMP	B1	Complete a single worksheet for all trees in Basin A and enter total area managed on the LID Implementation Form.
Basin B (Complete Sections B – J of second LID Implementation Form.)				
BMP B1	Left, back portion of building roof and landscape	Rain Garden BMP	F1	Size the footprint of these facilities. Sum the area managed found by both of these worksheets and enter area on a single line on the LID Implementation Form.
BMP B2	Right, back portion of building	LID Swale BMP	F1	
BMP B3	Driveway & parking lot	Porous Pavement (Rainfall) BMP	C1	Determine the depth of base rock needed to infiltrate the design storm.
BMP B4	Landscape area	Restored Soil to Garden BMP	N/A	
BMP B5	Landscape area	Tree Planting (Landscape) BMP	B1	Complete a single worksheet for all trees in Basin B and enter total area managed on the LID Implementation Form.

COMPLETING THE LID IMPLEMENTATION FORM (OVERVIEW & EXAMPLE PROJECT)

This section provides an overview of some of the most important points to consider when using the LID Implementation Form to create an LID site and to size BMPs. The example plans and completed form images are based on Basin A only in ***Figures 5-3*** and ***5-4***. Detailed instructions for steps can be found in "*Instructions for Selected Steps in the LID Implementation Form and Associated Worksheets*" below.

A. Create Site Layout & LID Strategy (Entire Site)

Form Steps 1 - 9 (Prevent Runoff): Layout site to protect natural resources and reduce impervious surfaces.

- Section A is for the entire project site. Complete this section once per project.
- Assess your site including testing the infiltration rate of soil throughout the site.
- Chapter 5 walks through the form.
- EXAMPLE: Create a preliminary map of the proposed site plan to help define the strategy and find drainage areas.

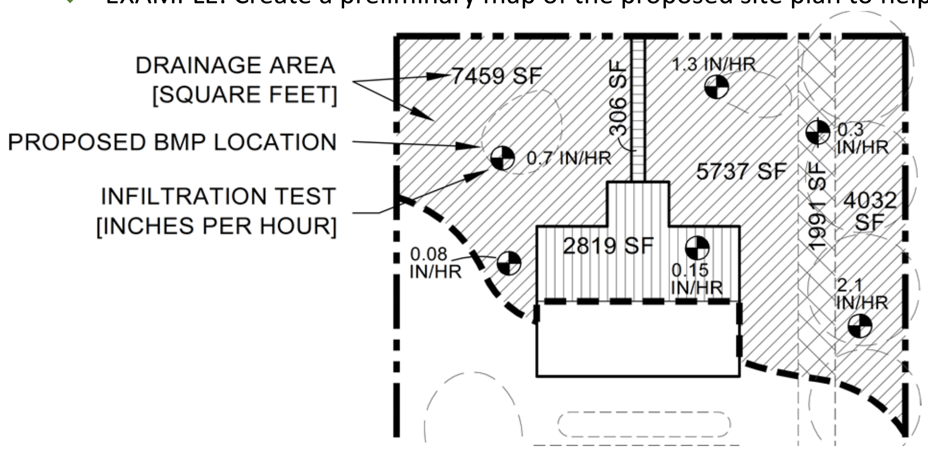


Figure 5-5. EXAMPLE PROJECT: Using the example from Figures 5-3 and 5-4, Basin A map showing drainage areas and testing locations and infiltration rates. Areas with low infiltration rates have impervious surfaces and porous pavement. Areas with higher infiltration rates have infiltration BMPS or are planted with trees. To complete the LID Implementation Form, similar information would have to be determined for Basin B so that the entire site can be considered.

Table 5-1. EXAMPLE PROJECT: Complete Section A of the LID Implementation Form for the entire site (i.e. Basins A & B shown in Figures 5-3 and 5-4, not just Basin A, shown in Figure 5-5).

Minimize Impervious Area	Incorporated	Not Feasible	Not Applicable	Justification if not incorporated
These practices reduce the drainage area to be managed in Runoff BMPs below and reduce stormwater management costs (and some of them also reduce overall project costs). If not incorporated, provide justification.				
1. **Shared parking spaces BMP**	x			
2. **Minimize Front Setbacks BMP**	x			
3. **Share a Driveway BMP**		x		No neighbors to share driveway with.
Limit Disturbance				
4. **Construction Sequencing BMP**	x			
5. **Conserve Fast(er) Draining Soils BMP**	x			

B. Prevent Runoff from Landscape Areas (Entire Site)

Form Step 6: Enter the total landscape area for the entire project site.
Form Steps 7-10: Enter area managed by:

- Cluster Development BMP
- Tree Protection BMP
- Tree Planting (Evergreen & Deciduous) BMP
- Restored Soils BMP

Form Step 11: Add all the landscape areas managed.
Form Step 12: Confirm all landscape areas have been managed by comparing Step 6 and Step 12.

- Section B is for the entire project site. Complete this section once per project.
- All landscape areas have been managed. The rest of the form sections apply only to hardscapes.

Table 5-2. EXAMPLE PROJECT: Complete Section B of the LID Implementation Form for BMPs A2 and A5 in Basin A (shown). A completed Section B for BMPs B4 and B5 in Basin B is also needed (not shown).

B. PREVENT RUNOFF FROM LANDSCAPE AREAS (ENTIRE SITE)

Definitions for entering areas for the rest of the form are as follows:
• Landscape drainage areas include protected forests or single trees and any type of proposed landscape surface (lawn, garden, meadow, shrubs, forests, etc)
• Hardscape drainage areas include any pavement or roof and may include porous pavements.
• Impervious drainage areas include any pavement or roof but do not include porous pavements or above ground pools. (The area of in-ground pools with an overflow to the sanitary sewer system need not be entered at all.)

Additional Instructions

6. Enter Landscape Drainage Area. Enter total drainage area of landscape surfaces for the entire site. | 17,228 | **square feet** | Apply at least one BMP to landscape areas until no landscape area is left unmanaged.

Limit Disturbance of Protected Landscape Areas

Apply these BMPs to landscape areas that will be protected in their natural current or restored state in the proposed development. These reduce the amount of impervious area to be managed in Runoff BMPs below and reduce stormwater management costs (and some of them also reduce overall project costs).

		Area Managed Equation					Area Managed	
7.	Cluster Development BMP. Enter natural landscape areas protected from all development impacts in first box and multiply by value shown to calculate area managed	= 1.00	x	0	square feet of BMP	=	0	square feet
8.	Tree Protection BMP. Enter area of tree canopy farther than 10 feet from an impervious area and properly protected from all development impacts, in first box and multiply by value shown to calculate area managed.	= 1.5	x	0	square feet of BMP	=	0	square feet

Prevent Runoff from Developed Landscape Areas

Apply these BMPs to any proposed landscape areas where disturbance has taken place. These reduce the amount of runoff to be managed in Runoff BMPs below.

		Area Managed Equation					Area Managed	
9.	Tree Planting BMP (Landscape). Enter the landscape area managed with trees.	= Complete worksheet B1. Tree Planting BMP (Landscape) to find area managed.				=	4,032	square feet
10.	Restored Soils BMP. Enter area of newly disturbed or existing landscape to be restored and planted with perennial flowers, shrubs, grasses, and grass-likes in first box and multiply by value shown to calculate area managed.	= 1.00	x	13,196	square feet of BMP	=	13,196	square feet
11.	**SECTION B AREA MANAGED SUBTOTAL: Calculate landscape areas managed with runoff prevention BMPs = Step 7 + Step 8 + Step 9 + Step 10**					=	17,228	square feet
12.	Is Step 11 equal to or greater than Step 6? If TRUE, then yes. If FALSE, then manage landscape areas until TRUE.					=	TRUE	

=7,459+5,737

Table 5-3. EXAMPLE PROJECT: To determine the value in Step 9, complete Worksheet B1 of the LID Implementation Form for BMP A5 in Basin A (shown). A completed Worksheet B1 for BMP B5 in Basin B is also needed (not shown).

WORKSHEET B1. TREE PLANTING (LANDSCAPE AREA) BMP WORKSHEET

Use this Worksheet to determine:
1. The maximum landscape area that may be managed with newly planted/proposed trees.
2. The landscape area managed by trees that may be entered on the LID Implementation Form for both deciduous and evergreen trees.

a	**In Basin:**		**A**					
b	See Chapter 4 Tree Planting BMP under Siting. Are all conditions met (especially soil volume) to plant tree(s) in a location where the tree(s) can grow to full maturity? If Yes, continue to Step c. If No, then this location is unsuitable for newly planted trees, so enter 0 in Step 9 of the LID Implementation Form.		Yes	Enter Yes or No				

Determine available proposed canopy of evergreen trees to manage landscape areas:

Evergreen (Landscape). Calculate the total mature canopy for multiple evergreen trees to manage landscape area runoff. (If desired, trees within 10 feet of impervious areas may be used to prevent runoff from hardscape, using Worksheet E1 instead.)

c	Small Canopy (for trees with small mature canopy area spreads, which include small trees and many trees with upright canopies, tree canopy diameter is about 20 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	315 square feet	x		# of small proposed trees	= 0	square feet
d	Medium Canopy (for trees with medium mature canopy area spreads, tree canopy diameter is about 25 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	490 square feet	x		# of med proposed trees	= 0	square feet
e	Large Canopy (for trees with large mature canopy area spreads, tree canopy diameter is about 30 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	700 square feet	x	4	# of large proposed trees	= 2800	square feet
f	Calculate available proposed evergreen canopy = Step c + Step d + Step e						2800	square feet
g	Calculate landscape area that could be managed by proposed evergreen trees = Step f x value shown.	=	1.50	x	2800	square feet	= **4200**	**square feet**

Determine available proposed canopy of deciduous trees to manage landscape areas:

Deciduous (Landscape). Calculate the total mature canopy for multiple trees. Enter only decidous trees to manage landscape area runoff. (Trees within 10 feet of impervious areas may be used to prevent runoff from hardscape, if desired. Use Worksheet E1 instead.)

h	Small Canopy (for trees with small mature canopy area spreads, which include small trees and many trees with upright canopies, tree canopy diameter is about 20 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	315 square feet	x		# of small proposed trees	= 0	square feet
i	Medium Canopy (for trees with medium mature canopy area spreads, tree canopy diameter is about 25 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	490 square feet	x		# of med proposed trees	= 0	square feet
j	Large Canopy (for trees with large mature canopy area spreads, tree canopy diameter is about 30 feet). Enter number of trees in first box and multiply by assumed canopy area.	=	700 square feet	x		# of large proposed trees	= 0	square feet
k	Calculate available proposed deciduous canopy = Step h + Step i + Step j						0	square feet
l	Calculate landscape area that could be managed by proposed deciduous trees = Step k x value shown.	=	1.00	x	0	square feet	= **0**	square feet
m	Calculate the total landscape area managed by proposed evergreen and deciduous trees = Step g + Step l						= **4200**	square feet

Determine area managed to enter on LID Implementation Form:

n	Enter the actual landscape area where trees will be planted.	=	4032	square feet
o	Enter the smaller of the values in Step m and Step n. Enter this value on the LID Implementation Form, Step 9 under the Area Managed column.	=	4032	**square feet**

C. Prevent Runoff from Hardscape Areas (Entire Site)

Steps 13-15: Enter area managed by:

- Depave Existing Pavement BMP
- Limit Disturbance: Minimal Excavation Foundations BMP
- Porous Pavement (Rainfall) BMP

Form Step 16: Add up all the hardscapes managed.

- BMPs in this section are assumed to have no runoff.

Table 5-4. EXAMPLE PROJECT: Complete Section C of the LID Implementation Form for BMP A2 in Basin A (shown). A completed Section C for BMP B4 in Basin B is also needed (not shown).

C. PREVENT RUNOFF FROM HARDSCAPE AREAS (ENTIRE SITE)									
13.	Depave Existing Pavement BMP. Enter area of existing impervious pavement that will be removed to become landscape area with trees in first box and multiply by value shown to calculate area managed.	=	1.00	x	0	square feet of BMP	=	0	square feet
14.	Limit Disturbance: Minimal Excavation Foundations BMP. Enter area of roof without a basement below it in first box and multiply by value shown to calculate area managed.	=	1.00	x	0	square feet of BMP	=	0	square feet
15.	Porous Pavement (Rainfall) BMP. Enter area of porous pavement that manages ONLY the rainfall it receives in first box and multiply by value shown to calculate area managed. Requires licensed engineer for design.	=	1.00	x	1,990	square feet of BMP	=	1,990	square feet
16.	**SECTION C AREA MANAGED SUBTOTAL: Calculate hardscape areas managed with runoff prevention BMPs = Step 13 + Step 14 + Step 15**						=	1,990	square feet

D. Calculate Total Remaining Hardscape Drainage Area to Be Managed (basin)

Form Steps 17-19: Enter the number of basins (i.e. when the direction of flow splits into different directions) where development will take place and which basin is being addressed by Sections D – I of the LID Implementation Form. Enter the remaining hardscape area.

- GOAL! Manage all the runoff from hardscape areas for the given design storm.
- This section and the rest of the form apply only to a single basin. Complete an LID Implementation Form for each basin.

Table 5-5. EXAMPLE PROJECT: Complete Section D of the LID Implementation Form for Basin A (shown) and Basin B (not shown).

D. CALCULATE TOTAL REMAINING HARDSCAPE DRAINAGE AREA TO BE MANAGED (BASIN A)			
17. Enter the number of basins on this project.	2	LID Imp Forms	If more than one, complete an LID Implementation Form, Sections D through J for each basin, which is defined in instructions in Chapter 5.
18. Enter the basin addressed by this LID Implementation Form, Sections D through J.	A		Assign a letter or other designation to each basin as required in Chapter 3 "The LID Design Process", "Permit Drawing Requirements for All Projects".
19. Enter Remaining Impervious Drainage Area. Enter total drainage area of existing (to remain) and proposed hardscape surfaces in BasinA not already managed in Section C.	= 2819 + 306 3,125	square feet	Apply BMPs below applicable to hardscape areas until no area is left unmanaged.

E. Prevent Runoff from Impervious Areas (Basin)

Form Steps 20-20: Enter the area managed by:

- Contained Planters BMP
- Vegetated Roofs (Green Roofs) BMP
- Tree Protection BMP
- Tree Planting BMP

Form Step 23: Add all the hardscape areas managed in Section C. Remaining runoff is directed to individual BMPs in the worksheets for Sections E (preferred) and G.

- BMPs in this section have some runoff, which will be directed to a runoff reduction BMP in subsequent steps.

Table 5-6. EXAMPLE PROJECT: Complete Section E of the LID Implementation Form for Basin A (shown). A completed Section E for Basin B is also needed (not shown). The example project has none of these BMPs, so enter zeros, as shown.

E. PREVENT RUNOFF FROM IMPERVIOUS AREAS (BASIN A)									
	These Runoff Prevention BMPs for hardscapes only partially reduce runoff. Direct remaining runoff to a (preferably Runoff Reduction) BMP in subsequent sections.		**Area Managed Equation**					**Area Managed**	
20.	Contained Planter(s) BMP and Vegetated Roofs (Green Roofs) BMP. Enter area where these BMPs are placed over impervious drainage areas in first box and multiply by value shown to calculate area managed.	=	0.50	x	0	square feet of BMP	=	0	square feet
21.	Limit Disturbance: Tree Protection BMP (Impervious). Enter impervious area to be managed by the canopy of existing trees in first box and multiply by value shown to calculate area managed.	=	0.50	x	0	square feet of BMP	=	0	square feet
22.	**Tree Planting BMP (Impervious). Enter impervious area to be managed by trees planting within 10 feet of impervious area.**		Complete worksheet E1. Tree Planting BMP (hardscape) to determine total area managed.					**0**	square feet
23.	**SECTION D AREA MANAGED SUBTOTAL: Calculate hardscape area managed using BMPs that Prevent Runoff = Step 20 + Step 21 + Step 22**						=	**0**	**square feet**

F. Reduce Runoff from Hardscape Areas (Basin)

Form Steps 24-31: Direct remaining runoff to Runoff Reduction BMPs:

Most Preferred:

- Porous Pavement (Runoff) BMP
- Infiltration Rain Garden or LID Swale BMP (Worksheet F1)
- Infiltration Stormwater Planter BMP (Worksheet F2)
- Soakage Trench BMP (Worksheet F3)
- Drywell BMP

Less Preferred:

- Water Quality Conveyance Swale BMP
- Dispersion: Vegetated Filter Strip BMP (Worksheet F4)
- Dispersion: Downspout Disconnection BMP (Worksheet F5)
- ❖ Complete worksheets for each facility to determine the footprint/size or engage a licensed engineer to implement BMPs that have no worksheets (see Chapter 2).

Form Step 32: Calculate area managed by Runoff Reduction BMPs.

- ❖ **HINT! If all runoff from hardscape areas for the given design storm has been managed, skip ahead to Section H.**

Table 5-7. EXAMPLE PROJECT: Complete Section F of the LID Implementation Form for BMPs A1 and A3 in Basin A (shown). A completed Section E for BMPs B B1 and B2 in Basin B is also needed (not shown).

F. REDUCE RUNOFF FROM HARDSCAPE AREAS (BASIN A)

Size Facilities to Infiltrate (Higher Volumes of) Runoff

24.	Porous Pavement (Runoff) BMP. Enter the impervious area managed with porous pavement.	Porous Pavement (Runoff) BMP must be sized by a licensed engineer.		square feet
25.	Infiltration Rain Garden or LID Swale BMP. Enter the area managed with a rain garden or LID swale.	Complete worksheet F1. Infiltration Rain Garden or LID Swale BMP to size BMP.	3,125	square feet
26.	Infiltration Stormwater Planter BMP. Enter the area managed with a stormwater planter.	Complete worksheet F2. Infiltration Stormwater Planter BMP to size BMP.		square feet
27.	Soakage Trench BMP. Enter the area managed with a soakage trench.	Complete worksheet F3. Soakage Trench to size BMP.		square feet
28.	Drywell BMP. Enter the remaining area managed with a drywell.	Drywells must be sized by a licensed engineer.		square feet

Size Facilities to Infiltrate (Lower Volumes of) Runoff with Flow-Based BMPs

If opportunities for all other BMPs have been exhausted, a flow-based facility may be implemented. The BMPs are listed below in the order of most preferred first (WQ Conveyance Swale) to least preferred (Downspout Disconnect).

29.	Water Quality Conveyance Swale BMP. Enter the area managed with a water quality conveyance swale.	Water quality conveyance swales must be sized by a licensed engineer.		square feet
30.	Dispersion: Vegetated Filter Strip (VFS) BMP. Enter the area managed with a vegetated filter strip.	Complete worksheet F4. Dispersion: Vegetated Filter Strip BMP to size BMP.		square feet
31.	Dispersion: Downspout Disconnection BMP. Enter the area managed with a disconnected downspout.	Complete worksheet F5. Dispersion: Downspout Disconnection BMP to determine site suitability.		square feet

32.	**SECTION F AREA MANAGED SUBTOTAL: Calculate remaining area managed using BMPs that Reduce Runoff = Step 24 + Step 25 + Step 26 + Step 27 + Step 28 + Step 29 + Step 30 + Step 31**	=	3,125	square feet

Table 5-8. EXAMPLE PROJECT: Complete Worksheet F1 for the rain gardens in Basin A (BMP A1 shown in this table, BMP A3 shown in Table 5-10) and rain garden (BMP B1) and LID swale (BMP B2) in Basin B (not shown).

WORKSHEET F1. INFILTRATION RAIN GARDEN & LID SWALE BMP WORKSHEET

For multiple rain gardens or LID swales, complete this worksheet as many times as needed, add the values in Step h from all F1 worksheets and enter this total on the LID Implementation Form. Use this Worksheet to:
1. Confirm site suitability for infiltration of runoff using rain gardens of LID swales.
2. Determine the top elevation area of a single rain garden or LID swale.

a	**Rain Garden or LID Swale Designation:**	**A3**					
b	**In Basin:**	**A**					

Confirm suitability for infiltration of runoff:

c	See Chapter 4 Vegetated Stormwater Facilities under Siting. Are all conditions met to safely infiltrate runoff from other surfaces? If Yes, continue to Step d. If No, then site is unsuitable for vegetated stormwater facilities. Skip to Step 28 of the LID Implementation Form to investigate the possibility of using a drywell.	Yes	Enter Yes or No
d	Enter tested design infiltration rate, ideally performed within the footprint of the vegetated stormwater facility. If the infiltration rate is less than 0.5 inch/hour, a licensed engineer must perform hydrologic modeling. If the infiltration rate is greater than or equal to 0.5 inch/hour, continue to Step e.	0.7	inches/hour

Determine impervious areas generating runoff that drain to Rain Garden or LID Swale BMP A3:

e	Contained Planter(s) BMP, Vegetated Roofs (Green Roofs) BMP, Limit Disturbance: Tree Protection BMP (Impervious) and Evergreen Tree Planting BMP. Enter areas where these BMPs are placed over or overhang impervious drainage areas in first box and multiply by value shown to find area generating runoff to manage. See Worksheet E1 for mature canopy spread assumptions for small, medium, and large trees to be planted.	=	0.50	x	0	=	0	square feet
f	Tree Planting (Deciduous, Impervious) BMP. In the first box, enter mature canopy spread for the species of decidous tree(s) to be planted to manage impervious area. Then, multiply by the value shown to find the area generating runoff to manage. See Worksheet E1 for mature canopy spread assumptions for small, medium, and large trees to be planted.	=	0.75	x	0	=	0	square feet
g	Unmanaged Impervious Areas. In the first box, enter the portion of impervious area draining to this Runoff Reduction BMP that will have no runoff prevention BMPs applied to it. Multiply by the value shown to find the area generating runoff to manage.	=	1.00	x	1,410	=	1,410	square feet
h	Calculate the total impervious area draining to this Runoff Reduction BMP = Step e + Step f + Step g. If greater than 10,000 square feet, redirect runoff (e.g. different piping or grading plan) until the total area draining to this BMP is less than 10,000 square feet; otherwise, a licensed engineer must size and design this BMP. If the value on this sheet is less than or equal to 10,000 square feet, enter value on Step 25 of the LID Implementation Form if only one infiltration rain garden or LID swale will be used; otherwise, sum all areas from F1 Worksheets in Step hand enter the total. (The total from multiple BMPs MAY be greater than 10,000 square feet.)					=	**1,410**	**square feet**

Table 5-8 (continued).

i	Enter the maximum desired ponding depth (based on design of overflow elevation of an area drain rim, lowest elevation of a constructed berm, or other approved overflow structure/strategy) corresponding to a ponding depth value in Table F1 below.	9	inches
j	Enter Sizing Factor. Using Table F1.1 (Water Quality) or Table F1.2 (Flow Control), enter the sizing factor that corresponds to the ponding depth in Step i, the tested design infiltration rate in Step d, and from the Table F1.1 or F1.2 depending on which storm event the BMP is being designed for.	0.08	

Table F1.1: Infiltration Rain Garden and LID Swale BMP Sizing Factors (Water Quality)	**Infiltration Rate [inches/hour]**							
	0.50-0.74	**0.75-0.99**	**1.00-1.40**	**1.50-1.90**	**2.00-3.90**	**4.00-5.90**	**6.00-8.90**	**9.00-12.00**
Ponding Depth = 6 inches	0.08*	0.06	0.05	0.04	0.03	0.02	0.02	0.02
Ponding Depth = 9 inches	0.08*	0.05**	0.04	0.03	0.03	0.02	0.02	0.01
Ponding Depth = 12 inches	0.08*	0.05**	0.04***	0.03	0.03	0.02	0.01	0.01

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 4.9 inches.
** Maximum ponding depth for this infiltration rate range will be 7.3 inches
*** Maximum ponding depth for this infiltration rate range will be 9.0 inches

Table F1.2: Infiltration Rain Garden and LID Swale BMP Sizing Factors (Flow Control)	**Infiltration Rate [inches/hour]**							
	0.50-0.74	**0.75-0.99**	**1.00-1.40**	**1.50-1.90**	**2.00-3.90**	**4.00-5.90**	**6.00-8.90**	**9.00-12.00**
Ponding Depth = 6 inches	0.33*	0.25	0.21	0.16	0.14	0.10	0.08	0.06
Ponding Depth = 9 inches	0.33*	0.22**	0.18	0.14	0.12	0.08	0.06	0.05
Ponding Depth = 12 inches	0.33*	0.22**	0.17***	0.12	0.10	0.07	0.06	0.04

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 5.0 inches.
** Maximum ponding depth for this infiltration rate range will be 7.5 inches
*** Maximum ponding depth for this infiltration rate range will be 10.0 inches

k	Confirm vegetation health. Have appropriate plants been chosen for level of moisture they are likely to receive, regardless of excavation depth and ponding depth set by overflow strategy in Step i? See Figure E-2 Wetland Status Indicators for the moisture zones in vegetated stormwater facilities. Plants are critical to the success of these systems. If the answer is no, redesign the planting plan to improve plant establishment and long-term viability, then enter a yes.	Yes	Enter Yes or No
l	Calculate the top footprint of rain garden or LID swale BMP and indicate this area on construction plans = Step h x Step j.	250	square feet
m	Ensure the rain garden or LID swale meets the minimum footprint area criteria in Table 3-7. If FALSE increase area in Step l until TRUE.	TRUE	

Table 5-9. EXAMPLE PROJECT: Complete Worksheet E1 for the rain gardens in Basin A (BMP A1 shown in table 5-9 and BMP A3 shown in this table) and rain garden (BMP B1) and LID swale (BMPB2) in Basin B (not shown).

WORKSHEET F1. INFILTRATION RAIN GARDEN & LID SWALE BMP WORKSHEET

For multiple rain gardens or LID swales, complete this worksheet as many times as needed, add the values in Step h from all F1 worksheets and enter this total on the LID Implementation Form. Use this Worksheet to:
1. Confirm site suitability for infiltration of runoff using rain gardens of LID swales.
2. Determine the top elevation area of a single rain garden or LID swale.

a	**Rain Garden or LID Swale Designation:**	**A3**						
b	**In Basin:**	**A**						

Confirm suitability for infiltration of runoff:

c	See Chapter 4 Vegetated Stormwater Facilities under Siting. Are all conditions met to safely infiltrate runoff from other surfaces? If Yes, continue to Step d. If No, then site is unsuitable for vegetated stormwater facilities. Skip to Step 28 of the LID Implementation Form to investigate the possibility of using a drywell.	Yes	Enter Yes or No
d	Enter tested design infiltration rate, ideally performed within the footprint of the vegetated stormwater facility. If the infiltration rate is less than 0.5 inch/hour, a licensed engineer must perform hydrologic modeling. If the infiltration rate is greater than or equal to 0.5 inch/hour, continue to Step e.	0.7	inches/hour

Determine impervious areas generating runoff that drain to Rain Garden or LID Swale BMP A3:

e	Contained Planter(s) BMP, Vegetated Roofs (Green Roofs) BMP, Limit Disturbance: Tree Protection BMP (Impervious) and Evergreen Tree Planting BMP. Enter areas where these BMPs are placed over or overhang impervious drainage areas in first box and multiply by value shown to find area generating runoff to manage. See Worksheet E1 for mature canopy spread assumptions for small, medium, and large trees to be planted.	=	0.50	x	0	=	0	square feet
f	Tree Planting (Deciduous, Impervious) BMP. In the first box, enter mature canopy spread for the species of decidous tree(s) to be planted to manage impervious area. Then, multiply by the value shown to find the area generating runoff to manage. See Worksheet E1 for mature canopy spread assumptions for small, medium, and large trees to be planted.	=	0.75	x	0	=	0	square feet
g	Unmanaged Impervious Areas. In the first box, enter the portion of impervious area draining to this Runoff Reduction BMP that will have no runoff prevention BMPs applied to it. Multiply by the value shown to find the area generating runoff to manage.	=	1.00	x	1,716	=	1,716	square feet
h	Calculate the total impervious area draining to this Runoff Reduction BMP = Step e + Step f + Step g. If greater than 10,000 square feet, redirect runoff (e.g. different piping or grading plan) until the total area draining to this BMP is less than 10,000 square feet; otherwise, a licensed engineer must size and design this BMP. If the value on this sheet is less than or equal to 10,000 square feet, enter value on Step 25 of the LID Implementation Form if only one infiltration rain garden or LID swale will be used; otherwise, sum all areas from F1 Worksheets in Step hand enter the total. (The total from multiple BMPs MAY be greater than 10,000 square feet.)					=	**1,716**	**square feet**

Table 5-9(continued).

i	Enter the maximum desired ponding depth (based on design of overflow elevation of an area drain rim, lowest elevation of a constructed berm, or other approved overflow structure/strategy) corresponding to a ponding depth value in Table F1 below.	9	inches
j	Enter Sizing Factor. Using Table F1.1 (Water Quality) or Table F1.2 (Flow Control), enter the sizing factor that corresponds to the ponding depth in Step i, the tested design infiltration rate in Step d, and from the Table F1.1 or F1.2 depending on which storm event the BMP is being designed for.	0.08	

Table F1.1: Infiltration Rain Garden and LID Swale BMP Sizing Factors (Water Quality)	Infiltration Rate [inches/hour]							
	0.50-0.74	0.75-0.99	1.00-1.40	1.50-1.90	2.00-3.90	4.00-5.90	6.00-8.90	9.00-12.00
Ponding Depth = 6 inches	0.08*	0.06	0.05	0.04	0.03	0.02	0.02	0.02
Ponding Depth = 9 inches	0.08*	0.05**	0.04	0.03	0.03	0.02	0.02	0.01
Ponding Depth = 12 inches	0.08*	0.05**	0.04***	0.03	0.03	0.02	0.01	0.01

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 4.9 inches.
** Maximum ponding depth for this infiltration rate range will be 7.3 inches
*** Maximum ponding depth for this infiltration rate range will be 9.0 inches

Table F1.2: Infiltration Rain Garden and LID Swale BMP Sizing Factors (Flow Control)	Infiltration Rate [inches/hour]							
	0.50-0.74	0.75-0.99	1.00-1.40	1.50-1.90	2.00-3.90	4.00-5.90	6.00-8.90	9.00-12.00
Ponding Depth = 6 inches	0.33*	0.25	0.21	0.16	0.14	0.10	0.08	0.06
Ponding Depth = 9 inches	0.33*	0.22**	0.18	0.14	0.12	0.08	0.06	0.05
Ponding Depth = 12 inches	0.33*	0.22**	0.17***	0.12	0.10	0.07	0.06	0.04

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 5.0 inches.
** Maximum ponding depth for this infiltration rate range will be 7.5 inches
*** Maximum ponding depth for this infiltration rate range will be 10.0 inches

k	Confirm vegetation health. Have appropriate plants been chosen for level of moisture they are likely to receive, regardless of excavation depth and ponding depth set by overflow strategy in Step i? See Figure E-2 Wetland Status Indicators for the moisture zones in vegetated stormwater facilities. Plants are critical to the success of these systems. If the answer is no, redesign the planting plan to improve plant establishment and long-term viability, then enter a yes.	Yes	Enter Yes or No
l	Calculate the top footprint of rain garden or LID swale BMP and indicate this area on construction plans = Step h x Step j.	250	square feet
m	Ensure the rain garden or LID swale meets the minimum footprint area criteria in Table 3-7. If FALSE increase area in Step l until TRUE.	TRUE	

G. Calculate remaining drainage area to be manaGed (Basin)

Form Step 36: Calculate the remaining drainage area to managed by treatment only (i.e. lined) facilities.

- Since these BMPs don't significantly reduce runoff, iideally, all runoff has already been managed in preceding sections.
- Having any remaining drainage area left at this step sometimes indicates inadequate consideration of stormwater during site planning. Revisit the site layout.

Table 5-10. Complete Section G of the LID Implementation Form for Basin A (shown) and Basin B (not shown).

G. CALCULATE REMAINING DRAINAGE AREA TO BE MANAGED (BASIN A)			
33.	**SECTION G AREA TO MANAGE: Calculate remaining drainage area to be managed = Step 19 - Step 23 - Step 32** =	**0**	**square feet**

H. Provide water quality treatment for remaining drainage areas (basin)

Form Steps 34-35: If opportunities for BMPs above are exhausted, direct the remaining drainage area in Section H to treatment only (i.e. lined) facilities (not preferred):

- Lined Rain Garden or Lined LID Swale BMP (Worksheet H1)
- Lined Stormwater Planter BMP (Worksheet H2)
- Complete worksheets to size facilities and calculate the area managed using lined BMPs.

Step 36: Calculate area managed using all lined BMPs.

Table 5-11. Complete Section H of the LID Implementation Form for Basin A (shown) and Basin B (not shown). Since all runoff has been managed by preceding sections, zeros can be entered as shown.

H. PROVIDE WATER QUALITY TREATMENT FOR REMAINING DRAINAGE AREAS (BASIN A)				
Size Facilities to Treat Runoff with Lined BMPs				
If opportunities for all other BMPs have been exhausted, a lined treatment-only facility may be implemented. If Step 33 = 0, skip to Step 41. Water quality treatment, not runoff volume reduction or flood control, is addressed by these approaches.				
34.	**Lined Rain Garden or Lined LID Swale BMP. Enter the area managed with a lined rain garden or lined LID swale.**	Complete worksheet H1. Lined Rain Garden or LID Swale BMP. Enter total area managed.		square feet
35.	Lined Stormwater Planter BMP. Enter the area managed with a lined stormwater planter.	Complete worksheet H2. Lined Stormwater Planter BMP. Enter total area managed.		square feet
36.	**SECTION H AREA MANAGED SUBTOTAL: Calculate area managed using lined BMPs = Step 34 + Step 35** =		**0**	**square feet**

I. Manage stormwater quality and/or flow control with ponds

Form Steps 37-39: If opportunities for BMPs above are exhausted, direct the remaining drainage area in Section H to Retention and Detention Structures.

- Wet Pond
- Extended Wet Pond
- Dry Detention Pond

Form Step 40: Calculate area managed using detention and retention structures.

Table. 5-12. Complete Section I of the LID Implementation Form to record area managed with retention and detention structures.

I. MANAGE STORMWATER QUALITY AND/OR FLOW CONTROL WITH PONDS (BASIN A)

Size Retention and Detention Structures for Entire Basin Draining to it

For larger sites with difficult conditions, detention and retention structures can be implemented for water quality and flow control requirements

37.	Wet Pond. Enter the area managed with a wet pond	Wet Ponds must be sized by a license engineer.		square feet
38.	Extended Wet Pond. Enter the area managed with an extended wet pond	Extended Wet Ponds must be sized by a license engineer.		square feet
39.	Dry Detention Pond. Enter the area managed with a wet pond	Dry Detention Ponds must be sized by a license engineer.		square feet
40.	**SECTION I AREA MANAGED SUBTOTAL: Calculate area managed using detention and retention structures = Step 37 + Step 38 + Step 39**	=	0	

J. Confirm Stormwater Management is Adequate

Form Step 45-47: Confirm that protection fencing has been adequately designed and shown throughout the construction documents and that all areas have been managed.

- GREAT JOB! You're on your way to creating a low impact development site! (Don't forget to provide detailed designs and work with contractors and maintenance staff to realize your water quality goals.)

Table 5-13. Complete Section I of the LID Implementation Form for Basin A (shown) and Basin B (not shown).

J. CONFIRM STORMWATER MANAGEMENT IS ADEQAUTE (BASIN A)			
Confirm area managed meets stormwater management goals			
41.	Protection Fencing. On each site plan generated for the construction documents, is protection fencing shown around all BMPs as required in Chapter 5? If yes, enter yes. If no, revisit site plans and ensure that fencing is shown around relevant BMPs, then enter yes.	YE	Enter Yes or No
42.	**Calculate total remaining drainage areas to manage = Step 33 - Step 36 - Step 40** =	**0**	**square feet**
43.	Has runoff for this project or basin been fully managed? (Not required for retrofits) Enter Yes if Step 42 =0. GREAT JOB. You're on your way to creating a low impact development site! (Don't forget to provide detailed designs and work with contractors and maintenance staff to realize your water quality goals.)! If Step 42 > 0, revisit the site layout and the infiltration testing report and/or choose other additional BMPs to implement, if possible. Provide justification for portions of runoff not managed.	YES	Enter Yes or No

INSTRUCTIONS FOR SELECTED STEPS IN THE LID IMPLEMENTATION FORM & ASSOCIATED WORKSHEETS

IMPORTANT! Some steps of the LID Implementation Form are self-explanatory. Only steps that need clarification are discussed in this section. **Do not attempt to complete the LID Implementation Form without referring to criteria in this section.**

A. Create Site Layout & LID Strategy (Entire Site)

These BMPs are placed on the LID Implementation Form to remind planners and designers to include them in their site design process. No areas need to be entered on the form for these BMPs. For projects with more than one basin, enter information in Section A only once for the entire site, on the first form.

Minimize Impervious Area

Steps 1 – 3. Minimize Impervious BMPs. Implement these BMPs according to guidance in **Chapter 4**. These practices will reduce the amount of runoff to be managed in Runoff BMPs in steps below and reduce stormwater management costs (and some of them also reduce overall project costs):

- Shared parking spaces BMP
- Minimize Front Setbacks BMP
- Share a Driveway BMP

Place a check under the “Incorporated” column for each practice that will be implemented. If a practice will not be implemented, place a check under either the “Not Feasible” or “Not Applicable” column and briefly justify why the practice cannot be used.

Limit Disturbance

Step 4. Limit Disturbance: Construction Sequencing BMP. Implement this BMP according to guidance in **Appendix B** and **Chapter 4**. Place a check under the “Incorporated” column if this BMP will be implemented. If not, place a check under either the “Not Feasible” or “Not Applicable” column and briefly justify why the practice cannot be used.

Step 5. Fast(er) Draining Soils BMP. Use preliminary infiltration testing (per “**Appendix C**: Infiltration Testing”) during the planning phase to determine the fast(er) draining soils areas that will identify open space areas least likely to generate runoff (see **Chapter 5** “*Cluster Development BMP*”) and to determine whether the following BMPs can be placed in fast(er) draining soils, ensuring they are as small and cost-effective as possible:

- Porous Pavement (Runoff) BMP
- Infiltration Rain Garden or LID Swale BMP
- Infiltration Stormwater Planter BMP
- Vegetated Filter Strip (VFS) BMP
- Drywell BMP
- Soakage Trench BMP

Place a check under the “Incorporated” column if preliminary infiltration testing was performed. If not, place a check under either the “Not Feasible” or “Not Applicable” column and briefly justify why preliminary infiltration testing cannot be performed.

B. Prevent Runoff from Landscape Areas (Entire Site)

Limit Disturbance of Protected Landscape Areas

Apply these BMPs to landscape areas that will be protected in their current state in the proposed development.

Step 7. Cluster Development BMP. Criteria for drainage areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in Appendix B and Chapter 4.
- DO enter the area or areas that will be left in the pre-developed condition and that will be protected by fencing per guidance in **Appendix B** "*Construction*".

Step 8. Tree Protection Area BMP. Tree roots extend beyond the dripline; therefore, stormwater management also extends beyond the dripline. The area managed by a protected tree is 1.5 times the canopy area. For determining the area where other landscape management BMPs should be installed, the additional area around the tree should be uniformly applied per **Figure 5-6**.

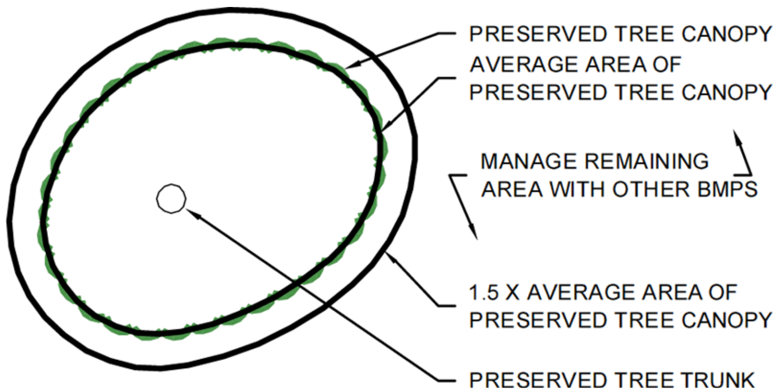


Figure 5-6. Tree preservation allows an area larger than the canopy to be counted as area managed. Apply this area uniformly around the tree canopy area.

Criteria for drainage areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter the tree canopy area that is forested or of a single tree or group of trees that that will be protected by fencing per guidance in **Appendix B** "*Construction*".
- DO NOT include forested areas already included on Cluster Development BMP above.
- Unless desired, DO NOT include trees within 10 feet of pavement, which can be used to manage impervious area in subsequent steps.)
-

Prevent Runoff from Developed Landscape Areas

Steps 9. Tree Planting BMP (Landscape). Complete Worksheet B1 to determine landscape area managed by evergreen and deciduous trees. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter trees that will overhang landscape areas, assuming a mature canopy spread, regardless of size of canopy at planting.
- DO NOT include any other managed landscape areas
- Unless desired, DO NOT include trees that are within 10 feet of impervious pavement, which can be used to manage runoff from impervious areas in subsequent steps.

Step 10. Restored Soils BMP. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter the proposed landscapes that will be restored after construction using the "Restored Soils BMP".
- DO enter areas that may contain rain gardens, stormwater planters, LID swales, vegetated filter strips, or water quality conveyance swales per subsequent steps in this form, since these areas already manage rainfall as well as runoff from other areas. Specific sizing for these facilities is provided in worksheets in subsequent steps.

C. Prevent Runoff from Hardscape Areas (Entire Site)

Step 13. Depave Existing Pavement BMP. Enter the area of existing pavement that will be removed to become a landscape area, implemented per guidance provided in **Chapter 4** "*Depave Existing Pavement BMP*", "*Restored Soils BMP*", and if applicable "*Tree Planting BMP*". Enter only existing hardscape areas that are impervious.

If trees will be planted, consider the following. Since trees require 2 cubic feet of soil per square foot of mature canopy, the minimum area of pavement converted to a landscape area with trees should be determined based on the projected mature canopy of the proposed tree: Minimum area = Canopy [sf] x 0.666.

Step 14. Limit Disturbance: Minimal Excavation Foundation BMP. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter areas of roof for buildings or sections of buildings supported by minimal excavation foundations, which include pier, post, or block footings or crawl spaces.
- DO NOT enter areas of roof for buildings or sections of buildings with a full basement below them.
- DO NOT enter areas of roof for buildings or sections of buildings with a slab footing or underground parking lot.

Step 15. Porous Pavement (Rainfall) BMP. Confirm site confirm site suitability. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter the area of porous pavement that manages ONLY the rainfall it receives. Enter areas that receive runoff from other places in subsequent steps in the LID Implementation Form.
- DO enter areas of existing to remain and proposed areas of porous pavement.

D. Calculate Total Remaining Hardscape Drainage Area to be managed (basin)

Note: Calculate drainage areas by the footprint of the area as they would be seen in plan. Land and roof slopes do not need to be accounted for when calculating drainage areas.

Step 17. Enter the number of basins for this project. Enter the number of basins. Projects where all runoff is directed to a single point will only have a single basin. Other projects may split a site up into multiple basins or the existing grades may have created multiple basins, as discussed above in “"Completing the LID Implementation Form", "Number of Forms per Project".

Step 18. Enter the basin addressed by this LID Implementation Form, Sections D through I. Each basin is required to be delineated and labeled (**Chapter 3** "*The LID Design Process*", "*Permit Drawing Requirements* *for All Projects*"). Enter a letter or other designation for the basin addressed by this particular LID Implementation Form.

Step 19. Enter Remaining Hardscape Drainage Area. Enter the area of hardscape, which may include roofs and any kind of pavement (roads, driveways, sidewalks, patios, and footpaths, regardless of whether they will be porous pavements or impervious pavements).

E. Prevent Runoff from Impervious Areas (Basin)

Step 20. Contained Planter(s) BMP, Vegetated Roofs (Green Roofs) BMP. Enter all areas where these BMPs are placed over impervious drainage areas in first box and multiply by value shown to calculate area managed. Areas meeting the criteria for each BMP as follows can be summed up together and entered on the LID Implementation Form.

Contained Planter(s) BMP. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter the area of contained planters over impervious hardscapes or on roofs.
- DO NOT enter contained planters over porous pavements areas.

Vegetated Roofs (Green Roofs) BMP. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter the area of roof covered by a vegetated roof.
- DO NOT enter drainage areas conveyed towards vegetated roofs.

Step 21. Limit Disturbance: Tree Protection BMP (Impervious). Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- Designers should confirm with their contractors, as soon as a contractor is on board, that the work being performed can be cost effectively performed without impacting the tree.
- An arborist certified by the International Society of Arboriculture (ISA) should be engaged during, at a minimum, the construction phase, but preferably during the planning or design phase, to provide recommendations for tree protection and health.
- Fence the critical root zone with durable fencing such as cyclone or wooden fencing, at least 3' tall. Orange construction fencing is discouraged due to its poor effectiveness at tree protection. See Appendix B "Construction".
- Indicate the area is a "Tree Protection Zone" using signage with any additional information needed so that subcontractors and delivery people are aware that traffic and materials storage are not allowed within the critical root zone. See **Chapter 4** "*Tree Protection BMP*".
- DO enter the existing canopy area overhangs an existing impervious area. It is intercepting rainfall and reducing runoff from those impervious areas.
- DO enter the existing canopy area of any trees where 70% of the ground area below the canopy will be protected from construction of any additional structures or pavements, (unless approved by an International Society of Arboriculture certified arborist). Excess disturbance under the canopy during a construction project is likely to harm the tree. Impacts won't be seen for a few years, long after the project team has completed the project.
- DO NOT enter the existing canopy area of invasive trees. These should be removed. (See Appendix E: Planting Specifications for resources on determining if a tree is considered invasive.)

Step 22. Tree Planting BMP (Impervious). Complete Worksheet E1 to determine the impervious area managed by planting a new tree. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter areas of trees that will be planted with 10 feet of a ground level impervious surface.
- DO enter areas of tree canopy that overhang a rooftop when the roof peak is no more than 15 feet high.
- Evergreen trees must be at least 5 feet tall.
- Deciduous trees must be at least 1.5-inch caliper.
- DO NOT enter areas covered in plants considered to be arborescent shrubs (*e.g.* Vine Maple)

Trees should be established over a 2-year irrigation period. Within this time period, if trees do not establish and instead their health declines, they must be replaced.

F. Reduce Runoff from Hardscape Areas (Basin)

For each runoff BMP that infiltrates runoff, sizing may be a more iterative process than BMPs in previous sections. Drainage areas may need to be split (e.g. adding or moving downspouts or changing the grading plan) to direct stormwater in a particular way to ensure that the footprint of the BMP will fit within the confines of the proposed area and that multiple BMPs will be distributed around the site, as needed to mimic predevelopment hydrology.

Note: Not all sites are suited to infiltrate runoff. If this is the case for your site based on siting guidance in **Chapter 4**, refer to **Table G-1 BMP Suitability Matrix** and revisit BMPs in Sections A, B, and C to maximize the areas that might be managed with BMPs that evaporate or infiltrate rainfall.

Size Facilities to Infiltrate (Higher Volumes of) Runoff

Step 24. Porous Pavement (Runoff) BMP. Porous pavement that manages runoff from other areas is required to be designed and sized by a licensed engineer and the base rock cannot be sized by only using a sizing factor. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter impervious areas conveyed to the porous pavement.

Step 25. Infiltration Rain Garden or LID Swale BMP. Complete Worksheet F1 to calculate the top area of a rain garden or LID swale to infiltrate runoff from all or a portion of the remaining drainage area. (In the ponding area, the bottom is smaller than the top, due to gentle side slopes.) Additional guidance for completing selected steps in Worksheet F1 is provided below. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter impervious areas draining to the infiltration rain garden or LID swale.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

Step 26. Infiltration Stormwater Planter BMP. Complete Worksheet F2 to size the stormwater planter footprint to infiltrate runoff from all or a portion of the remaining drainage area. (In the ponding area, the bottom and top elevations are the same size due to vertical side slopes created by a curb or wall.) Additional guidance for completing selected steps in Worksheet F2 is provided below. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter impervious areas conveyed to the stormwater planter.

- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

Step 27. Soakage Trench BMP. Complete Worksheet F3 to size the footprint of a soakage trench to infiltrate runoff from all or a portion of the remaining drainage area. Additional guidance for completing selected steps in Worksheet F3 is provided below. Soakage trenches can be sized using a sizing factor but must be designed by a licensed engineer if that configuration is an underground injection control (UIC, Chapter 4 "*Soakage Trench BMP*", "*UIC Authorization (not always required)*). Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter impervious areas conveyed to the soakage trench.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

Step 28. Drywell BMP. Size a drywell to infiltrate runoff from all or a portion of the remaining drainage area. Drywells are required to be designed and sized by a licensed engineer (per Appendix B "*Design*", "*Hydrologic Modeling*") and cannot be sized using a sizing factor since infiltration rates may vary with drywell depth. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter all impervious areas conveyed to a drywell.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.
-

Size Facilities to Infiltrate (Lower Volumes of) Runoff with Flow-Based Facilities

Step 29. Water Quality Conveyance Swale BMP. Size a water quality conveyance swale to treat the water quality design storm. Water quality conveyance swales are required to be sized by a licensed engineer (per Appendix B "*Design*", "*Hydrologic Modeling*") and cannot be sized using a sizing factor. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter areas with shrubs, trees, and/or areas planted with tall grasses, sedges, rushes and/or other groundcover capable of standing up while receiving flows.
- DO NOT enter areas planted with lawn or that will be maintained by mowing (unless this is required by ODOT or for fire management)

Step 30. Dispersion: Vegetated Filter Strip (VFS) BMP. Complete Worksheet F4 to size a vegetated filter strip to infiltrate runoff from all or a portion of the remaining drainage area. Vegetated filter strips have no depression to store runoff but are almost equal in grade to the surfaces that drain to them. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter areas with shrubs, trees, and/or areas planted with tall grasses, sedges, rushes and/or other groundcover capable of standing up while receiving flows.
- DO NOT enter areas planted with lawn or that will be maintained by mowing (unless this is required by ODOT).
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

Step 31. Dispersion: Downspout Disconnection. Complete Worksheet E6 to determine suitability for downspout disconnection to infiltrate runoff from all or a portion of a roof. Downspout disconnections have no depression to store or convey runoff but are almost equal in grade to the surfaces that drain to them. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP according to guidance in **Appendix B** and **Chapter 4**.
- DO enter areas with shrubs and/or areas planted with tall grasses, sedges, rushes and/or other groundcover capable of standing up while receiving flows.
- DO enter areas with existing or proposed trees capable of receiving additional water without impact to tree health (see **Chapter 4** "*Limit Disturbance: Tree Protection BMP*", "*Siting*").
- DO NOT enter areas planted with lawn or that will be maintained by mowing.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.
-

G. Calculate Drainage Area Managed with Runoff Prevention and Runoff Reduction BMPs (Basin)

Step 33. Calculate remaining drainage area to be treated only. The remaining lined BMPs treat stormwater on-site but cannot be relied upon to significantly reduce runoff. Therefore, they do not protect against downstream streambank erosion or flooding (see **Table G-1 BMP Suitability Matrix**).

H. Improve Water Quality Treatment From Remaining Drainage Areas (Basin)

Size Facilities to Treat Runoff with Lined Facilities

If opportunities for all other BMPs have been exhausted, a treatment only facility such as a lined vegetated stormwater facility may be implemented. For the most part, these facilities do not significantly reduce runoff and should be considered primarily as water quality treatment only facilities that will not protect the receiving stream health as well as the practices described in Sections A, C, D, and F above.

Step 34. Lined Rain Garden or LID Swale BMP. Complete Worksheet F1 to size a lined rain garden or LID Swale to treat runoff from all or a portion of the remaining drainage area. Additional guidance for completing selected steps in Worksheet F1 is provided below.
Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP per guidance provided in **Appendix B** and **Chapter 4**.
- DO enter areas conveyed to the lined rain garden or LID swale.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

Step 35. Lined Stormwater Planter BMP. Complete Worksheet F2 to size the stormwater planter footprint to treat runoff from all or a portion of the remaining drainage area. Criteria for areas entered on the LID Implementation Form are as follows:

- Implement this BMP per guidance provided in **Appendix B** and **Chapter 4**.
- DO enter all drainage areas conveyed to a lined stormwater planter.
- DO use one worksheet for each BMP. Add up the areas managed from all the worksheets and enter the total area managed on this step of the LID Implementation Form.

I. MANAGE STORMWATER QUALITY AND/OR FLOW CONTROL WITH PONDS (BASIN)

Size Retention and Detention Structures for Entire Basin Draining to it

Step 37-39. For larger sites with difficult conditions, detention and retention structures can be implemented for water quality and flow control requirements. Design of these structures requires a licensed engineer. Design recommendations are in **Chapter 4** and requirements for design are in **Chapter 2**.

J. Confirm Stormwater Management is Adequate (Basin)

Confirm area managed meets stormwater management goals

Step 41. Protection Fencing. Preventing soil compaction and other damage anywhere infiltration of rainfall or runoff will take place is key to the hydrologic function of these areas. Showing protection fencing on every site plan sheet in a set of construction drawings (civil, landscape, electrical, etc.) will alert each contractor and sub-contractor to the value of the natural resource to be protected, which may include soil or vegetation. It will also help contractors and subcontractors include this in their cost estimate when bidding the job, which is more likely to result in fencing, than if the fencing is left off the plans.
Protection fencing is needed to implement the following BMPs:

- Conserve Fast(er) Draining Soils BMP
- Cluster Development BMP (the natural areas to be protected)
- Tree Protection BMP (Landscape and impervious area credits)
- Porous Pavement BMP (Rainfall and runoff area credits)
- Infiltration Rain Garden BMP
- Infiltration LID Swale BMP
- Infiltration Stormwater Planter BMP
- Vegetated Filter Strip BMP
- Soakage Trench BMP

If protection fencing is not shown around each of the above BMPs on the construction/permit set, then no area managed values should be entered on the LID Implementation Form for those BMPs.

Step 43. Has runoff for the project or basin been fully managed? A zero in this box indicates that the project site or basin (i.e. portion of the project site) has been fully managed. Great work!
Any value greater than zero in this box indicates that the project site or basin has not been fully managed. Some questions to ask might include:

- Is there another way to lay out the site that allows infiltration BMPs to be located in faster draining soils?
- Are there less preferred BMPs that were not really investigated that could be explored?
- If high groundwater and steep slopes are limiting factors at the site, was the Table G-1 BMP Suitability Matrix used to identify and fully explore BMPs suitable for these conditions?
- Has the project minimized impervious surfaces and lawn as much as possible?

ADDITIONAL WORKSHEET INSTRUCTIONS

Most steps on the worksheets are self-explanatory. Some steps that might need some additional clarification are included below.

Worksheet F1 Infiltration Rain Garden or LID Swale

Worksheet F1, Step a. Rain Garden or LID Swale Designation. Create a designation of your choosing to differentiate each one of the rain gardens or LID swales that will be implemented in the current basin. You will need this worksheet for each separate rain garden or LID swale.

Worksheet F1, Step b. In Basin. Enter the basin that the rain garden(s) or LID swale(s) in Step a are located in.

Worksheet F1, Step e. Contained Planter(s) BMP, Vegetated Roofs (Green Roofs) BMP, Limit Disturbance: Tree Protection BMP (Impervious) and Evergreen Tree Planting BMP. These four BMPs prevent runoff in the same amount (by 50%). From areas managed by any or all of these BMPs, 50% still runs off, so enter the total area draining to the rain garden or LID swale for which the form is being completed.

Worksheet F1, Steps f – g. Similar to Step e above.

Worksheet F1, Step i. Enter the maximum desired ponding depth (based on design of overflow elevation of an area drain rim, lowest elevation of a constructed berm or other approved overflow structure). The ponding depth may vary with configuration and storm size (see **Chapter 4** "*Choosing the Best Vegetated Stormwater Facility Configuration* ", "*Vegetated Stormwater Facilities*"). Below are some examples that illustrate how to determine ponding depth for sizing facilities.

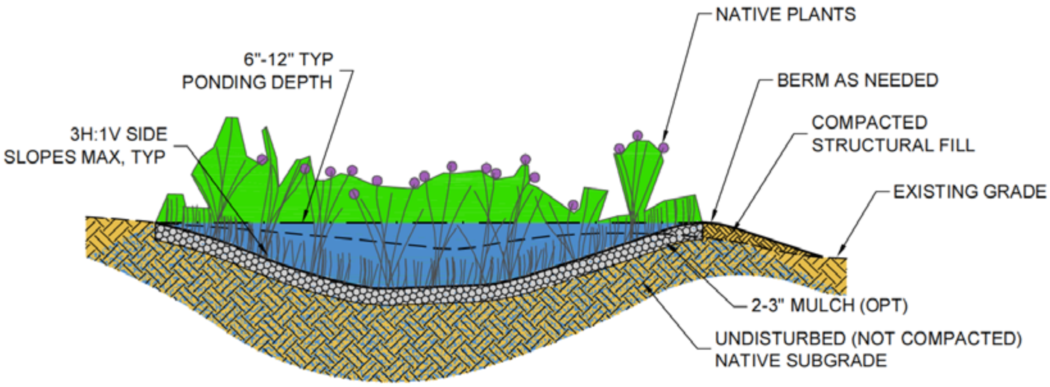


Figure 5-7 Example of an infiltration rain garden or LID swale with a berm serving as the overflow structure. The ponding depth in this configuration is equal to the difference between the bottom of the facility and the top elevation of the lowest point of the berm. Enter the difference between these two elevations on the LID Implementation Form.

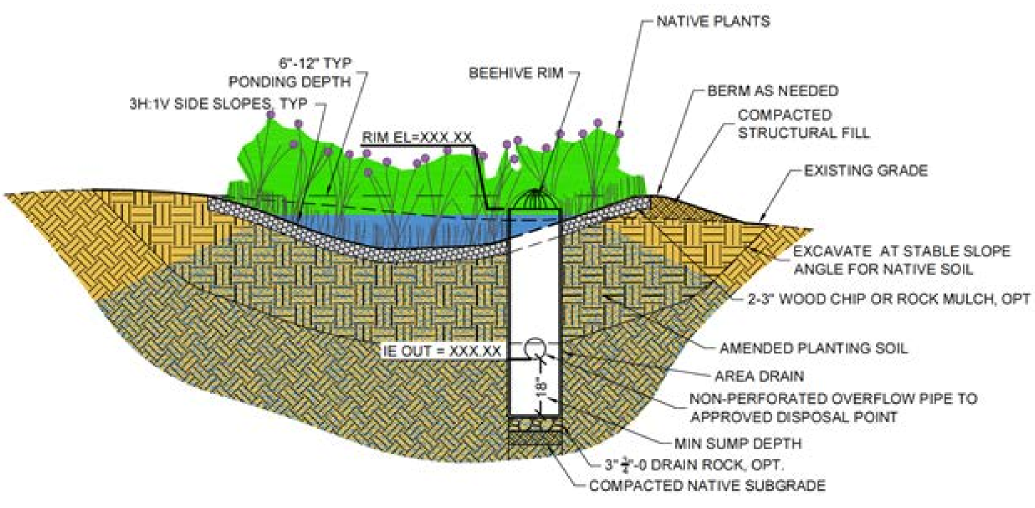


Figure 5-8 Example of an infiltration rain garden or LID swale with an area drain as the primary overflow structure and a berm as the secondary (large storm) overflow structure. According to guidance in Chapter 4 "Vegetated Stormwater Facilities", the rim elevation should be set high enough to allow the water quality storm to be completely infiltrated without overflowing. In this case, enter the difference between the bottom elevation of the ponding area (depression) and the rim elevation of the area drain or other overflow structure.

Worksheet F1, Step j. Enter Sizing Factor. Pre-calculated sizing factors such as the ones in this table allow end-users to size a runoff reduction BMP based solely on the size of the area draining to it (which will be done in subsequent steps of this worksheet). The sizing factors in the LID Implementation Form are specific to The City of Grant Pass and rain gardens and LID swales.

Example 5-1. How to use Table F1 in faster draining soils (1.5 to 12 inches/hour):
Given:
Infiltration rate entered in Worksheet F1, Step d = 1.8 inches/hour
Ponding depth entered in Worksheet F1, Step i = 12 inches

Table 5-14. Rain garden and LID swale BMP sizing, example table for a 1.2-inch storm.

	Infiltration Rate [inches/hour]							
	0.50-0.74	**0.75-0.99**	**1.00-1.40**	**1.50-1.90**	**2.00-3.90**	**4.00-5.90**	**6.00-8.90**	**9.00-12.00**
Ponding Depth = 6 inches	0.08*	0.06	0.05	0.04	0.03	0.02	0.02	0.02
Ponding Depth = 9 inches	0.08*	0.05**	0.04	0.03	0.03	0.02	0.02	0.01
Ponding Depth = 12 inches	0.08*	0.05**	0.04***	0.03	0.03	0.02	0.01	0.01

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 4.9 inches.
** Maximum ponding depth for this infiltration rate range will be 7.3 inches
*** Maximum ponding depth for this infiltration rate range will be 9.0 inches

Sizing factor = **0.03,** so enter this on Worksheet F1, q.

Example 5-2. How to use Table F1 in slower draining soils (0.5 to 1.4 inches/hour):
Given:
Infiltration rate entered on Worksheet F1, step d = 0.64 inches/hour
Ponding depth entered on Worksheet F1, step i = 12 inches

Table 5-15. Rain garden and LID swale BMP sizing.

	Infiltration Rate [inches/hour]							
	0.50-0.74	**0.75-0.99**	**1.00-1.40**	**1.50-1.90**	**2.00-3.90**	**4.00-5.90**	**6.00-8.90**	**9.00-12.00**
Ponding Depth = 6 inches	0.08*	0.06	0.05	0.04	0.03	0.02	0.02	0.02
Ponding Depth = 9 inches	0.08*	0.05**	0.04	0.03	0.03	0.02	0.02	0.01
Ponding Depth = 12 inches	0.08*	0.05**	0.04***	0.03	0.03	0.02	0.01	0.01

In slow draining soils, facilities must empty in 30 hours, so runoff must be spread out. No need to build your BMP to pond any more than the following ponding depths:
*Maximum ponding depth for this infiltration rate range will be 4.9 inches.
** Maximum ponding depth for this infiltration rate range will be 7.3 inches
*** Maximum ponding depth for this infiltration rate range will be 9.0 inches

Cells with asterisks means that the BMP is not predicted to achieve the desired ponding depth at this infiltration rate, because it also must infiltrate desired volumes within 30 hours. Creating more storage for stormwater runoff in slow draining soils without expanding the footprint will only cause the facility to have standing water beyond the 30-hour maximum. Maximum ponding depths predicted by hydrologic modeling are provided in the footnotes to optimize the depth of the rain garden, reduce excavation costs, and help put the right plant in the right place (see Appendix E Plant Specifications).

In this case, the maximum ponding depth predicted for this infiltration rate range is 4.9 inches, so this is what should be designed for (see Step k) and shown on the plans.

Sizing factor = **0.08,** so enter this on Worksheet F1, j.

Worksheet F1, Step k. Confirm vegetation health. Putting the right plant in the right place is crucial to water quality treatment. While many conditions will contribute to the health of a plant (see **Appendix E** Planting Specifications), moisture is the driving factor in plant health in these facilities. At least two conditions can contribute to poor plant health because a plant that prefers one moisture regime receives another:

- The location of inlets (wetter) and outlets (drier) and the flow of water through the facility as it fills up and overflows has not been accounted for. See ***Figure E-2*** "Wetland status indicators for the moisture zones in vegetated stormwater facilities" for more information.
- If slow draining soils control facility ponding depth and a larger depth of ponding is implemented anyway, plants adapted to moist conditions will not thrive or may not survive at all at higher elevations than the maximum ponding depth. For instance, in the slow draining soils example above (**Example 5-2**), water is only predicted to reach a level of 4.9 inches above the bottom elevation of the facility, but if the pond is excavated to 12 inches, then plants that prefer relatively dry conditions (per **Figure E-2**) should be chosen for the slopes from 4.9 above the facility bottom to the overflow height, since this area will be much less frequently inundated.

Worksheet F1, Step l. Calculate the top footprint of rain garden or LID swale BMP. Multiply the drainage area conveyed to the rain garden or LID swale by the sizing factor.

Example 5-3: How to size a rain garden or LID swale using a sizing factor

Given:

Drainage area = 950 square feet

Simplified sizing factor = 0.08

Top of rain garden or LID swale = 950 x 0.08 = **76 square feet**

For retrofit projects, check to see whether the area calculated exists or can be created, for example by removing pavement per the "Depaving Existing Pavement BMP", in a place where conveyance to it is feasible. Retrofit projects are not required to fully size facilities. A facility smaller than the calculated area will overflow more often but can still provide some benefit to watershed health.

Worksheet F1, Step m. Ensure the rain garden or LID swale meets the minimum footprint area criteria in **Table 4-5**. Rain gardens and LID swales have maximum side slopes of 3:1 (horizontal: vertical), so these BMPs have a minimum footprint for each ponding depth, based solely on geometry. This step checks whether the BMP is big enough for the desired ponding depth entered in step i.

Worksheet F2 Infiltration Stormwater Planter

Worksheet F2, Steps a – j. Similar or the same as instructions for Worksheet F1, Steps a – j.

Worksheet F2, Step k. Confirm vegetation health. Have appropriate plants been chosen for level of moisture they are likely to receive, regardless of excavation depth and ponding depth set by overflow strategy in Step 59?

Putting the right plant in the right place is crucial to water quality treatment. While there are many conditions that will contribute to the health of a plant (see **Appendix E** "Planting Specifications"), moisture is the driving factor in plant health in these facilities. The location of inlets (more wet) and outlets (more dry) and the flow of water through the facility as it fills up and overflows should be accounted for. See "**Figure A-2** Wetland status indicators for the moisture zones in vegetated stormwater facilities" for more information.

Worksheet F2, Step l. Size footprint of Stormwater Planter BMP. Multiply the drainage area conveyed to the stormwater planter by the sizing factor.

Example 5-4: How to size a stormwater planter using a sizing factor

Given:

Drainage area = 950 square feet

Simplified sizing factor = 0.031

Top of stormwater planter = 950 x 0.031 = **29 square feet**

For retrofit projects, check to see whether the area calculated exists or can be created in a place where conveyance to it is feasible. Retrofit projects are not required to fully size facilities. A facility smaller than the calculated area will overflow more often, but can still provide some benefit to watershed health. Retrofits that are too small should be involve a licensed engineer to ensure that overflows will not damage downstream structures on and off the property.

Worksheet F3 Soakage Trench

Worksheet F2, Steps a – j. Similar or the same as instructions for Worksheet F1, Steps a – j.

Worksheet F3, Step k. Calculate the area of the soakage trench. Multiply the remaining drainage area conveyed to the soakage trench by the sizing factor.

Example 5-5: How to size a soakage trench using a sizing factor

Given:

Drainage area = 950 square feet

Simplified sizing factor = 0.101

Top of soakage trench = 950 x 0.101 = **96 square feet**

For retrofit projects, check to see whether the area calculated exists or can be created in a place where conveyance to it is feasible. Retrofit projects are not required to fully size facilities. A facility smaller than the calculated area will overflow more often but can still provide some benefit to watershed health. Retrofits that are too small should involve a licensed engineer to ensure that overflows will not damage downstream structures on and off the property.

Worksheet H1 Lined Rain Garden or LID Swale

Worksheet F2, Steps a – b. Similar or the same as instructions for Worksheet F1, Steps a – b.

Worksheet H1, step d. Determining the infiltration rate of imported soil mix. A lined rain garden or LID swale will incorporate "imported soil" per **Appendix D**: Specifications. Based on the D10, which is the size of particles that comprise the smallest 10% of the mix, estimate the infiltration rate using ***Table H1.1***.

For information on completing additional steps within this worksheet, refer to guidance provided above on completing Worksheet F1 for infiltration rain gardens and LID swales.

Worksheet H2, Steps e – l. Similar or the same as instructions for Worksheet F1, Steps e – l.

Worksheet H2 Lined Stormwater Planter

Worksheet H2, Steps a – l. Similar or the same as instructions for Worksheet F1, Steps a – l.

CHAPTER 6: OPERATIONS & MAINTENANCE (O&M) AGREEMENT

Table of Contents

OPERATIONS & MAINTENANCE (O&M) AGREEMENT

To function as intended over the long term, BMPs 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 development permit, the owner must sign an O&M agreement with the City of Grants Pass (O&M Form, included below), committing the owner and future owners to certain operation and maintenance activities. This agreement must be recorded with the deed in the City of Grants Pass's during the site plan review process.

Maintenance responsibility of BMPs located within public street right-of-ways or easements dedicated to the City will be the responsibility of the City. 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. Under no circumstance shall a private property owner place fill, trash, lawn trimmings, leaves, or unapproved plants into public or private BMPs.

FORM O&M INSTRUCTIONS

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 Parks & Community Development at 541-450-6060.

- Fill out Box 1, including owner's name, telephone number, mailing address, site address, and site legal description.
- For Box 2, depending on which types of BMPs are being installed on the site, attach the corresponding BMP Maintenance Activities to the O&M Form, and check the applicable box (or boxes).
- 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.
- In Box 4, either sketch the property or include a separate site plan sheet including street frontage (label street name); means of access and access easements, if necessary; buildings; parking lots; walkways; and driveways. Indicate with *'s and/or polygons where each BMP is to be located, and label each one.
- Read the legal requirements in Box 5.
- Under witness of a certified notary, sign the form in Box 6, and have it notarized.
- Submit the completed Form O&M with the building permit application for review by the City of Grants Pass.

This Box for City of Grants Pass Recording Use Only

AFTER RECORDING, RETURN TO:

Public Works
101 NW A St.
Grants Pass, OR 97526

FORM O&M: Operations & Maintenance Agreement for Best Management Practices	
Permit Application #:	Project #:
BOX 1	
Owner's Name:	Phone Number: (_____) ______-_________
Mailing Address:	
Site Address:	
Site Legal Description:	
BOX 2	
Type of Practices. *Check all that apply:* ☐ Wet Pond ☐ Extended Wet Pond ☐ Dry Detention Facility ☐ Cluster Development ☐ Tree Protection ☐ Tree Planting ☐ Depaving and/or Restored Soils ☐ Contained Planter ☐ Vegetated Roof ☐ Porous Pavement (Type: ____________) ☐ Rain Garden ☐ Stormwater Planter ☐ LID Swale ☐ Soakage Trench ☐ Drywell ☐ WQ Conveyance Swale ☐ Dispersion BMP ☐ Level Spreader	
BOX 3	
Party Responsible for maintenance of Best Management Practice (BMP). *Check One:* ☐ Property Owner ☐ Homeowner's Association ☐ Other (describe) ___________________________	
Contact Information (only if other than owner)	
Maintenance Contact Name:	Phone Number: (_____)______-_________
Maintenance Contact Address:	
Estimated Date of Installation (mm/yyyy):	
Prepared By:	
BOX 4 Insert site plan here or attach separate sheet.	The 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-filling with the City of Grants Pass. Call (541)450-6110 for information or assistance.

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 (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 OF GRANTS PASS INSPECTIONS. OWNER grants to the CITY OF GRANTS PASS the right to inspect the private stormwater Facilities. The CITY OF GRANTS PASS 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 OF GRANTS PASS 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 OF GRANTS PASS) 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 OF GRANTS PASS CORRECTIONS. If correction of all OWNER or CITY OF GRANTS PASS identified Deficiencies is not completed within thirty (30) days after OWNER'S inspection or CITY OF GRANTS PASS notice, CITY OF GRANTS PASS shall have the right to have any Deficiencies corrected. The CITY OF GRANTS PASS (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 OF GRANTS PASS for work performed to correct such Deficiencies ("CITY OF GRANTS PASS Correction Costs") following OWNER'S failure to correct any Deficiencies in the Facilities. OWNER shall pay to CITY OF GRANTS PASS the City of Grants Pass Correction Costs within thirty (30) days of the date of the invoice. If payment is not made within 30 days, the CITY OF GRANTS PASS shall collect pursuant to APPROPRIATE CITY OF GRANTS PASS STATUTE OR CODE regarding enforcement of cost assessment. OWNER understands and agrees that upon non-payment, City of Grants Pass Correction Costs shall be secured by a lien on OWNER'S property for the CITY OF GRANTS PASS Correction Cost amount plus interest and penalties.

VI. EMERGENCY MEASURES. If at any time the CITY OF GRANTS PASS reasonably determines that the Facilities create any imminent threat to public health, safety or welfare, the CITY OF GRANTS PASS may immediately and without prior notice to the Owner take measures reasonably designed to remedy the threat. The CITY OF GRANTS PASS 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 homeowner's association comprised of the owners of the benefiting properties. However, the respective owners of each property shall be jointly and severally liable for CITY OF GRANTS PASS Correction Costs if not otherwise paid. All notices to OWNER shall be sent to the address designated in writing by the homeowner's 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 Josephine 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 and 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:

CLUSTER DEVELOPMENT BMP MAINTENANCE ACTIVITIES FORM

The following activities apply to natural areas (*e.g.* forests, riparian areas, meadows, etc.) outside of the developed area of a project/development site, as shown on the site plan in Box 4. Maintenance of natural areas should be minimal to none. Maintain natural areas as follows:

- Avoid pruning, watering, fertilizing, spraying, and mulching of natural areas unless directed by an International Society of Arboriculture certified arborist or a qualified forest or other landscape manager.
- Weed and pest management should be performed with integrated pest management (IPM) techniques, which are a systematic approach to reducing toxics use in landscapes. (See Appendix E: Plant Specifications of "LID Guidance: A Practical Guide to Watershed Health.")
- Steep slopes that are graded during construction and left grassy as open space tend to have problems with erosion and sometimes even landslides. Managing soils from these areas could become very high maintenance. Under the definition of limiting disturbance, which is to preserve and protect natural resources, these areas are not natural areas, but might appear to be to maintenance staff seeing the site for the first time. In this case, steep slopes should be re-vegetated with vegetation that can resist erosion as appropriate (*e.g.* shrubs, trees, and other deeply rooted plants).

TREE PROTECTION BMP MAINTENANCE ACTIVITIES

The following activities apply to trees within the developed area of a project/development site, as shown on the site plan in Box 4. The level of maintenance of existing protected trees may vary with how well trees were protected in previous development phase. Activities include:

- Fertilize trees immediately with phosphorus, potassium, calcium, magnesium, and other macro- and micro-nutrients as indicated by a soil test. Do not over fertilize with an off-the-shelf nitrogen-phosphorus-potassium (NPK) or weed-and-seed products, which can pollute downstream waterways and groundwater.
- Fertilize lightly with nitrogen after 1 year. If recommended by an arborist, light annual applications of nitrogen may be made for the next 3 to 5 years.
- Mulch trees once a year with organic matter compost or wood chips to maintain 2-4 inches of mulch. Pull mulch away from tree trunk to avoid rotting the trunk.
- In the absence of adequate rainfall, apply at least 1 inch of water per week by deep soaking methods for a minimum of 2 (smaller trees) to 5 years (larger trees) or as recommended.
- Inspect trees annually for at least 3 to 5 years after construction to look for changes in condition and signs of insects or disease.
- Remove trees that are badly damaged or are in irreversible decline if unsuitable for wildlife habitat. For more information on proper tree removal and replacement, see the Oregon State University Extension publication "*Tree Protection on Construction and Development Sites*". For deciduous trees, a pruning schedule and specific guidance to improve tree stability during storms is provided in "*Developing a Preventative Pruning Program: Young Trees*"[1]. If the tree is located in a less public area and can be cut to be short, consider leaving some of the trunk of removed trees standing, to serve as habitat for wildlife.
- Develop a regular maintenance program that incorporates fertilization and integrated pest management techniques to get best results at lowest cost.
- Pruning is the deliberate removal of tree branches and limbs to achieve a specific objective in the alteration of a tree's health and form. Regular inspections to determine a tree's pruning needs

[1] *University of Florida, IFAS Extension. Retrieved from: http://edis.ifas.ufl.edu/pdffiles/EP/EP31500.pdf*

should be a part of every tree maintenance program. Always determine the objective for pruning before beginning the work. For detailed information on pruning techniques, see the Oregon State University Extension publication "Tree Protection on Construction and Development Sites"[2]. In addition, the American National Standards Institute (ANSI) publishes tree pruning and safety standards, known as ANSI A300 (Part 1): Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Pruning). The ISA has developed BMPs for pruning in relationship to the ANSI standards; these guidance documents are available for sale through the ISA Web site[3].

TREE PLANTING BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to newly planted trees, as shown on the site plan in Box 4. The amount of maintenance a tree requires depends on the species, the tree's location in the landscape, its age, and the care (or abuse) it has been given throughout its lifetime. Basic tree maintenance begins with regular inspections to determine a tree's needs, which may include pruning, mulching, fertilization, irrigation, and pest management.

New Tree Care after Planting.

Maintenance specific to new trees is as follows:

- Prune only dead, broken, crossed, or rubbing branches; inspect for pruning needs annually.
- Irrigate trees during the 2-year establishment period. Irrigate trees more in the first year and less to much less in subsequent years. In addition, trees benefit from varying irrigation seasonally. At the beginning of summer, after the rains stop, water a little. Increase irrigation volume as the summer/dry season continues. Taper off irrigation as the rains return. Depending on your area and rainfall patterns, irrigation may be needed from May to October. Apply 5-10 gallons to each newly planted tree, once/week, as appropriate for the tree.
- Inspect newly planted trees quarterly for the first 5 years to evaluate condition and maintenance needs.
- Remove tree watering rings after one year.
- Remove stakes and guying materials, if used, after one year.
- Develop an integrated maintenance and care program using fertilization BMPs and integrated pest management practices to reduce costs as well as negative impacts on the environment.

Long-term maintenance

- Pruning is the deliberate removal of tree branches and limbs to achieve a specific objective in the alteration of a tree's health and form. Regular inspections to determine a tree's pruning needs should be a part of every tree maintenance program. Always determine the objective for pruning before beginning the work. For detailed information on pruning techniques, see the Oregon State University Extension publication "Tree Protection on Construction and Development Sites"4. In addition, the American National Standards Institute (ANSI) publishes tree pruning and safety standards, known as ANSI A300 (Part 1): Tree, Shrub, and Other Woody Plant Maintenance –

---

[2] *Oregon State University, Extension Services. (2009). Tree Protection on Construction and Development Sites. Retrieved from: http://goo.gl/Tl5kOU*
[3] *International Society of Arboculture. Retrieved from: http://www.isa-arbor.com/*
[4] *Oregon State University, Extension Services. (2009). Tree Protection on Construction and Development Sites. Retrieved from: http://goo.gl/Tl5kOU*

Standard Practices (Pruning). The ISA has developed BMPs for pruning in relationship to the ANSI standards; these guidance documents are available for sale through the ISA Web site5.

- Properly remove and replace trees as needed. For more information on proper tree removal and replacement, see the Oregon State University Extension publication "Tree Protection on Construction and Development Sites". For deciduous trees, a pruning schedule and specific guidance to improve tree stability during storms is provided in "Developing a Preventative Pruning Program: Young Trees"6.
- Mulch trees once a year with organic matter compost or wood chips to maintain 2-4 inches of mulch. Pull mulch away from tree trunk to avoid rotting the trunk.

DEPAVE EXISTING PAVEMENT & RESTORED SOILS BMPS MAINTENANCE ACTIVITIES

The following activities apply to landscape areas within the developed area of a project/development site where the Restored Soils BMP has been implemented, which includes Depave (*i.e*. demolish) Existing Pavement BMP. See the site plan in Box 4.
Maintenance of restored soils is similar to any landscape area.

- Remove weeds twice a year, around May and October or as needed before weeds go to seed.
- Replenish compost in gardens to a depth of 2-3 inches and lawns 1/4 inch, annually.
- Reduce or eliminate the use of fertilizers, herbicides, pesticides, and permanent irrigation, especially if using all or predominantly native plants.
- Leaf litter left on grass over the winter may kill it; however, leaf litter left to decompose landscape areas, instead of raking in the fall is an effective mulch.
- If the leaf litter aesthetic is not desirable, Mulch once a year with 2-4" of organic matter compost (see Specifications in Grants Pass Stormwater Management Manual, **Appendix D**[7]) in perennial garden areas or for turf areas, aerate and top-dress with ¼" fine mulch.
- Alternative: Mulch once a year with 2-4" of wood chips for perennial gardens and single trees. See Tree Planting BMP Maintenance Activities for more information on maintenance of individual trees.
- To establish perennial plants, irrigate more in the first year and less to much less in subsequent years. Vary irrigation seasonally. At the beginning of summer, after the rains stop, water a little. Increase irrigation volume as the summer/dry season continues. Taper off irrigation as the rains return. Depending on your area and rainfall patterns, irrigation may be needed from May to October.

The volume of water and frequency of watering varies with the type of plant:

- Trees: 5-10 gallons, once/week
- Shrubs: 3-5 gallons once/week
- Groundcover: 1-2 gallons, once or twice/week
- Perennial herbs: ½ gallon, twice/week

CONTAINED PLANTERS BMP MAINTENANCE ACTIVITIES

The following activities apply to contained planters located over impervious hardscapes, as shown on the site plan in Box 4. Since contained planters are above ground, depending on the soil and wind regime, they are more subject to freezing and may dry out faster than the soil around plants that are in the ground.

---

[5] [5] *International Society of Arboculture website. Retrieved from: http://www.isa-arbor.com/*
[6] *University of Florida, IFAS Extension. Retrieved from: http://edis.ifas.ufl.edu/pdffiles/EP/EP31500.pdf*
[7] *City of Grants Pass should provide information here in the footnote on where to find this document*

Maintenance for contained planters is similar to conventional landscape maintenance practices:

- Remove weeds twice a year, around May and October or as needed before weeds go to seed.
- Replenish compost to a depth of 2-3 inches annually. Avoid NPK fertilizers (nitrogen -- phosphorus -- potassium) as nitrogen is a common pollutant found in waterways and will easily dissolve in water, flow out of the container bottom onto an impervious surface, and likely into a pipe that drains to a waterway. Replenishing the 2-3" of organic compost every year should provide adequate nutrition slowly and safely.
- Repot plants as needed with native soil (compost amended if necessary) or imported topsoil. Avoid potting soil, which will over nourish plants and cause nutrient pollution as described above.
- Replace dead plants. Consider that some plants are not well-suited to containers. Avoid or minimize flowering plants, which require more fertilizer than non-flowering plants.
- Irrigate perennial plants more in the first year and less to much less in subsequent years. Vary irrigation seasonally. At the beginning of summer, after the rains stop, water a little. Increase irrigation volume as the summer/dry season continues. Taper off irrigation as the rains return. Depending on your area and rainfall patterns, irrigation may be needed from May to October.

  The volume of water and frequency of watering varies with the type of plant:
  - Shrubs: 3-5 gallons once/week
  - Groundcover: 1-2 gallons, once or twice/week
  - Perennial herbs: ½ gallon, twice/week.

  Since contained planters will be placed over and presumably surrounded by impervious pavement or hot roofs, water plants once a week from July to mid-September after establishment period. Vegetables and other annuals may need a different volume of water than specified above.

VEGETATED ROOF (GREEN ROOF) BMP MAINTENANCE ACTIVITIES

Experience in the Pacific Northwest has shown vegetated roofs are surprisingly easy to maintain after the establishment period. The following maintenance activities apply to vegetated roof areas as shown on the site plan in Box 4. Maintenance is most demanding during the 3-year plant establishment period. Ongoing inspection and maintenance activities (including during the plant establishment period), include:

Ongoing inspection and maintenance activities (including during the plant establishment period), include:

- For roofs designed without irrigation, watering is left to nature. Where some plants may die, they can be replaced by casting sedum cuttings over the soil in the fall at less cost than watering all summer.
- For roofs with irrigation, water plants during the dry season with no more than 1 inch of water every 10 days. During the wet season, do not irrigate at all. Wet summers or over-irrigation may encourage weed growth.
- Inspect plants in early summer and early fall for overall health and coverage. Replace plants as needed in the fall. Perform weeding at the same visits and more often as needed, removing weeds before they go to seed. In Western Oregon, checking for weeds in late May or early June may limit the necessary weeding to once a year. Remember, irrigation encourages weed growth, so weeding may be needed more often. Do not apply herbicides or pesticides since these pollutants will be efficiently exported downstream.
- Inspect structures such as membrane (if visible), irrigation system, drains, parapets, and access structures annually. As necessary, remove sediment and debris around drains and unclog. Repair the structural integrity of the systems. Contact the manufacturer to repair leaks or tears in the membrane.

- Inspect plant health. If plants are struggling, correct the causes, which may include too much or too little water, pests, condensate from the HVAC system, or chemical spills from rooftop equipment maintenance.
- Inspect for and correct any erosion after large storms (i.e. 2 inches in 24 hours or extreme/high intensity cloud bursts) until plant coverage has been achieved.
- Some vegetated roofs may be designed to receive many visitors, who may not understand what they are visiting. This may increase the level of maintenance, for example by requiring more frequent trash pickups.
- Inspect the irrigation system annually. Look for exposed piping, broken irrigation heads, and especially leaks, which could be very detrimental to the stormwater performance of the vegetated roof and greatly increase vegetation related maintenance activities. Winterize and de-winterize the irrigation system make repairs as needed.
- Install erosion control fabrics against wind as needed to prevent loss of growing medium when replanting.

POROUS PAVEMENT BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to all porous pavement types (*i.e*. porous asphalt, pervious concrete, permeable pavers, & porous gravel), as shown on the site plan in Box 4. Maintenance activities for porous pavements are as follows:

Prevent Clogging

- Inspect landscape areas twice a year for erosion. Implement erosion prevention and sediment control measures as needed per the Oregon DEQ Construction Stormwater Erosion and Sediment Control and replant as soon as possible.
- Remove trash and litter, which may carry dirt. Frequency will vary with foot traffic. Busy commercial districts will need more frequent litter pick-ups than suburban or rural residential streets.
- Notify all landscape contractors of their responsibility to help maintain the pavement by requiring them to identify an alternative place to dump landscape materials.
- Never apply cinders to porous pavement. Remove snow and ice with snowplows or liquid deicers. Snowplowing is best; however, raise the plow when snowplowing over pavers, since the plow could catch edges. A number of environmentally sound, salt-free, liquid deicers are available and should be used. According to the National Ready Mixed Concrete Association, deicers should not be applied to pervious concrete in the first year after installation[8]. Other pavements, do not appear to have this sensitivity.
- Remove moss mechanically once a year during the dry season. All pavement in the Pacific Northwest is susceptible to moss. Do not apply mossicides. Some moss is acceptable.
- Maintain porous pavement and surrounding landscapes with integrated pest management. Fertilizers, pesticides, herbicides, or fungicides are all pollutants likely to leach through porous pavement.

Maintain Structures

- Control structures, such as catch basins and manholes should be cleaned out twice a year.
- Inspect and maintain permanent signage, if applicable.

[8] *Stormwater Solutions website. Retrieved from: http://www.estormwater.com/maintenance-pervades-pervious-concrete*

POROUS ASPHALT AND PERVIOUS CONCRETE SPECIFIC MAINTENANCE ACTIVITIES

In addition to the maintenance activities necessary for all porous pavements, perform the following maintenance activities for porous asphalt and pervious concrete areas as shown on the site plan in Box 4.

- Never seal coat porous asphalt.
- Damaged areas of 50 square feet or less may be patched with conventional asphalt, up to 10% of the total porous pavement area.
- Remove material on surface. The cleaning interval, which might range from every 6 months to every 3 years, should be based on possible exposure to sediments. Use one or more of the following methods:
    - Vacuum twice per year. If the pavement is in a public ROW where agencies sweep the streets with a vacuum truck, then porous pavements will receive this recommended maintenance. It's difficult to get suction on a porous pavement that hasn't at least partially clogged, so this may not be a useful alternative until years into the pavement's life cycle.
    - Pressure washing can be done at an angle to the pavement and not directly into it. Employ erosion control measures when pressure washing. Vactor truck pressure washing once per year is especially good at removing moss. Leaf blowers during the dry season, when material can be blown, are also an option.
    - Leaf/Litter vacuums have been used successfully, the City of Olympia uses a Minuteman Parker Vac-35[9].
    - Propane torches are useful to kill moss on concrete, but avoid using them on asphalt, which can be damaged by the heat.

Test Surface Permeability Specific to Porous Asphalt and Pervious Concrete. If the infiltration rate of the pavement slows over time, it may be desirable to test the infiltration rate. When the pavement is suspected of draining slower than needed for the design storm, test pervious concrete or porous asphalt surfaces per ASTM C1701.

PERMEABLE PAVERS SPECIFIC MAINTENANCE ACTIVITIES

In addition to the maintenance activities necessary for all porous pavements, perform the following maintenance activities for permeable paver areas as shown on the site plan in Box 4.

- Manage weeds. Permeable paver surfaces have a tendency to grow plants in the infill spaces. Use integrated pest management approaches such as hand-pulling or by using a torch. Commercial maintenance services with trucks that will burn all the weeds off at once are available in Oregon.
- Remove material on surface for maintenance or to unclog a clogged surface. Vacuuming, pressure washing, and leaf blowing may all be used on these systems; however, operations may remove or disturb the infill rock. Replenish it with clean rock meeting the AASHTO No. 8 or equivalent specification (see **Appendix D**).

Test Surface Permeability Specific to Permeable Pavers. Same as porous asphalt and pervious concrete, but test permeability per ASTM C1781.

POROUS FLEXIBLE PAVING SYSTEMS SPECIFIC MAINTENANCE ACTIVITIES

In addition to the maintenance activities necessary for all porous pavements, perform the following maintenance activities for porous flexible paving system areas as shown on the site plan in Box 4.

[9], *Gwilym, K. (2014). WSU & Puget Sound Partnership Permeable Pavement LID Workshop: Operations and Maintenance: Page 23. Retrieved from: http://goo.gl/h5erqF*

Refer the specific manufacturer's maintenance requirements to this O&M Agreement:
Manufacturer: ______________________________________

Some general guidance is as follows:

- For porous flexible paving systems with grass, maintenance is similar to turf.
- For flexible paving systems with gravel, broom or rake dislodged gravel back in place.
- Manage weeds. Use integrated pest management approaches such as hand-pulling (during the wet weather when soils are softer and roots can be effectively removed), or by burning or pouring hot water on weeds.
- Inspect for bare soil, exposed rings, ruts, poorly growing grass from too much shade, and thatch.
- In the case of spills, ruts, or disturbance to access underground utilities, the flexible paving systems may be cut with a sod cutter, set aside, and put back in placed after subgrade has been reconstructed.
- Avoid aeration since this machinery will damage the pavement.
- Snow plowing may be done by "using standard truck-mounted snow plowing blades with small skids on the corners to keep the bottom of the blade"[10] about 1" above the grass surface.

POROUS GRAVEL SPECIFIC MAINTENANCE ACTIVITIES

In addition to the maintenance activities necessary for all porous pavements, perform the following maintenance activities for porous gravel areas as shown on the site plan in Box 4.

- Manage weeds. Hand pull, burn with a torch, or pour hot water on them in May and October.
- If the rock surface gets clogged, carefully shovel the first 1 to 2 inches of rock and rinse it off in a disconnected landscape area, which is an area that does not drain to any sort of structured inlet or towards any surface like a driveway or road that drains to a structured inlet. Employ appropriate erosion control techniques during the washing, as necessary to prevent erosion and capture sediment.

RAIN GARDEN, STORMWATER PLANTER, & LID SWALE BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to rain gardens, stormwater planters, LID swales, and/or water quality conveyance swales, as shown on the site plan in Box 4.

- Do not mow these facilities, regardless of whether they are planted with lawn/sod or bunch grasses. This greatly reduces the capacity for the facility to slow flows and settle out solids.

Inspect the facility a minimum of 4 times per year and perform needed maintenance as follows:

- Maintain a calm flow of water entering the facility via downspout pipes or other inlets.
    - o Identify erosion sources and control them when soil is exposed, or erosion channels are forming. A settling basin or other effective means shall be placed around the point where water is discharged into the facility to slow the water and prevent erosion. Fill erosion channels with approved soil mix, not mulch, compost, or rock, and replant using a species of plant in the facility adjacent to the eroded channel.
    - o Identify and correct sources of sediment and debris.
- Remove sediment and debris from:
    - o The pretreatment sump

---

[10] *Marine Amazing website. Stormwater Management. Retrieved from:* *http://www.psparchives.com/publications/our_work/stormwater/lid/2009_Local_Assitance/005_Appendices/Grasspave2MaintenanceGuide.pdf*

  - Facility surface when more than 1" thick or damaging vegetation. Minimize damage to vegetation.
  - The facility outlet, such as overflow drain or conveyance swale.
  - Curb cuts when depth exceeds ¼ inch.
  - **S**tabilize slopes with plants and appropriate erosion control measures when soil is exposed, or erosion channels are forming. Fill eroded channels with approved soil and replant. If flows can be redirected temporarily, redirect flows until plants establish. Check for erosion as a result of redirected flows on the next site visit.
- Maintain the design ponding depth by:
  - Repairing any structural elements that may leak from cracks or worn sealant
  - Maintaining the design elevation of check dams
- Soil should allow storm water to infiltrate uniformly through the BMP.
  - If the facility does not drain within 48 hours, scrape 1 inch of soil out of the facility and replace with imported soil meeting the specifications provided in Appendix D: Specifications "*Treatment Soil*". Infiltration test the facility to confirm drainage by either soaking the entire facility with water or by observing the facility during the next rain event.
  - If facility does not drain after scraping 1", try another 1" depth.
  - If facility does not drain after scraping 2", salvage plants, till and replant the facility.
  - Debris in quantities that inhibit infiltration shall be removed routinely (*e.g.*, no less than quarterly), or upon discovery.
- Vegetation should be healthy and dense enough to provide filtering while protecting underlying soils from erosion with at least 95% coverage of bare soil in three years.
  - Replenish mulch until vegetation is established and shading the bottom of the facility.
  - Remove fallen leaves and debris from deciduous plant foliage, especially if the facility is in a roadway with trees located upstream from a curb.
  - Don't string trim ornamental grasses, sedges or rushes. These may be raked.
  - Remove nuisance (*i.e*. plants blocking the inlet) and non-native and invasive vegetation (*i.e.* weeds such as Himalayan blackberries and English Ivy) when discovered.
  - Remove dead vegetation and woody material before it covers 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.
  - Maintain vegetation using integrate pest management approaches such as hand pulling weeds. Avoid the use of fertilizers, pesticides, and herbicides, as these are common pollutants found in waterways.
  - Irrigate during the establishment period. Watering and weeding may be needed frequently within the first 1 to 3 years during Oregon's very dry summers, but this should taper off dramatically if you choose native perennial plants. The goal during the establishment period is to make plants as "drought proof" as possible by watering deeply and infrequently. Shallow, frequent watering will only make plants dependent on continued watering.
  - To establish perennial plants, you'll need to irrigate more in the first year and less to much less in subsequent years. In addition, plants benefit from varying irrigation seasonally. At the beginning of summer, after the rains stop, water a little. Increase irrigation volume as the summer/dry season continues. Taper off irrigation as the rains return. Depending on your area and rainfall patterns, irrigation may be needed from May to October.
  - The volume of water and frequency of watering varies with the type of plant:
    - Trees: 5-10 gallons, once/week
    - Shrubs: 3-5 gallons once/week

        - Groundcover: 1-2 gallons, once or twice/week
        - Perennial herbs: ½ gallon, twice/week.
    - After the 2 – 3 year establishment period, irrigation would theoretically not be needed; however, plantings surrounded by impervious pavement will probably require occasional irrigation beyond the establishment period, indefinitely.
- Exercise spill prevention measures when handling substances that can contaminate stormwater.
    - Correct releases of pollutants as soon as identified:
        - Make sure the area is safe to enter
        - Block the outflow of the BMP
        - Block the inflow of the BMP
        - Stop the release of the hazmat
        - Clean up the flow path to the BMP
        - Clean out the BMP, replacing soil, amended soil and vegetation as necessary.

SOAKAGE TRENCH BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to soakage trenches, as shown on the site plan in Box 4. Inspect the facility a minimum of 4 times per year during each season and after major storms and perform needed maintenance as follows:

- Confirm via the observation port or other structure that the facility is emptying out/infiltrating. Clogged facilities (*i.e.* not draining within 30 hours) must be completely reconstructed or relocated.
- Remove debris from pipes and other conveyance.
- Repair or replace damaged pipes.
- For soakage trenches that receive runoff from adjacent surfaces, sediment and debris will tend to clog the surface of the facility. Vacuum sediment from rocks. If water can no longer drain into the facility, clogging of the top geotextile has occurred. Using sediment control techniques such as compost berms and biobags, carefully remove and clean rock on the surface. Replace the geotextile fabric on the top, being careful not to damage the fabric on the sides. Place the cleaned rock back over the geotextile fabric. Dispose of sediment in trash. Sweeping regularly will reduce the likelihood of clogging. High traffic areas will clog faster than low traffic areas.
- Maintain manufactured structures like silt basins and water quality manholes per manufacturer's operations and maintenance guidelines. The manufacturers of structures on this site include (continue listing below if more than two):

  Manufacturer: ________________________________

  Manufacturer: ________________________________

DRYWELL BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to drywells as shown on the site plan in Box 4. Properly cared for drywells in Oregon are still functioning after 80 years. It is unlikely that a facility can be repaired when it becomes clogged, so proper maintenance is critical.
Maintenance activities include:

- Remove excess debris from all structures twice a year.
- Control erosion from areas draining to drywell.
- Pick up and remove trash.
- Maintain piping to and from drywell using industry standard best practices. Remove any vegetation that might clog these.

- Inspections should occur frequently and decline in frequency with larger facilities.
  Vacuum excess sediment from the pretreatment sump and the sump installed on the bottom of the drywell itself on an annual basis in the fall or more often as dictated by site conditions.

WATER QUALITY CONVEYANCE SWALE BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to water quality conveyance swales as shown on the site plan in Box 4.

Inspect the facility a minimum of 4 times per year and perform needed maintenance as follows:

- Maintain a calm flow of water entering the facility via downspout pipes or other inlets.
  - Identify erosion sources and control them when soil is exposed, or erosion channels are forming. A settling basin or other effective means should be placed at the point where water is discharged into the facility to slow the water and prevent erosion. Fill erosion channels with approved soil mix, not mulch, compost, or rock, and replant using a plant species found in the facility adjacent to the eroded channel.
  - Identify sources of sediment and debris and correct.
- Remove sediment and debris from:
  - Pretreatment sump
  - Facility surface when more than 1" thick or damaging vegetation. Minimize damage to vegetation.
  - Facility outlet, such as overflow drain or conveyance swale.
  - Curb cuts when depth exceeds ¼ inch.
- Stabilize slopes with plants and appropriate erosion control measures when soil is exposed, or erosion channels are forming. Fill eroded channels with approved soil and replant. If flows can be redirected temporarily, redirect flows until plants establish. Check for erosion due to redirected flows on the next site visit.
- Maintain the design ponding depth by:
  - Repairing any structural elements that may leak from cracks or worn sealant
  - Maintaining the design elevation of check dams
- Vegetation should be healthy and dense enough to provide filtering while protecting underlying soils from erosion with at least 95% coverage of bare soil in three years.
  - Replenish mulch until vegetation in the bottom of the WQ conveyance swale is established and shading the bottom of the facility.
  - Remove fallen leaves and debris from deciduous plant foliage, especially if the facility is in a roadway with trees located upstream from a curb.
  - Don't string trim ornamental grasses, sedges or rushes. These may be raked.
  - Remove nuisance (*i.e.* plants blocking the inlet) and non-native and invasive vegetation (*i.e.* weeds such as Himalayan blackberries and English Ivy).
  - Remove dead vegetation and woody material before they cover 10% of the rain garden surface area. Vegetation should be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed.
  - Maintain vegetation using integrate pest management such as hand pulling weeds. Avoid use of fertilizers, pesticides, and herbicides, as these are common pollutants found in waterways.
- Exercise spill prevention measures when handling substances that can contaminate stormwater. Correct releases of pollutants as soon as identified:
  - Make sure the area is safe to enter
  - Block the outflow of the BMP
  - Block the inflow of the BMP

  - Stop the release of the hazmat
  - Clean up the flow path to the BMP
  - Clean out the BMP, replacing soil, amended soil and vegetation as necessary.
- Mow if required by ODOT.

DISPERSION BMP MAINTENANCE ACTIVITIES

The following maintenance activities apply to dispersion BMPs (*i.e.* vegetated filter strips or downspout disconnection) as shown on the site plan in Box 4.
Common maintenance tasks are as follows:

- Mow and trim grasses (when dry) to lengths appropriate to the type and species of grass. Longer grass is generally better, and mowing is not required if it is not desired.
- Identify and correct sources of sediment and debris.
- Inspect for and remove excess sediment (maximum depth of 2 inches) that may affect vegetation growth in the dispersion area or the level spreader. Dispose of sediment in the trash.
- Replace vegetation as needed. If a plant did not do well, choose a different plant.
- Repair eroded areas where channels have formed by filling them with soil, lightly compacting them with tamping or boot compaction, and reestablish vegetation. Do not fill eroded channels with mulch. If possible, redirect flows around the establishing vegetation for three (3) months. Inspect other areas around redirecting device (ex. sandbag) to ensure that this redirection is not causing additional erosion. If plants receiving redirected flows are small or not very sturdy and erosion is or may occur, biobags (a sediment control measure, which is a bag with compost or wood chips) will allow water to enter the vegetated filter strip slowly and may be a better way to prevent erosion than redirecting flows.
- Because vegetated filter strips look very similar to a regular garden, some sort of permanent demarcation, such as fencing (even something as simple and attractive as a 2-foot-tall post and chain fence) should be installed if the area is receiving regular foot traffic that is compacting soils and/or impacting plant health.

LEVEL SPREADER MAINTENANCE ACTIVITIES

The following maintenance activities apply to level spreaders, as shown on the site plan in Box 4.

In high sediment areas, level spreaders will be high maintenance elements of a BMP. Spreading water out so that it cascades over a level spreader instead of concentrating at a single point and causing erosion is difficult to achieve. While the level spreader design recommended here may be high maintenance, it will reduce problems with erosion and is considered an effective means of spreading out flows.

The main maintenance activity with a level spreader is keeping the rock clean, so that the rough edges of the angular rock remain exposed to the runoff and are able to slow and spread it. This slowing of runoff causes sediments to settle out and serves as pretreatment for a best management practice such as a vegetated filter strip or a rain garden.

Maintenance activities include:

- Remove weeds twice a year if enough sediment accumulates to grow weeds but not enough accumulates to warrant cleaning the rock.
- Clean rock before the angular rock is completely buried in sediment. Frequency will depend on the type of pavement and if any uphill landscape areas draining across the pavement are stabilized. Roofs generally contribute the least amount of sediment, although roofs near highways will have more particulates deposited on their surface. Generally, for roads, sediment will increase

with the number of cars on them. Lawns will contribute the highest volume of sediment, if they happen to be uphill of the pavement that drains to the vegetated filter strip.

Using a flat shovel, remove the rock to a depth of at least 6 inches. Install appropriate erosion control techniques (See the DEQ's "Construction Stormwater Erosion and Sediment Control Manual[11]) such as biobags or wattles. On a plastic tarp, hose off the rock, ideally located in an area that is hydraulically isolated and will not drain to a catch basin or other conveyance system. Place the clean rock back and dispose of sediment and organic matter in the trash.

- Stabilize landscapes draining to the level spreader to reduce maintenance.
- Maintain and re-establish, if necessary, if flows into the facility are not well distributed across the level spreader.
- Sweep rocks back into place as needed to prevent a tripping hazard condition.

WET, EXTENDED WET, AND DRY DETENTION PONDS

Maintenance activities for ponds will be unique each project. Project planner must submit an adapted maintenance plan with application package. The maintenance plan below should serve as a minimum guideline to maintenance activities.

Ponds are constructed ponds with a permanent pool of water. Pollutants are removed from stormwater through gravitational settling and biologic processes. Extended Wet Ponds are constructed ponds with a permanent pool of water and open storage space above for short-term detention of large storm events. Pollutants are removed from stormwater through gravitational settling and biologic processes. Dry Detention Ponds are constructed ponds with temporary storage for the detention of large storm events. The stormwater is stored and released slowly over a matter of hours.

All facility components, vegetation, and source controls shall be inspected for proper operations and structural stability. Gauges located at the opposite ends of the wet pond shall be maintained to monitor sedimentation. Gauges shall be checked 2 times per year. These inspections shall occur, at a minimum, quarterly for the first 2 years from the date of installation, and 2 times per year thereafter, and within 48 hours after each major storm event.

Training and/or Written Guidance information for operating and maintaining Ponds shall be provided to all property owners and tenants. A copy of the O & M Plan shall be provided to all property owners and tenants.

Inspection Logs shall be kept by the facility owner demonstrating the following items have been inspected and are being maintained properly:

- **Access** to Ponds shall be safe and efficient. Vehicular routes shall be maintained to design standards to accommodate size and weight of vehicles. Obstacles preventing maintenance personnel and/or equipment access shall be removed.
- **Debris and Litter** shall be removed to prevent channelization, clogging, and interference with plant growth. Fallen leaves and debris from deciduous plant foliage shall be raked and removed.
- **Erosion Damage** shall be identified and controlled when native soil is exposed or erosion channels are forming.
- **Inlets** shall be cleared when conveyance capacity is plugged to ensure unrestricted stormwater

[11] *Oregon Department of Environmental Quality. (2013). Water Quality Division. Construction Stormwater Erosion and Sediment Control manual. Retrieved from: http://www.deq.state.or.us/wq/wqpermit/docs/general/npdes1200c/ErosionSedimentControl.pdf*

flow to the wet pond.

- **Nuisance or Prohibited Vegetation** from the Eugene Plant List (such as blackberries or English Ivy) shall be removed when discovered. Invasive vegetation contributing up to 25% of vegetation of all species shall be removed and replaced.
- **Outlets and Overflow Structures** shall be cleared when 50% of the conveyance capacity is plugged.
- **Piping** shall be examined and re-installed if more than 1-inch of settlement. Remove sediment deposits to maintain flow capacity.
- **Rocks or Other Armoring** shall be replaced when only one layer of rock exists above native soil.
- **Sedimentation** build-up near or exceeding 50% of the facility capacity shall be removed every 2-5 years, or sooner if performance is being affected. Wet Ponds shall be dredged when 1 foot of sediment accumulates in the pond.
- **Slopes** shall be stabilized using appropriate measures when native soil is exposed.
- **Vegetation** shall be healthy and dense enough to provide filtering while protecting underlying soils from erosion and minimizing solar exposure of open water areas. Vegetation producing foul odors shall be eliminated. Dead vegetation shall be removed to maintain less than 10% of area coverage or when wet pond function is impaired. Vegetation shall be replaced within 3 months, or immediately if required to maintain cover density and control erosion where soils are exposed. Vegetation, large shrubs or trees that limit access or interfere with wet pond operation shall be pruned or removed. Grass (where applicable) shall be mowed to 4”-9” high and grass clippings shall be removed.

Spill Prevention Measures shall be exercised on site when handling substances that contaminate stormwater. Releases of pollutants shall be corrected as soon as identified. Gravel or ground cover shall be added if erosion occurs, e.g., due to vehicular or pedestrian traffic.

Non-Chemical Pest Control measures shall be taken to prevent development of insects, mosquitoes, and rodents.

- If a complaint is received or an inspection reveals that the pond is significantly infested with mosquitoes or other vectors, the property owner/owners or their designee will be required to eliminate the infestation. Control of the infestation shall be attempted by using first non-chemical methods and secondly, only those chemical methods specifically approved by the City.
- Acceptable methods include but are not limited to the following:
  - Installation of predacious bird or bat nesting boxes.
  - Alterations of pond water levels approximately every four days in order to disrupt mosquito larval development cycles.
- If non-chemical methods have proved unsuccessful, contact the City prior to use of chemical methods such as the mosquito larvicides Bacillus thurengensis var. israeliensis or other approved larvacides. These materials may only be used with City approval if evidence can be provided that these materials will not migrate off-site or enter the public stormwater system. Chemical larvicides shall be applied by a licensed individual or contractor.

CHAPTER 7: ON-SITE SOURCE CONTROLS
TABLE OF CONTENTS

ON-SITE SOURCE CONTROLS - INTRODUCTION

Some site characteristics and uses may generate specific pollutants that are not addressed solely through implementation of the stormwater quality measures identified in **Chapter 2**. The site characteristics and uses in this chapter have been identified as potential sources for chronic loadings or acute releases of pollutants such as oil and grease, toxic hydrocarbons, heavy metals, toxic compounds, solvents, abnormal pH levels, nutrients, organics, bacteria, chemicals, and suspended solids. This chapter presents source controls for managing these pollutants at their source.

Industrial facilities may be subject to additional requirements through State of Oregon issued NPDES permits or as outlined in Oregon Administrative Rules (OAR) 340 Division 041. Lists of prohibited discharges to the City's storm sewer system is found in the Municipal Code. The City has used these standards in the development of the listed source controls so that stormwater discharges can better meet these criteria.

The requirements and implementation of this chapter is in addition to the applicable water quality, and flow control requirements.

Applicants may propose alternatives to the source controls identified in this chapter. Proposal of an alternative source control or alternative design element will require an additional review process.

Site Uses and Characteristics That Trigger Source Controls

Projects with the following site uses and characteristics are subject to the design methodologies of this chapter:

- Fuel dispensing facilities and surrounding traffic areas
- Above-ground storage of liquid materials
- Solid waste storage areas, containers, and trash compactors
- Outdoor storage of bulk materials
- Equipment and/or vehicle washing facilities
- Stormwater and groundwater management for development on land with suspected or known contamination

Applicants are required to address all the site characteristics and uses listed throughout this chapter. For example, if a development includes both a fuel dispensing area and a vehicle washing facility, the source controls in both sections will apply.

Source Control Goals and Objectives

The specific source control standards are based on the following goals and objectives:

A. Prevent stormwater pollution by eliminating pathways that may introduce pollutants into stormwater.

B. Protect soil, groundwater and surface water by capturing acute releases and reducing chronic contamination of the environment.

C. Direct contaminated discharges (including wash water) to a destination that meets all applicable code requirements and facilitates cleanup.

D. Direct areas that have the potential for acute releases or accidental spills and are not expected to regularly receive flow or require water use (such as covered fuel islands or covered containment areas), to an approved method of containment or destination.

E. Safely contain spills on-site, avoiding preventable discharges to the storm drain, wastewater facilities, surface water bodies, or underground injection control structures (UICs).

F. Emphasize structural controls over operational procedures. Structural controls are not operator dependent and are considered to provide more permanent and reliable source control. Any proposals for operation-based source controls need to describe the long-term viability of the maintenance program.

Signage

Informational signage is required for certain site uses and activities that may pollute stormwater. Signage addresses good housekeeping rules and provides emergency response measures in case of an accidental spill.

Required spill response supplies must be clearly marked, located where the signage is posted (or the location of the supplies must be clearly indicated by the signage), and must be located near the high-risk activity area. Required spill response supplies, such as absorbent material and protective clothing, should be available at all potential spill areas. Employees must be familiar with the site's operations and maintenance plan and proper spill cleanup procedures.

All signage shall conform to the standards described in the following box. Additional signage for specific activities is noted in applicable sections.

Signs shall be 8.5" x 11" or larger and located to be plainly visible from all activity areas. More than one sign may be needed to accommodate larger activity areas. Signs shall be water-resistant and shall include the following information:

- Safety precautions for self-protection and spill containment.
- Immediate spill response procedures—for example: "Turn the valve located at..." or "Use absorbent materials"
- Emergency contact(s) and telephone number(s)—for example: "Call 911"

Request for Alternative Design Method of Source Control

Applicants must notify the City's Public Works Department of their request in writing, specifying the reason for the request and supporting it with technical and factual data.

Staff will check the supporting information submittal for completeness prior to review and decision. If the request cannot be satisfied with this process, the adjustment review process will be implemented.

FUEL DISPENSING FACILITIES

Fuel Dispensing Facilities include areas where fuel is transferred from bulk storage tanks to vehicles, equipment, and/or mobile containers (including fuel islands, above ground fuel tanks, fuel pumps, and the surrounding pad). This applies to large-sized gas stations as well as single-pump fueling operations.

Cover

The fuel dispensing area shall be covered with a permanent canopy, roof, or awning so precipitation cannot come in contact with the fueling activity areas. Rainfall shall be directed from the cover to an approved stormwater destination.

Covers 10 feet high or less shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area/pad it is to cover.

Covers higher than 10 feet shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated fueling activity area/pad it is to cover.

Pavement

A paved fueling pad shall be placed under and around the fueling activity area with asphalt or concrete and shall meet all applicable building code requirements. Sizing of the paved areas shall be adequate to cover the activity area, including placement and number of the vehicles or pieces of equipment to be fueled by each pump.

Fuel pumps shall be located a minimum of seven feet from the edge of the fueling pad.

Drainage

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains. This will prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to a spill controlled holding area. Surrounding runoff shall be directed away from the hydraulically isolated fueling pad to a stormwater destination that meets all stormwater management practices of this manual and other applicable code requirements.

Signage

Signage shall be provided at the fuel dispensing area and shall be plainly visible from all fueling activity areas. Signage must clearly specify the location of any applicable spill control kits, shut-off valves, etc. and include all necessary instructions for their use.

Spill Control Holding Area

A spill control holding area shall be installed on the discharge line of the fueling pad. The tee section shall extend 18 inches below the outlet elevation, with an additional 3 feet of dead storage volume below the tee to provide storage for oil and grease. The total containment volume shall be no less than 110% the volume of the largest container or 10% of the total volume of product stored, whichever is larger. The holding area shall be located on private property.

Shut-Off Valves

Shut-off valves may be required to protect the City stormwater systems or onsite infiltration facilities of spill risks from chemicals and other constituents that provide a danger for wide spread contamination, system damages or risk to the public health. Manual shut-off valves shall not be permitted unless a request for an adjustment is approved by the City.

Shut-off valves may be required in the following situations:

- Site or activity areas where corrosives or oxidizers are used or stored (for example, concentrated acids are corrosives having a pH of less than or equal to 5.0 and bases such as sodium or ammonium hydroxide having a pH of greater than or equal to 12.0, common oxidizers are hydrogen peroxide and bleach); or
- Substances which are water soluble or float on water; or
- Solvents and petroleum products

Additional requirements

- **Installation, alteration, or removal of above-ground fuel tanks larger than 55 gallons, and any related equipment,** are subject to additional permitting requirements by the City of Grants Pass.
- **Bulk fuel terminals**, also known as tank farms, will require the following:
  - Secondary containment equal to 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.
  - A separate containment area for all valves, pumps and coupling areas with sub-bermed areas either in front of or inside the main containment areas. These sub-bermed areas

are required to have rain shields and be directed to a temporary holding facility for proper disposal.

- <u>An impervious floor within all containment areas</u>. Floors must be sealed to prevent spills from contaminating the groundwater.
- <u>Truck loading and off-loading areas</u>. These areas shall follow cover, pavement, drainage, spill control, and shut-off valve requirements identified for fuel dispensing facilities.

Underground fuel tanks less than 4,000 gallons in size are subject to additional permitting requirements by Oregon's Department of Environmental Quality (DEQ) and tanks larger than 4,000 gallons are referred to the Federal Environmental Protection Agency (EPA). For technical questions and permitting, call DEQ's Western Region main office at 1-800-844-8467 and ask for the Underground Storage Tank Permitting Department.

ABOVE-GROUND STORAGE OF LIQUID MATERIALS

Containment

Liquid materials shall be stored and contained in such a manner that if the container(s) is ruptured, the contents will not discharge, flow, or be washed into a receiving system. A containment device and/or structure for accidental spills shall have enough capacity to capture a minimum of 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

Containers, such as double-walled containers, with internal protection are considered to meet this requirement.

Cover

Storage containers (other than tanks) shall be completely covered to prevent stormwater contact. Runoff shall be directed from the cover to a stormwater destination that meets all stormwater management practices of this manual and other applicable code requirements.

Covers 10 feet high or less shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Covers higher than 10 feet shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Pavement

All above ground storage of liquid material must occur in paved areas. The storage area shall be paved with asphalt or concrete and shall meet all applicable building code requirements. Sizing of the paved areas shall be adequate to cover the area intended for storage.

Drainage

All paved storage areas shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater draining on to a storage area.

Covered storage areas: Limited to zero precipitation is expected to accumulate under covered storage areas. Drainage facilities <u>are not required</u> for the contained area beneath the cover.

Signage

Signage shall be provided at the liquid storage area and shall be plainly visible from all surrounding activity areas.

SOLID WASTE STORAGE

Solid Waste Storage Areas, Containers, and Trash Compactors include outdoor areas with one or more facilities that store solid waste (both food and non-food waste) containers. Single and double-family residential solid waste storage areas, containers, and trash compactors are exempt from this code subsection.

Solid waste includes both food and non-food waste or recycling. Solid waste containers include compactors, dumpsters, compost bins, grease bins, recycling areas, and garbage cans. Debris collection areas used only for the storage of wood pallets or cardboard is excluded from these requirements.

The following site uses and activities apply to this section and include all commercial and industrial development with facilities that store solid wastes, both food and non-food.

- Outdoor solid waste storage areas.
- Multi-family (three or more) residential sites if a shared trash collection area is proposed.
    - Multi-residential ONLY. A request can be made to direct the drainage from the hydraulically isolated activity area to the development's stormwater quality facility. For more information, refer to Additional Requirements below.
- Activity areas used to collect and store refuse or recyclable materials, such as can or bottle return stations and debris collection areas.
- Facilities whose business is to process and/or recycle wood pallets or cardboard.
- Compactors (regardless of use).

Design

For approval of solid waste storage and handling activity areas in the City of Grants Pass, Cover, Pavement, Isolation, and Drainage requirements will apply.

Cover

A permanent canopy, roof, or awning must be provided to cover the solid waste storage activity area and shall be constructed to cover the activity area so rainfall cannot come in contact with the waste materials being stored. The cover shall be sized relative to the perimeter of the hydraulically isolated activity area it is to cover. Runoff shall be directed from the cover to a stormwater destination that meets all stormwater management practices of this manual and other applicable code requirements.

OUTDOOR STORAGE OF BULK MATERIALS

Any bulk materials storage location that is not completely enclosed by a roof and sidewalls is an outdoor storage area.

Bulk Materials Categories

Bulk materials are separated into three categories based on risk assessments for each material stored: high-risk, low-risk, and exempt.

Table 7-1: Bulk materials risk assessment categories

High-Risk Materials	Low-Risk Materials	Exempt Materials
• Recycling materials with potential effluent • Corrosive materials (*e.g.* lead-acid batteries) • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Asphalt • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human wastes • Treated Lumber	• Recycling materials without potential effluent • Scrap or salvage goods • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products without potential effluent • Unwashed gravel/rock • Composting Operations	• Washed gravel/rock • Finished lumber • Plastic products (hoses, gaskets, pipe, *etc.*) • Clean concrete products (blocks, pipe, *etc.*) • Glass products (new, non-recycled)

Cover

Low-risk materials must be covered with a temporary plastic film or sheeting at a minimum.

High-risk materials are required to be permanently covered with a canopy or roof to prevent stormwater contact and minimize the quantity of rainfall entering the storage area. Runoff shall be directed from the cover to a stormwater destination that meets all applicable code requirements.

Covers 10 feet high or less shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Covers higher than 10 feet shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Pavement

Low-risk material storage areas are not required to be paved.

High-risk material storage areas shall be paved beneath the structural cover, floors must be sealed.

Drainage

Low-risk material storage areas are allowed in areas served by standard stormwater management systems.

However, all erodible materials being stored must be protected from rainfall.

If materials are erodible, a structural containment barrier shall be placed on at least three sides of every stockpile to act as a barrier to prevent uncontaminated stormwater from running onto the storage area and carrying pollutants away. If the area under the stockpile is paved, the barrier can be constructed of asphalt berms, concrete curbing, or retaining walls. If the area under the stockpile is unpaved, sunken retaining walls or ecology blocks can be used. The applicant shall clearly identify the method of containment on the building plans.

For **high-risk** material storage areas, the paved area beneath the structural cover shall be hydraulically isolated through grading, structural containment berms or walls, or perimeter drains to prevent runoff. Significant amounts of precipitation are not expected to accumulate in covered storage areas, and thus, drainage facilities <u>are not required</u> for the containment area beneath the cover.

Additional Requirements

Storage of pesticides and fertilizers may need to comply with specific regulations outlined by the Oregon Department of Environmental Quality (DEQ). For answers to technical questions, call DEQ's Western Region main office at 1-800-844-8467.

Signage shall be provided at the storage area if hazardous materials or other materials of concern are stored. Signage shall be located so it is plainly visible from all storage activity areas. More than one sign may be needed to accommodate large storage areas.

Alternative Protection Measures

In lieu of covering mineral resource mining, recovery, stockpiling, and processing operations and low-risk material storage areas receiving land use approval, the applicant may propose alternative protection measures that demonstrate that stormwater runoff from the site will not contaminate adjoining properties, surface waters, and ground water as part of their land use application.

MATERIAL TRANSFER AREAS/LOADING DOCKS

Material Transfer Areas/Loading Docks include areas that are either interior or exterior to a building, designed to accommodate a commercial truck/trailer being backed up to or into them, and used specifically to receive or distribute materials to and/or from commercial trucks/trailers. Includes loading/unloading facilities with docks, and large bay doors without docks.

These requirements also apply to all development proposing the installation of new material transfer areas or structural alterations to existing material transfer areas (*e.g.*, access ramp regrading, leveler installations) with the following characteristics:

- The area is designed (size, width, *etc.*) to accommodate a **commercial truck (1 ton and larger)** or trailer being backed up to or into it; <u>and,</u>
- The area is designed so that it can be used to receive or distribute materials to and from trucks or trailers.

Two standard types of **material transfer areas** associated with buildings are:

- Loading/unloading facilities with docks
- Large bay doors without docks

The requirements in this section do not apply to material transfer areas or loading docks used only for midsized to small-sized passenger vehicles and areas restricted by lease agreements or other regulatory requirements to storing, transporting or using materials that are classified as domestic use, for example, primary educational facilities (elementary, middle or high schools), or buildings used for temporary storage, and churches.

Cover

The hydraulically isolated areas in front of loading docks are required to be permanently covered with a canopy or roof to prevent stormwater contact and to minimize the quantity of rainfall entering the loading dock area. Runoff shall be directed from the cover to a stormwater destination that meets all stormwater management practices of this manual and other applicable code requirements.

Covers 10 feet high or less shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Covers higher than 10 feet shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated activity area.

Pavement

A paved material transfer area shall be placed underneath and around the loading and unloading activity area with asphalt or concrete that meets all applicable building code requirements. This will reduce the potential for soil contamination with potential impacts on groundwater and will help control any acute or chronic release of materials present in these areas.

Drainage

Loading Docks: Drainage from the hydraulically isolated area shall be contained and disposed of per appropriate codes.

An appropriately sized storage structure (such as a catch basin with no outlet or dead-end sump) will be required

Bay Doors and Other Interior Transfer Areas: Because interior material transfer areas are not expected to accumulate precipitation, installation of floor drains is not required or recommended. It is preferable to handle these areas with a dry-mop or absorbent material.

Isolation

Loading Docks: The first three feet of the paved area, measured from the building or dock face, shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away.

Bay Doors and Other Interior Transfer Areas: Bay doors and other interior transfer areas shall be designed so that stormwater runoff does not enter the building. This can be accomplished by grading or drains. Interior surfaces may not drain or be washed down to the exterior of the building.

Signage

Signage shall be provided at the material transfer area and shall be plainly visible from all surrounding activity areas.

Additional Requirements

Bay doors and other interior transfer areas shall provide a 10-foot “no obstruction zone” beyond the entrance within the building. This will allow the transfer of materials to occur with the truck or trailer end placed at least 5 feet inside the building, with an additional staging area of 5 feet beyond that. The “no obstruction” zone shall be clearly identified on the stormwater management plan and on the building plan at the time of the building permit application. The area shall be identified at the facility by painting the “no obstruction zone” with bright or fluorescent floor paint.

EQUIPMENT AND/OR VEHICLE WASHING FACILITIES

Equipment and/or Vehicle Washing Facilities include designated equipment and/or vehicle washing or steam cleaning areas, including smaller activity areas such as wheel washing stations.

Cover

The washing area shall be covered with a permanent canopy or roof so precipitation cannot come in contact with the washing activity area. Precipitation shall be directed from the cover to a stormwater destination that meets all stormwater management practices of this manual and other applicable code requirements.

Covers 10 feet high or less shall have a minimum overhang of 3 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.

Covers higher than 10 feet shall have a minimum overhang of 5 feet on each side. The overhang shall be measured relative to the perimeter of the hydraulically isolated washing activity area it is to cover.

Pavement

A paved wash pad shall be placed under and around the washing activity area with asphalt or concrete that meets all applicable building code requirements. Sizing of the paved area shall adequately cover the activity area, including the placement of the vehicle or piece of equipment to be cleaned.

Drainage

The paved area beneath the cover shall be hydraulically isolated through grading, berms, or drains to prevent uncontaminated stormwater from running onto the area and carrying pollutants away. Drainage from the hydraulically isolated area shall be directed to the City’s wastewater facility, or authorized pretreatment facility and shall have isolation capability. Surrounding runoff shall be directed away from the hydraulically isolated washing pad to a stormwater destination that meets all applicable requirements of this manual.

Oil Control

All vehicle and equipment washing activities will be reviewed for needed oil controls to comply with the City’s wastewater discharge limits. The following design criteria are established for oil/water separators discharging to a wastewater facility:

Washing Areas Protected with a Cover or Located Inside a Structure

- Baffled oil/water separators and spill control (SC-Type) separators shall not be allowed for use with equipment and/or vehicle washing applications. *Note: activities and processes of a washing facility change over time and the introduction of heat and surfactants may occur.*
- Coalescing plate separators shall be designed to achieve 100 ppm non-polar oil and grease in the effluent from the peak flow generated by the washing activity. Testing information must be submitted by the manufacturer of the unit that supports the 100 ppm effluent standard at the calculated flow rate.
    - Standard flow from a 5/8” hose is estimated to be 10 gpm.

    - For specially designed washing units, check the vendor specifications for maximum flow rates.
- Any pumping devices shall be installed downstream of the separator to prevent oil emulsification.
- Separator details must be shown on the building plans submitted for permit, and shall match manufacturer specifications and details, including the unit flow rate, effluent water quality, and maximum process flow rate.

On-site Wash Recycling Systems

Wash recycling systems may be used for oil control as long as they can meet effluent discharge limits for the City's wastewater system. A detail of the wash recycling system and vendor specifications identifying effluent efficiencies shall be submitted as part of the building plans at the time of building permit application.

APPENDIX TABLE OF CONTENTS

APPENDIX A: SITE PLANNING CHECKLISTS

TABLE OF CONTENTS

APPENDIX A: SITE PLANNING CHECKLISTS

The following checklists are provided to help ensure that information critical to implementing LID sites is available during the early site planning phase. Perform at least "blue font" checklist items and submit with Permit Application Package when using the Simplified Sizing Approach. Checklist is required for Simplified Sizing Approach and recommended for the Engineered Design Approach.

SITE ASSESSMENT CHECKLIST

A site assessment checklist[1] in both Adobe Acrobat Reader (.pdf) and Excel (.xls) format has been provided on the City of Grants Pass webpage at [enter URL here]. The following is a checklist of items that are directly or indirectly related to water quality and may be helpful to investigate when inventorying the site.

Conditions that are most relevant to correctly implementing BMPs in this guidance are written in blue.

(See Checklist after Page A-5)

SITE SURVEY PLAN

The area of survey may vary and should include, at a minimum, at least 10 feet beyond the *area of disturbance* proposed. The *area of disturbance* may vary greatly from the *proposed project improvements* and can depend on such things as the proposed site layout, on-site slopes and existing grades, and locations of public utilities where proposed connections will be made.

For all new development and re-development projects, a surveyor should survey the following minimum items and accurately map them, if present on-site:

Legal:

- Right of ways on both sides of all street frontages
- Property and lot lines with bearings & lengths
- All easements
- Legal description
- Tax lot info
- Street names

Surveyor data:

- Benchmarks
- Monuments
- Iron pipes
- Brass screws
- Basis of bearings & elevations
- North arrow
- Professional stamp
- Contact info for surveyor

Elevation data:

- Contours in appropriate intervals (0.5' for flat areas, 1' for average areas, and 2' for steep areas)

[1] *Adapted from the Southeast Michigan Low Impact Development Manual with permission from the Southeast Michigan Council of Governments.*

- Spot elevations on a 25-foot grid and at changes in grade such as at walls, curbs (indicate top of curb and gutter elevations or curb height), flow lines, swales and ditches, centerline and/or crown or valley, etc.
- Both contours and spots should extend at least 10' beyond the property line and/or across the street to the curb

Utilities:

- Utility vaults and above-grade fixtures such as gas valves, water valves, water meters, traffic boxes, fire backflow assembly, water backflow assembly, fire hydrants, etc.
- Storm structures including catch basins, manholes, water quality facilities and devices, cleanouts, etc. Include all relevant elevation data including rim elevations and invert elevations; pipe size and direction if more than one pipe. In the public ROW, provide information for at least two storm manholes or more if necessary so that inverts all along pipes fronting the property can be found.
- Power poles (indicate with a symbol where the guy wires extend), light poles, traffic poles, overhead lines.
- Sewer manholes and cleanouts. In the public ROW, provide information for at least two sewer manholes or more if necessary so that inverts all along pipes fronting property can be found. Subsurface pipe and cable network marked out by a utility locate company for water lines, storms sewers, sanitary sewers, telephone, cable, gas, etc. that serve the site

Land Cover:

- Extent of buildings with dimensions of buildings and dimensions to property lines
- The boundaries of all land cover types such as asphalt, gravel, concrete, bus shelters, etc.
- For street frontages, survey should extend across the street to include curb line, pedestrian ramps, and sidewalks.
- Water features such as wetlands, streams, ditches, ponds, etc.
- Walls (show length & width)
- Site furniture such as bollards, benches, fences, etc.
- Trees with greater than 3" diameter, tree wells, and major vegetation such as hedges. Include type of tree and draw spread of branches to scale and outline of massed trees.

INFILTRATION TESTING REPORT

BMPs that require an infiltration test to properly implement include conserve fast(er) draining soils, minimal excavation foundations, porous pavement, rain gardens, stormwater planters, LID swales, dispersion (vegetated filter strips and downspout disconnections), soakage trench, drywells, water quality conveyance swales, wet ponds, wet extended ponds, and dry detention ponds.

The infiltration testing report should include:

- A test for every 10,000 square feet or per qualified professional.
- Flow rates in inches/hour of soil horizons that may be used for infiltration, considering infiltration facility type and construction.
- Investigation by over excavation after testing to confirm sufficient depth to water table (3'), bedrock (2'), or other confining soil layer (2').
- Map with locations of testing.

TREE INVENTORY REPORT

To implement the Cluster Development BMP or the Tree Protection BMP, an International Arboriculture Society certified arborist should provide, at a minimum, the following information:

For each tree:

- Common name
- Tree number corresponding to mapped location

- Diameter at breast height
- Health
- Height
- Limb spread

General:

- Maintenance recommendations
- Hazardous trees to be removed
- Specimen or potential heritage trees worth saving
- Construction and maintenance phase tree protection recommendations
- Understory condition
- Limits of contiguous cover
- Areas where stands of trees might be healthy if other trees are removed for development

Map showing:

- Tree location and number
- Healthy tree stands

DEPAVING PROJECT CHECKLIST

The following is a checklist of major steps in a depaving project. Refer to Chapter 4 "*Minimize Impervious Area: Depave Existing Pavement BMP*" for detailed guidance.

- Locate utilities (Call 811 to mark underground utilities in the public right-of-way. If uncertain about the location of private utilities likely to be within the depaving area, call a private utility locate company, also.)
- Perform an infiltration test (see Appendix C: Infiltration Testing)
- Test soil for contamination, as needed
- Draw up a site plan and a planting plan
- Make a budget based on the design
- Obtain permits
- Order a drop box for pavement materials to be stored and hauled away
- Find volunteers or contractors
- Prepare the surface
- Depave
- Remove gravel
- Excavate and grade per plans
- Restore soils per Chapter 4 "*Restored Soil BMP*"
- Install landscaping
- Perform other site work defined on site plan

Sustainable Site Planning Checklist

	Check	Notes
Consider on-site natural resources		
Water Resources:		
Wetlands?		
Floodplains?		
Wellhead protection areas?		
Existing well?		
Riparian buffers?		
Naturally vegetated swales/drainageways?		
Seasonal high water table?		
Problems with run-on from neighboring properties?		
Land Forms:		
Steep slopes?		
Existing topography, contours?		
Depth to bedrock?		
Existing land cover/uses?		
How does size and shape of the site affect stormwater mgmt?		
Are there areas where development should generally be avoided?		
Evidence of soil erosion/landslides?		
Soils:		
Hydrologic soil groups?		
Tested infiltration rates?		
Erodibility?		
Swell potential?		
Hydric solid present?		
Texture?		
Fertility?		
Soil biology?		
Chemical properties? (pH, macro- & micronutrients)		
Livability:		
Aesthetics?		
Viewsheds?		
Sense of place?		
Opportunities to create private, semi-private, and public spaces?		
Noise source?		
Microclimate:		
Wind tunnels caused by vegetation/building orientation?		
Wind breaks?		
Solar access?		
Temperature variation?		

Sustainable Site Planning Checklist

	Check	Notes
Evaporation/moisture variation?		
Vegetation:		
Special status trees?		
Threatened or endangered species habitat?		
Blocks of habitat and corridors or connections between habitat patches?		
Native plant communities?		
Distinctive individual plants or communities?		
Vegetation that could provide shade to buildings, parking lots, or recreational areas?		
area?		
Invasive species/noxious weeds?		
Wildfire risks?		
Resources to be salvaged (topsoil, boulders, rocks, trees, etc.)?		
Renewable Energy:		
Geothermal?		
Wind?		
Hydroelectric?		
Solar?		
Air Quality:		
Pollen Sources?		
Smoke sources? (controlled burns, wildfire, etc.)		
Consider on-site infrastructure/built environment.		
Utilities:		
Wastewater system?		
Stormwater system?		
Structures with potential to serve as cisterns? (pools, spaces under existing buildings, etc.)		
Water?		
Gas?		
Electric?		
Communication?		
Livability:		
Beloved infrastructure? (Gathering spaces, arbor, etc.)		
Cultural:		
Historic infrastructure? (signs, bridges, entryways)		
Historic register? (Local, state, or national?)		
Archeological site?		
Air Quality:		
Areas of idling?		
Land Coverage/Uses:		

Sustainable Site Planning Checklist

	Check	Notes
Total site area		
Impervious area:		
Impervious area covered by evergreen tree canopy		
Impervious area covered by deciduous tree canopy		
Roof		
Sidewalks		
Vehicular pavement		
Other (swimming pools, basketball court, etc.)		
Semi-porous area		
Lawn		
Naturalized		
Ornamental beds		
Food gardens		
Paving surfaces (pavers, mulch, boardwalk)		
Other		
Porous area		
Forest		
Project data:		
Contaminants from past uses (leaking tanks, pesticides, herbicides, etc.)?		
Existing stressors (noise, odor, excessive light, etc.)?		
Infrastructure to be salvaged (asphalt, concrete, buildings [deconstruction])?		
Water Resources:		
Fish/mammal barriers to passage?		
Off-site drainage?		
Drainage patterns before and after finish grading?		
Locations of discharge outfalls/points?		
Size of discharge outfalls/points?		
Type of discharge outfalls/points?		
Areas used for storage of soils or wastes?		
Erosion and sediment control facilities/structures including vegetative practices?		
Staging/Storage Considerations:		
Disturbance area?		
Total surface area of the site, broken down by phases of development?		
Timetable for sequence of major events?		
Type of material used for fill?		
Volume of cut?		

Sustainable Site Planning Checklist		
	Check	**Notes**
Volume of fill?		
Recycling area?		
Composting area?		
Consider regional natural resources.		
Water Resources:		
Receiving water body for site drainage?		
Major/minor watershed location?		
EPA Level III ecoregion (EPA website)?		
State stream use/standards designation/classification?		
Special high quality designations? (e.g., natural rivers, cold water fishery)		
Rare or endangered species or communities present?		
Are there required water quality standards?		
303d/impaired stream listing classifications?		
Existing or planned Total Maximum Daily Loads (TMDLs) for the waterbody?		
Aquatic biota, other sampling/monitoring?		
Other special fishery issues?		
Neighboring wells?		
Downstream flooding problems?		
Vegetation:		
Major habitat types?		
Regional connection to a special habitat system (migratory routes, wildlife corridors, etc., neighboring publicly owned natural lands)?		
Wildfire risks?		
Land Development Impacts:		
Additional development anticipated for the area that could lead to further restrictions? (e.g., protection of downstream land and water uses)		
Additional development anticipated for the area that could lead to further opportunities? (e.g., partnerships in multi-site or regional water quality or quantity controls)		
Nearby construction sites that may have natural materials that can be salvaged for use on your site?		
Macroclimate:		
Seasonal wind direction?		
Wind speed?		
Annual and monthly precipitation patterns?		
Annual solar budget?		

Sustainable Site Planning Checklist

	Check	Notes
Air Quality:		
Particulates?		
Pollen?		
Dissolved pollutants?		
Smoke?		
Consider regional infrastructure/built environment.		
Utilities:		
Sanitary sewer system?		
Water?		
Storm drainage system?		
Gas?		
Electric?		
Communication?		
Livability:		
Transportation options (mass transit, bicycle & pedestrian facilities, roadways)?		
Recreational opportunities, community resources, and other amenities?		
Existing stressors (noise, odor, excessive light, etc.)?		
Walkable?		
Neighborhood architectural context?		
Cultural:		
Historical values, certified or non-certified?		
Known/potential archaeological values?		
Suppliers of materials and services locations:		
Native plant nurseries?		
Local manufacturers/suppliers of building materials?		
Deconstruction services?		
Re-use facility for salvaged materials (Restore, Rebuilding, etc.)?		
Recycling facility for construction waste?		
Air Quality:		
Located on busy street?		
Located on truck route?		
Areas of idling?		
Street canyons?		
Consider municipal, state, and federal guidelines/laws.		
Master plans (Stormwater, Transportation, Parks, Watersheds, etc.):		
Is development concept consistent with the master plan?		

Sustainable Site Planning Checklist

	Check	Notes
Consistent with goals/policies of the plan?		
Preservation of natural resources consistent with priority areas/maps?		
Water regulations (e.g., ordinances, engineering standards):		
Consistent with local existing regulations?		
Wetland regulations?		
Tree/woodlands ordinance?		
Riparian buffer ordinance?		
Open space requirements?		
Clustering and/or PUD options?		
Overlay districts?		
Wellhead protection?		
Erosion and sedimentation requirements?		
Are LID solutions:		
required?		
or incentivized?		
or enabled?		
or prohibited?		
Reduced building setbacks allowed?		
Curbs required?		
Rain gardens, stormwater planters, green streets allowed?		
Street width, parking requirements, other impervious requirements?		
Grading requirements?		
Landscaping that allows native vegetation?		
Stormwater requirements?		
Peak rate?		
Total runoff volume?		
Water quality?		
Maintenance?		
State floodplain requirements?		
Contaminated sites have followed state "due care" requirements for soil and groundwater?		
Consistent with state and federal wetland and/or inland lakes and streams regulations?		
Other Regulations?		
State and federal threatened and endangered species?		
Consistent with county/state road requirements?		
Fire Department:		
Recommendations for wildfire areas?		
Vehicular circulation?		

Sustainable Site Planning Checklist

	Check	Notes
Road widths?		
Cul-de-sac/hammerhead requirements?		
Planning:		
Zoning ordinances?		
Urban renewal?		
Comprehensive plan overlay?		
Historic resource?		
Conservation overlay?		
Setbacks:		
front		
side		
back		
other		
Required minimum outdoor area?		
Consider the programmatic requirements.		
is development concept consistent with the master plan?		
Consistent with owner's programmatic needs for sites and buildings?		
Stakeholder Process:		
Does the site have current users? Can these uses be accommodated in the new design?		
Who are the new users?		
Integrated design team roles defined?		
Project principles and goals defined?		
Purpose for project and design intent defined?		
Future primary and secondary stakeholders identified?		
Environmental and social goals defined (qualitative, quantitative)?		
Stakeholder engagement/charrette?		

APPENDIX B: BMP IMPLEMENTATION CRITERIA

Table of Contents

APPENDIX B: BMP IMPLEMENTATION CRITERIA

Planning, design, construction, and maintenance criteria and considerations common to multiple BMPs are provided in this appendix.

PLANNING

Infiltration Testing

Perform infiltration testing per Appendix C for all infiltration BMPs. Refer to **Appendix C**, **Table C-1** for a list of BMPs requiring infiltration. Size the BMPs based on the finding of the infiltration test.

DESIGN

BMP Sizing Methods

There are two approaches to sizing facilities:

1. **Simplified Sizing Approach**
2. **Engineered Design Approach**

Simplified Sizing Approach

As outlined in **Chapter 2** and in sections throughout **Chapter 4**, sizing of BMPs may be performed using the Simplified Sizing Approach described in detail in **Chapter 5**. As long as the requirements for water quality and flow control are met (**Chapter 2**), sizing does not require a licensed engineer. A description of the Simplified Sizing Approach is in **Chapter 2**, "*Simplified Sizing Approach*".

Engineered Design Approach

BMPs that do not meet requirements for the Simplified Sizing Approach must be designed by a licensed engineer. Modeling is used to size BMPs and predict how facilities will respond to and manage stormwater, and is often performed for the entire site, which should include runoff prevention and runoff reduction BMPs.

The design criteria for hydrologic modeling is outlined in **Chapter 2**, "*Stormwater Management: Water Quality*" and "*Stormwater Management: Flow Control*". If designing only for water quality, the BMP will not count as managing the drainage area for flow control and either an additional BMP for flow control will be required (unless approved by City Engineer) or the BMP must be designed for flow control.

Use the following hydrologic criteria to size facilities:

- Due to the continuous nature of our storms, facilities should drain the volume of the design storm in 30 hours or less.
- Water quality: Follow design requirements in **Chapter 2** "*Stormwater Management: Water Quality*"
- Flow Control: Follow design requirements in **Chapter 2** "*Stormwater Management: Flow Control*"
- Modeled with approved methods below.

MODELING

Design Storms

The National Oceanic and Atmospheric Administration (NOAA) has published isopluvial charts showing rainfall depths for a range of recurrence intervals in certain geographic areas. Table B-1 presents the rainfall depths for the City of Grants Pass obtained from NOAA isopluvial charts.

Table B-1. 24-hour Storm Depths

Storm Event	Precipitation (in)*
2-year	3
5-year	3.7
10-year	4.1
25-year	5
50-year	5.5
100-year	5.9

*Source: NOAA Atlas 2, Volume X

Another parameter of a design storm is how the given amount of precipitation is distributed over the duration of the storm (temporal distribution). A hyetograph illustrates the typical temporal distribution of a storm. The hyetograph shape is theoretical and is based on historical data collection and extrapolation. The Natural Resource Conservation Service (NRCS) has developed region-specific hyetographs for the State of Oregon. For Grants Pass, the NRCS recommends the use of a Type 1A distribution. The 25-year storm hyetograph is illustrated in ***Figure B-1***.

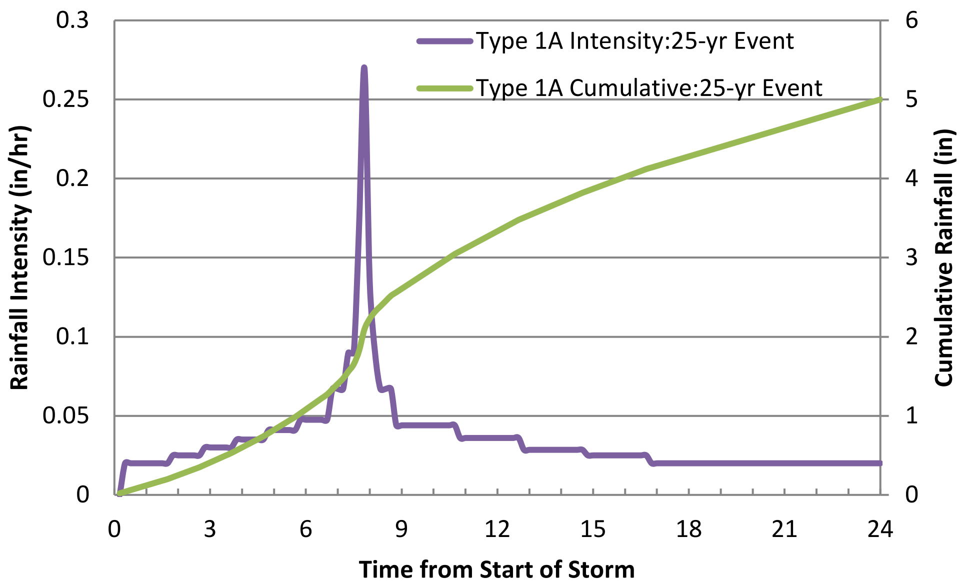


Figure B-1: Type 1A 25-year storm hyetograph.

Santa Barbara Urban Hydrograph

The Santa Barbara Urban Hydrograph (SBUH) method may be applied to small, medium, and large projects. It is a recommended method for completing the analysis necessary for designing flow control facilities when not using the Simplified Sizing Approach.

The Natural Resource Conservation Service "*Urban Hydrology for Small Watersheds*" (NRCS TR-55) method may be applied to small, medium, and large projects. This is also one of the recommended methods for completing hydrologic analyses necessary for designing flow control facilities when not using the Simplified Sizing Approach.

The Santa Barbara Urban Hydrograph (SBUH) method was developed by the Santa Barbara County Flood Control and Water Conservation District to determine a runoff hydrograph for an urbanized area. It is a simpler method than some other approaches, as it computes a hydrograph directly without going through intermediate steps (i.e., a unit hydrograph) to determine the runoff hydrograph.

The SBUH method is a popular method for calculating runoff, since it can be done with a spreadsheet or by hand relatively easily. The SBUH method is the method approved by the City for determining runoff when doing flow control calculations.

Elements of the SBUH Method

The SBUH method depends on several variables:

- Pervious (A_p) and impervious (A_{imp}) land areas
- Time of concentration (T_c) calculations
- Runoff curve numbers (CN) applicable to the site
- Design storm

These elements shall all be presented as part of the submittal process for review by staff. In addition, maps showing the pre-development and post-development conditions shall be presented to help in the review.

Land Area

The total area, including the pervious and impervious areas within a drainage basin, shall be quantified in order to evaluate critical contributing areas and the resulting site runoff. Each area within a basin shall be analyzed separately and their hydrographs combined to determine the total basin hydrograph. Areas shall be selected to represent homogenous land use/development units.

Time of Concentration

Time of concentration, T_c, is the time for a theoretical drop of water to travel from the furthest point in the drainage basin to the facility being designed. (In this case, T_c is derived by calculating the overland flow time of concentration and the channelized flow time of concentration.) T_c depends on several factors, including ground slope, ground roughness, and distance of flow. The following formula for determining T_c is:

$$T_c = T_{t1} + T_{t2} \ldots + T_{tm}$$

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{60V}$$

For sheet flow of less than 300 feet, use Manning's kinematic solution to compute T_t:

$$T_t = \frac{0.42(nL)^{0.8}}{(P_2)^{0.5}s^{0.4}}$$

Shallow concentrated flow for slopes less than 0.005 ft/ft:

$$V = 16.1345(s)^{0.5}\ [Unpaved\ surfaces]$$

$$V = 20.3282(s)^{0.5}\ [Paved\ surfaces]$$

Where,

T_t = travel time (minutes)

T_c = total time of concentration, (minutes) (minimum T_c = 5 minutes)
n = Manning's roughness coefficient[1]
L = flow length (feet)
V = average velocity (ft/s)
P_2 = 2-year, 24-hour rainfall depth (inch) (enter 3.0 inches for this variable (refer to Table B-1))
s = slope of hydraulic grade line (land slope ft/ft)

When calculating T_c, the following limitations apply:

- Overland sheet flow (flow across flat areas that does not form into channels or rivulets) shall not extend for more than 300 feet.
- For flow paths through closed conveyance facilities such as pipes and culverts, standard hydraulic formulas shall be used for establishing velocity and travel time.
- Flow paths through lakes or wetlands may be assumed to be zero (i.e. T_c = 0).

Runoff Curve Numbers

Runoff curve numbers were developed by the Natural Resources Conservation Service (NRCS) after studying the runoff characteristics of various types of land. Curve numbers (CN) were developed to reduce diverse characteristics such as soil type, land usage, and vegetation into a single variable for doing runoff calculations.

(Refer to the TR-55 "*Urban Hydrology for Small* Watersheds" Tables 2-2a through Table 2-2d for a list of Curve Numbers)

Rational Method

The Rational Method may be used for hydrologic modeling by a licensed engineer with approval from the City Engineer.

The Rational Method is[2]:

$$Q = C_f CiA$$

Where:
$Q =$ Peak flow in cubic feet per per second (cfs)
$C_f =$ Runoff coefficient adjustment factor to account for reduction of infiltration and other losses during high intensity storms
$C =$ Runoff coefficient to reflect the ratio of rainfall to surface runoff
$i =$ Rainfall intensity in inches per hour (inch/hour)
$A =$ Drainage area in acre (acre)

Computer Modeling

Different Software can be used for performing hydrologic modeling. A list of Grants Pass approved computer models are:

1. AutoCAD Civil 3D - Hydraflow extensions
2. The US Army Corps of Engineers "Hydrologic Modeling System" (HEC-RES)
3. The Environmental Protection Agency's Storm Water Management Model (EPA-SWMM)
4. Other software approved by City Engineer

[1] Urban Hydrology for Small Watersheds. (1986). *United States Department of Agriculture Natural Resources Conservation Service Conservation Engineering Division.*
[2] APPENDIX F – RATIONAL METHOD. (2014). *ODOT Hydraulics Manual,* 7-F-1-7-F-1. Retrieved March 12, 2014, from http://www.oregon.gov/ODOT/GeoEnvironmental/Docs_Hydraulics_Manual/Hydraulics-07-F.pdf

Currently, many developers in the Grants Pass region use AutoCAD Civil 3D with Hydraflow extensions to perform hydrologic modeling of stormwater. An example of parameters entered into and calculated by the software are shown in Table B-2 and Figures B-2 through B-7. Modeling parameters are at the discretion of the engineer and may differ from what is show below.

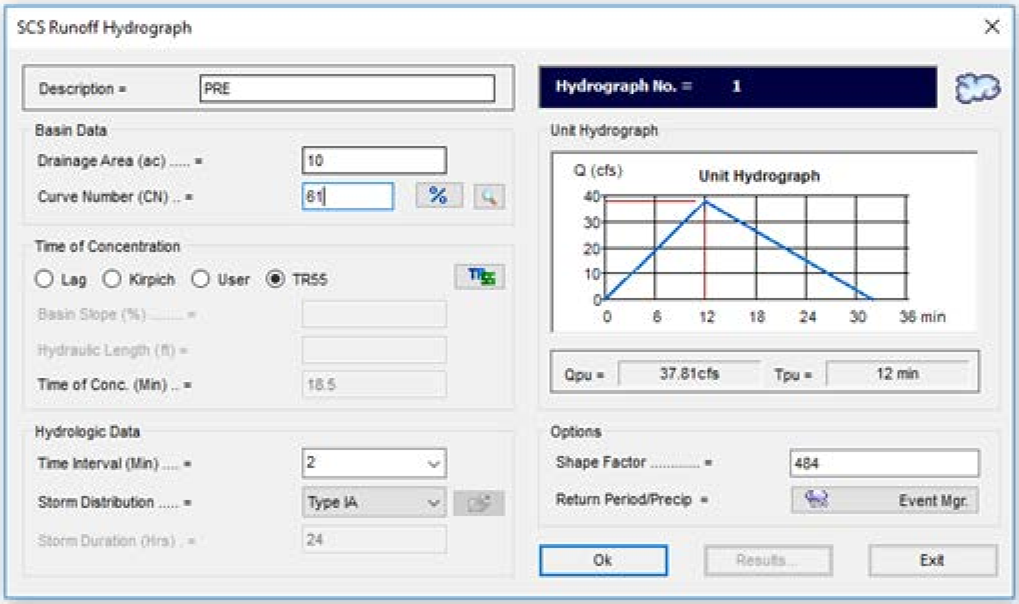


Figure B-2: Hydrograph input page.

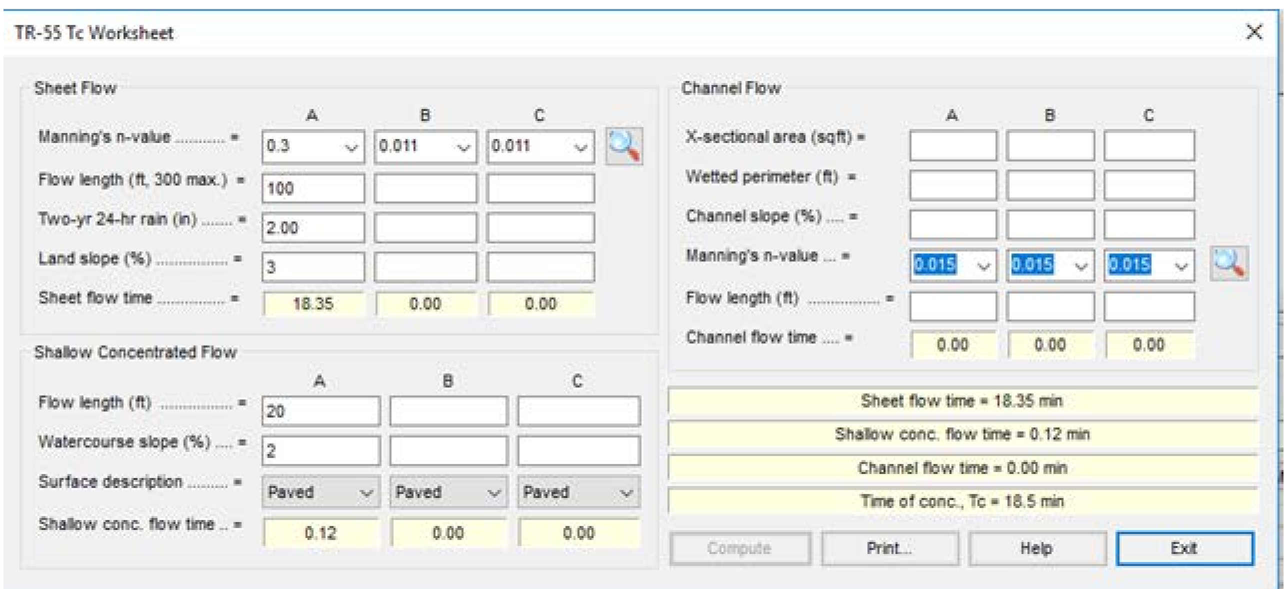


Figure B-3: Time of concentration.

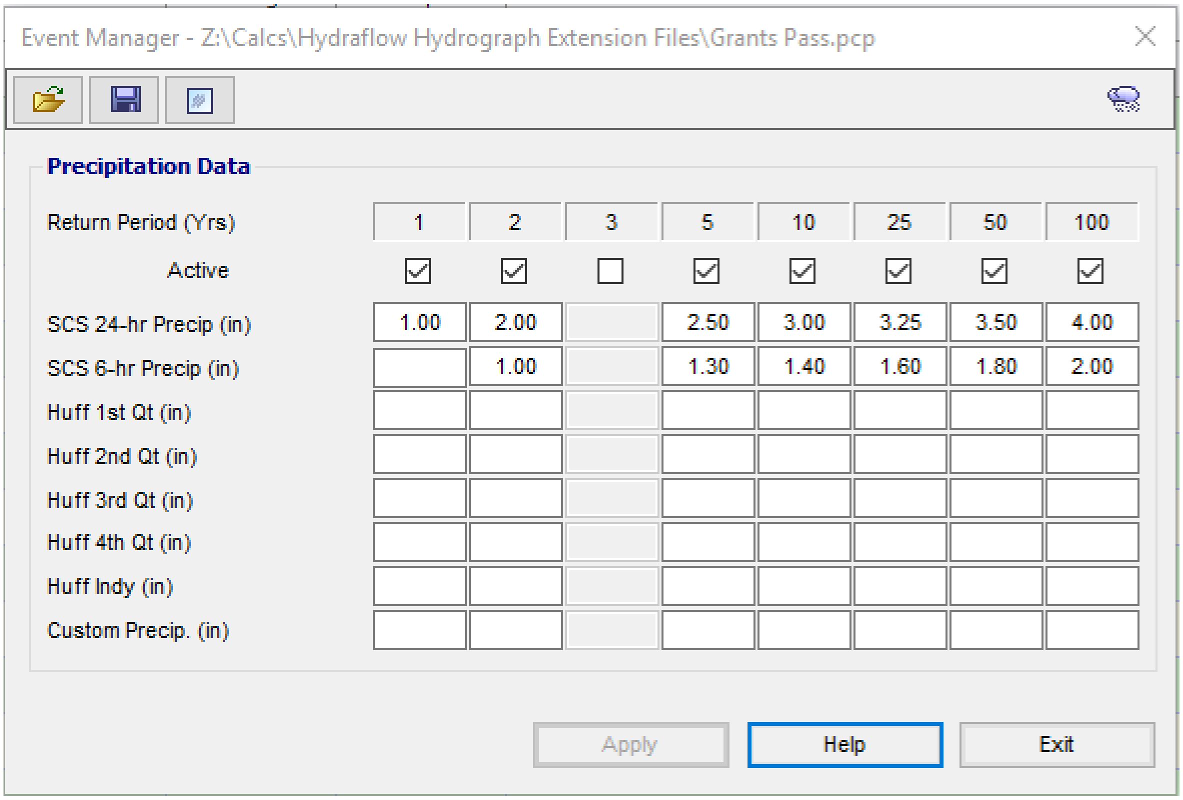


Figure B-4: IDF curves.

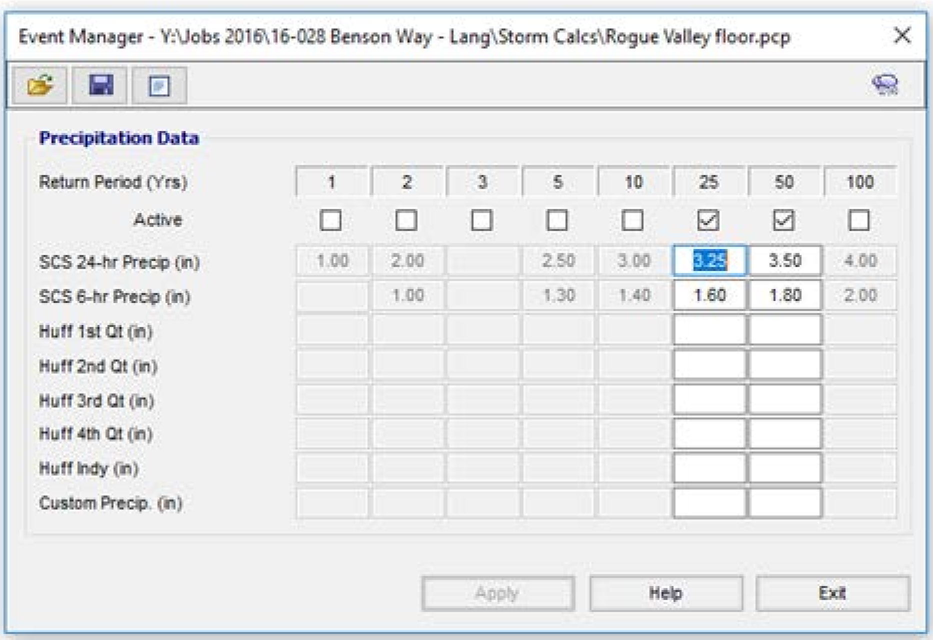


Figure B-5: Event manager tool.

Land Use Description	Hydrologic Soil Group			
Residential	**A**	**B**	**C**	**D**
Average lot size:				
1/8 acre or smaller	77	85	90	92
1/4 acre	61	75	83	87
1/3 acre	57	72	81	86
1/2 acre	54	70	80	85
1 acre	51	68	79	84
2 acre	46	65	77	82
1/8 acre or smaller	77	85	90	92
Paved parking lots and roofs	98	98	98	98
Streets and roads:				
Paved with curbs	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Commercial and business areas	89	92	94	95
Industrial districts	81	88	91	93
Open spaces, lawns, and parks:				
Good condition	39	61	74	80
Fair condition	49	69	79	84
Fallow	77	86	91	94
Row crops	72	81	88	91

*Average Runoff Condition. Ia = 0.25

Source: Soil Conservation Service TR-55

Figure B-6: table for conditions for the curve number.

Table B-2. Hydrograph Report (Displayed parameters do not reflect recommended parameters and are for demonstration purposes only)

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2015 by Autodesk, Inc. v10.4 — Friday, 09 / 8 / 2017

Hyd. No. 2

POST

Hydrograph type	= SCS Runoff	Peak discharge	= 2.018 cfs
Storm frequency	= 50 yrs	Time to peak	= 8.00 hrs
Time interval	= 2 min	Hyd. volume	= 38,146 cuft
Drainage area	= 10.000 ac	Curve number	= 72*
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= User	Time of conc. (Tc)	= 5.00 min
Total precip.	= 3.50 in	Distribution	= Type IA
Storm duration	= 24 hrs	Shape factor	= 484

* Composite (Area/CN) = [(3.000 x 98) + (7.000 x 61)] / 10.000

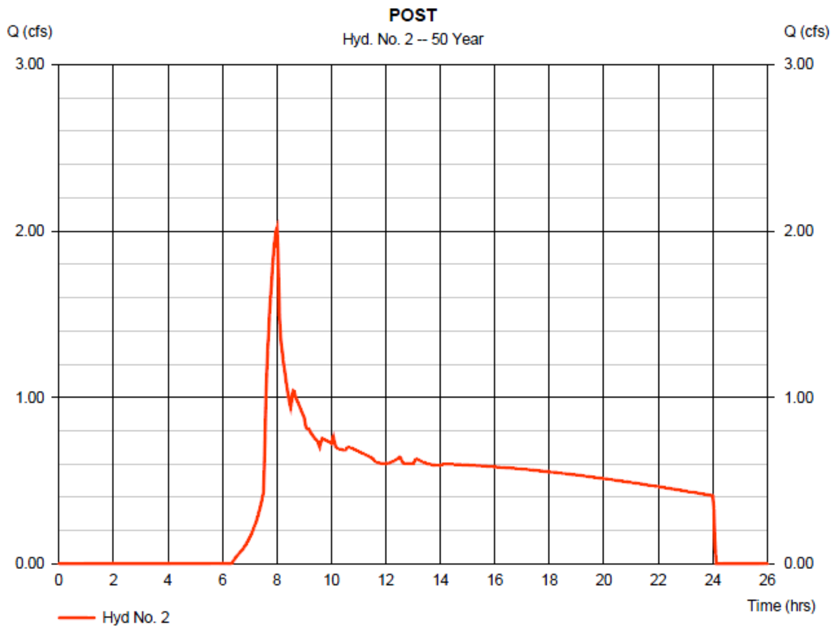


Figure B-7: Example post development hydrograph output from Civil 3D Hydraflow software.

BMP Design Criteria

Each of the design criteria in this section should be accommodated in the design of the following BMPs:

- Vegetated Roof BMP (except information in “Infiltration Facility Siting” does not apply)
- Porous Pavement BMP
- Rain Garden, Stormwater Planter, & LID Swale BMP
- Soakage Trench BMP
- Drywell BMP
- Water Quality Conveyance Swale BMP
- Dispersion BMPs

Infiltration Facility Siting. In order to protect structures and natural features from water quantity impacts such as localized flooding or landslides, infiltration facilities have a number of vertical and horizontal setbacks, defined in **Chapter 4**.

Initially, evaluate, select and apply runoff prevention BMPs. Comprehensively applying multiple runoff prevention practices to manage runoff at a site may preclude the need for design and installation of some runoff reduction BMPs. This would save considerable costs related to BMP construction and maintenance for the life of the facility.

High-Flow Bypass. Depending on site conditions and how vegetated facilities are designed, exposure to high velocity flows can cause erosion and impact long-term functioning and maintenance as well as their value for water quality protection. In these cases, employ a high-flow bypass system to allow only selected flows to enter an LID facility, while routing the rest around the facility. For instance, an opportunity to retrofit a pavement area might create a smaller than desired rain garden, just big enough to store and infiltrate the volume of the water quality storm, but a bypass structure could send the remaining storm volumes to another facility such as a drywell for infiltration; thereby protecting the water quality facility from erosive flows, reducing maintenance, and protecting downstream banks from erosion. A control structure similar to those used in detention basins is one example of how this might be achieved. If a curb and gutter is adjacent to the vegetated facility, then a passive bypass system can be achieved by careful grading that allows stormwater flows that exceed the water quality storm event to simply continue flowing along the curb and gutter when the ponding area is full.

Figure B-8. This facility is being eroded and exporting sediment off-site. A high-flow bypass or better plant placement and establishment could help.

Safe Overland Route. No stormwater facility can be designed for every size storm. There will always be a lower frequency, larger storm that cannot be accommodated regardless of how large a storm size is managed; therefore, incorporate a safe overland route for all stormwater facilities that allows water to take a route that will minimize property damage.

Clearly indicate this flow path on the plans. Final grades critical to overland conveyance should be confirmed as a “punch list item” at the end of the construction phase by the designer to ensure that runoff will actually flow where intended during the design phase.

- **Approved Discharge Point/Outlet**. Overflow structures must direct excess stormwater to an approved discharge point as approved by The City of Grants Pass. Approved discharge points may be drainage ditches, nearby streams, or existing storm drain systems. Connection to an underground perforated pipe outside the limits of a BMP, or a drywell or soakage trench (see “*Drywells BMP*” or “*Soakage Trenches BMP*” for more information on underground injection controls) will require registration through the Oregon Department of Environmental Quality.

Materials Choices. Downspouts, gutters, rain chains and other conveyance materials should not be made of copper, galvanized steel (leaches zinc), or iron, which leach harmful metals into waterways even when those metals pass through soil and plants. Art is often desired to celebrate stormwater; however, unless the material is known to be non-polluting (e.g. concrete, stainless steel, untreated wood), artwork should be located outside the facility where it will not come in extended contact with ponded or flowing stormwater.

Maintenance Considerations during Design, **Sediment Removal.** Maintenance of conventional "gray" stormwater infrastructure, such as catch basins, pipe and culverts, has focused primarily on reducing sediment loads and preventing clogging. Removal of sediment is even more critical for BMPs such as rain gardens, planters, swales and porous pavements. If sediments are in a structure like a manhole or catch basin, they are usually vacuumed out. Public facilities will require access for a large maintenance vehicle.

CONSTRUCTION

BMPs and contributing drainage areas should be constructed to protect water quality and maximize function as follows:

Protecting Permeability

For the reasons described in **Chapter 3** “*The LID Construction Process*”, permeability of the soil should be carefully protected throughout the construction phase using the following techniques:

Install Protection Fencing. Areas of high permeability on the site should have been discovered through infiltration testing in the planning phase (see **Appendix C**: Infiltration Testing). It is the responsibility of the general contractors and subcontractors to install protection fencing as shown on the plans and to respect the boundaries of it.

At the beginning of construction, before clearing and grubbing, fence off all infiltration areas (*i.e*. the footprint of infiltration facilities) and the area under tree canopy to be protected (see **Chapter 4** "*Tree Protection BMP*") to prevent vehicular and foot traffic that will compact soils and reduce the infiltration rate of native soils. The most effective protection fencing is something that cannot be easily moved out of the way, such as cyclone fencing at least 3 feet high, which is more expensive than the less effective plastic orange fencing, but which can often be rented on a temporary basis. Keep fencing in place until site construction is complete. Some construction traffic is possible within the footprints of infiltration facilities, which is described in more detail below in "*Protect permeability when working inside a BMP footprint*" and in the "*Construction*" sections of BMPs in **Chapter 4**.

Figure B-9. Orange protection fencing at this project is not deterring stockpiling within the tree canopy. Inadequate tree root protection often leads to health issues that turn a healthy tree into a hazard tree. Tree protection is covered in detail in Chapter 4.

Figure B-10. Avoid foot or vehicular traffic before, during, and after construction. This backhoe is excavating from outside the rain garden, as outlined by the white paint in the grass.

Don't use an infiltration LID facility location as a temporary sediment pond. If a temporary sediment pond is needed as a sediment control strategy, avoid building this measure within the footprint of any of the following BMPs:

- Porous Pavement BMP
- Infiltration Rain Garden, Stormwater Planter, or LID Swale BMPs

- Soakage Trench BMP
- Drywell BMP
- Water Quality Conveyance BMP
- Dispersion BMP

On large sites, usually over 5 acres, a sediment control facility called a “Temporary Sediment Basin” may control runoff from a construction site. On conventional projects, the footprint of the future detention basin often serves as the location of this temporary basin and runoff from the stripped site (which can be very high on large sites) is directed to it. At the end of construction, the detention basin is dredged. This is convenient and acceptable in conventional development, since detention basins are not designed to infiltrate.

Low impact development sites should infiltrate and evaporate to the greatest extent possible. Directing sediment-laden runoff to these footprints of an infiltration rain garden or a porous pavement will probably clog the facility. If soil is clogged, it will not infiltrate the volume of runoff expected or may fail entirely. In addition, dredging operations are likely to compact the subgrade, especially if the subgrade is wet and clayey. Clogged soils also make vegetation establishment and survival difficult, which eliminates this key role in treating stormwater and reducing maintenance. In addition to fencing off the area, route construction runoff around all infiltration facilities using sand bags, slope drains, or other means. The only LID BMP footprints acceptable for settling out sediment are lined facilities. Directing runoff to any LID facility on very tightly constrained sites will be reviewed on a case-by-case basis.

- Protect excavated soils from rain exposure. Until soils can be planted and mulched, cover soils with jute or other natural, breathable material or by waiting until the last moment to expose soils. In the case of vegetated stormwater facilities where soil will be imported, the exposed surface may also be covered in mulch immediately upon excavation. The mulch may be left in place as subsequent layers of rock or soil are placed.

Figure B-11. Fine clay particles exposed to rain fall have re-sorted and clogged this infiltration facility.

- If soils are exposed to rain, fine soil particles will be picked up and moved around and may clog the native subgrade soils creating a naturally impervious layer. In clayey soils, restoring permeability can be difficult. In the case that soils are accidentally exposed to rain, if soils don’t clump, rake the surface to loosen soil before proceeding. If soils do clump, wait until they dry before raking them or try applying the Restored Soils BMP (described in detail in **Chapter 4**) to the bottom of the facility.
- Protect permeability when working inside a BMP footprint. Take care not to compact soil within the infiltration facility footprint when installing overflow structures that may require compaction under them, such as area drains and non-perforated pipes. Compact only the soil underneath the structure or in the pipe trench. Perforated pipes located within the facility footprint of rain gardens, stormwater planters, and other vegetated BMPs are not designed to receive loading from vehicular

traffic, so compaction underneath these is not desirable.

- Use track equipment and/or work from the sides of the facility footprint (*i.e.* infiltration area) when using machinery for construction operations. For other techniques specific to certain BMPs, see the "*Construction*" sections of BMPs in **Chapter 4.**

Call Before You Dig, Locating Underground Utilities

- Call 811, a free service, to locate utilities in the public right-of-way of any project. On sites with existing utilities or infrastructure, hire a private utility locate company to mark underground private utilities.

MAINTENANCE

BMPs and contributing drainage areas should be maintained to protect water quality and maximize function as follows:

- **Integrated Pest Management.** Maintain BMPs and sites with integrated pest management using little to no herbicides, pesticides, or fertilizers. Using "cides" impacts the soil life responsible for creating long-term permeability and can actually increase long-term maintenance efforts. Avoid spraying "cides" on impervious surfaces.
- **Irrigation.** Maintain with irrigation as needed to conserve water. (See Appendix E, "*Establishment Period Maintenance*".
- **Trimming Grasses and Shrubs.** Encourage vegetation to grow and become dense. For example, unless flows into the facility are blocked, vegetation doesn't need to be thinned. Preferably, plants are allowed to grow tall since this will encourage root penetration into native soils increasing the infiltration rate of the facility over time. In addition, do not trim grasses and shrubs right before or during the rainy season (September to June), since plants will have less structure to reduce runoff through evaporation and evapotranspiration.

APPENDIX C: INFILTRATION TESTING

TABLE OF CONTENTS

OVERVIEW OF INFILTRATION TESTING

Infiltration testing is used to determine the soil's infiltration rate. Performing infiltration testing allows BMPs to be adequately sized to drain within 30 hours and to not exceed the design ponding depth. Minimum infiltration rates are provided in **Chapter 4** "*Siting*" for each BMP. BMPs are sized for the either the water quality storm or the flow control design storm (See **Chapter 2**).

Sizing factors are provided for BMPs using the Simplified Sizing Approach. To size a BMP, infiltration testing must be performed as outlined in this Chapter at the location(s) of proposed BMPs. Refer to the "*LID Worksheets*" to determine what sizing factor is required for your BMP based on your design ponding depth and tested infiltration rate.

Infiltration based BMPs will have a larger footprint for soils with lower infiltration rates and will have smaller footprints for soils with higher infiltration rates. To minimize the size of a BMP, it is recommended to test multiple locations to find faster draining soils (See **Chapter 4**, "*Conserve fast(er) draining soils*"). If the Engineered Design Approach is used to size a BMP, infiltration testing must be performed by a qualified professional. Criteria for vertical separation must be met as specified in this Chapter and for the BMP requirements in **Chapter 4**.

APPLICABILITY

Infiltration Testing - Simplified Sizing Approach

Infiltration testing may be performed by the landowner or any other qualified licensed professional or contractor when using the Simplified Sizing Approach. All requirements for the Simplified Sizing Approach must be met as defined in **Chapter 2**. An **infiltration testing form** must be submitted to the City before constructing BMPs. When using the Simplified Sizing Approach to size a BMP, the following infiltration testing forms must be submitted to the City:

1. **Simplified Sizing Approach Infiltration Testing Form**
2. **Data entry form**
3. **Photo of infiltration testing setup**
    a. Include level indicator in photo

A copy of the Simplified Sizing Approach Infiltration Testing Form and an example Data Entry form are at the end of this chapter and available from the City website.

Infiltration Testing – Engineered Design Approach

Infiltration testing must be performed by a Professional Engineer, Registered Geologist, Soil Scientist or other professional testing service with equivalent training and experience in determining the permeability of soils when the Engineered Design Approach is used to size a BMP. All requirements for the Engineered Design Approach must be met as defined in **Chapter 2**.

Perform infiltration testing to implement the following BMPs:

Table C-1. List of BMPs requiring infiltration testing and sizing approaches applicable to each. BMPs sized with the Simplified Sizing Approach can be sized by the landowner or any other qualified licensed professional or contractor. BMPs sized with the Engineered Design Approach require a Professional Engineer, Registered Geologist, Soil Scientist or other professional testing service with equivalent training and experience in determining the permeability of soils.

Best Management Practice (BMP)	Simplified Sizing Approach†	Engineered Design Approach†	Is Infiltration Testing Required
Conserve fast(er) draining soils BMP			
Cluster Development BMP			
Tree Protection BMP			
Minimal Excavation Foundation BMP			
Construction Sequencing BMP			
Depave existing pavement BMP			
Restored Soil BMP			
Contained Planter BMP			
Tree Planting BMP			
Vegetated Roof (Green Roofs) BMP			
Porous Pavement BMP			
Rain Garden			
Stormwater Planter			
LID Swale BMP			
Soakage Trench BMP			
Drywell BMP			
Water Quality Conveyance Swale BMP			
Dispersion BMP			
Wet Pond			
Extended Wet Pond			
Dry Detention Ponds			
† Applies when meeting requirements in Chapter 2	=YES	=NO or N/A	

TIMING

Tests should not be conducted:

- In the rain
- Within 24 hours of a storm greater than 1/2 inch, or
- When the ground is frozen.

Different protocol, as described below in "Test Infiltration", apply to wet-weather versus dry-weather testing.

LOCATION

The test measures infiltration of a very small and specific area.

In new developments and redevelopments with generous open space, infiltration tests should be performed across the proposed development area during the planning phase. Once the location of facilities is determined, additional design phase infiltration testing may be needed if the initial tests were not conducted within the footprint of the proposed facility.

In retrofits with limited areas to choose from, infiltration testing in the planning phase isn't needed. Simply test directly over the proposed facility location.

Never test under the canopy of a tree, since this could damage the tree. Healthy trees are critical to watershed health and should be protected, not damaged and removed to locate another stormwater management BMP (see **Chapter 4** "*Tree Protection BMP*"). Healthy trees provide "enhanced infiltration" (see **Chapter 5**) and can be assumed to be faster draining soils. Unhealthy trees should probably be removed from a development site, based on an arborist's report (see **Appendix A**), but if the health of a tree is unknown at the time of infiltration testing, test outside the canopy.

NUMBER OF TESTS

The number of infiltration tests for large sites varies widely. More tests are needed for sites with variable soil conditions than for sites that are uniform. In urban sites, where soils may have been disturbed a number of times over many years, soil conditions may vary greatly over small distances, so more tests may be needed. If the proposed facility has a large area, 1 test per 10,000 square feet within the area is recommended. A licensed engineer can assist with identifying soil uniformity and identifying the appropriate number of tests.

SAFETY

Always call 811 to locate utilities before testing begins[1]. Infiltration tests may require extensive excavation and can be potentially dangerous. Observe relevant Occupational Safety and Health Administration (OSHA) regulations.

EQUIPMENT NEEDED

To perform an infiltration test, you will need:

- Shovel and/or post-hole digger
- Yardstick or ruler
- Water source
- Some clean gravel (in clay soils)
- Pencil
- Paper
- Watch or timer
- Watering can (optional)

[1] *Oregon 811, Utility Notification Center. Retrieved from: http://digsafelyoregon.com/*

Figure C-1. Anyone fit enough to dig can perform an infiltration test with commonplace tools.

TESTING DEPTH

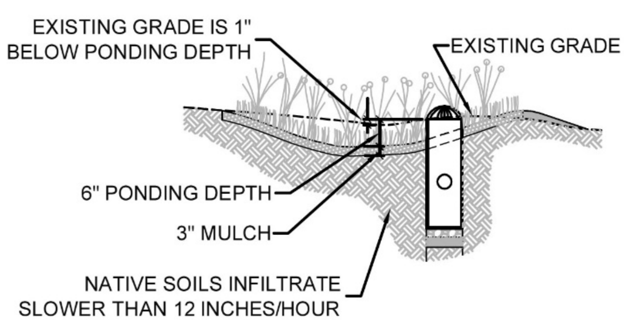
Testing depth varies with existing and final conditions, testing goals, and BMP choices. For testing depth of drywells, see **Chapter 4** "*Drywell BMP*" "*Infiltration Testing*".

Runoff prevention. If fast(er) draining soils will simply be conserved, an infiltration test depth of 6 inches to 12 inches into the soil just below the ground cover vegetation and topsoil, is sufficient depth.

Runoff reduction. Infiltration testing should be performed at the expected depth of the bottom of the facility; however, infiltration testing may also determine the depth of the facility, as well as the location. For example, soils just 6" below existing grade may be suitable for infiltration and have enough nutrients to support plant growth in a rain garden. Evaluate a very simple rain garden that doesn't replace or amend the native soils by testing the soils shallowly. Since the suitability at this shallow depth cannot be known until the test is completed, dig a few test holes at different elevations a few feet apart and test them simultaneously.

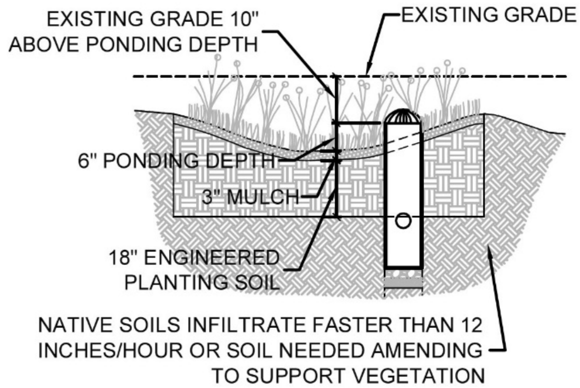
Existing and proposed finish grades should be used to determine appropriate testing depths for all applicable BMPs, similar to the examples below.

Example C-1 Simple infiltration rain garden (existing grade elevation similar to final grade)



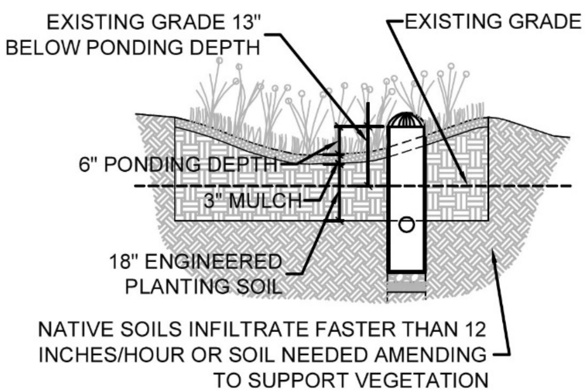
Infiltration testing depth = -1" (elevation difference) + 6" (ponding depth) + 3" (mulch) **= 8 inches below existing grade**

Example C-2 Infiltration rain garden with imported soil (existing grade elevation higher than final grade)



Infiltration testing depth = 10" (elevation difference) + 6" (ponding depth) + 3" (mulch) + 18" imported soil **= 37 inches below existing grade**

Example C-3 Infiltration rain garden with imported soil (existing grade elevation lower than final grade)



Infiltration testing depth = -13" (elevation difference) + 6" (ponding depth) + 3" (mulch) + 18" imported soil **= 14 inches below existing grade**

FALLING HEAD TEST

The falling head test is one of the oldest and simplest methods, commonly used for designing septic fields. It has been used successfully on LID projects for over 30 years by some professionals in the field and is the method recommended here. For testing method of drywells, see **Chapter 4** "*Drywell BMP*" "*Infiltration Testing*".

Perform a falling head test as follows:

1. Dig a test hole with a post-hole digger or a larger area with a shovel. The area of the hole doesn't matter. Dig a hole to the appropriate depth as discussed above.
2. If soils are clayey, scrape the sides of the hole a little (i.e. scarify). Remove the scraped material from the bottom of the hole and place an inch or so of clean gravel at the bottom; otherwise, the tiny clay particles will be suspended in the water to follow and form an impermeable barrier (appearing as a sheen) around the sides and bottom of the hole.
3. Push a pencil or nail into the side of the hole from which to measure the water level drop over time. The height above the bottom of the hole (or gravel if included) will determine the water

level depth. Because water is so heavy, deeper water will result in faster overall infiltration rates, so this is accounted for in the following:

- **Runoff Prevention.** Place the pencil or nail 6 inches above the bottom of the hole.
- **Runoff Reduction.** The depth of water should reflect the amount of water that might be ponded in a runoff reduction BMP. For instance, if the ponding depth will be 9 inches, then place the pencil or nail 9 inches above the bottom of the hole. If the ponding depth is unknown, 6 inches is conservative.

4. Fill the hole with water gently to the top of the pencil or nail. Record the exact time you stop filling the hole (if soils are fast draining, measure time down to the second) and the time it takes to drain completely.
5. If testing during the rainy season and soils are saturated, go on to step 6. If testing during the dry season and soils are dry, refill the hole again and repeat steps 2 to 4 **two more times**. The infiltration rate of the **third** test will give you the best measure of how quickly your soil absorbs water when it is fully saturated, as it would be during a rainy period of the year or during a series of storms that deliver a lot of rainfall in a short period of time. Occasionally, due to water changing the soil structure, infiltration rates can increase over short time periods during the test, but on average, the infiltration rate should generally decrease with each round.
6. To calculate the infiltration rate, divide the distance that the water dropped by the amount of time it took for it to drop. For example, if the water dropped 6 inches in 12 hours, then 6 divided by 12 equals 0.5 inches per hour.
7. If testing is for porous pavement managing direct rainfall only, skip to step 8. For rain gardens and stormwater planters and porous pavements managing runoff, if the slowest infiltration rate measured is less than 0.5 inches per hour, then dig another hole nearby, but 3 to 6 inches deeper, and repeat steps 1 to 4 to see if there's a faster draining soil that could be over excavated to. Repeat this process at various depths down to another 2 feet, or until you have at least 0.5 inches per hour infiltration. If you can't find a suitable area with an infiltration rate of at least 0.5 inches per hour, infiltration BMPs must be designed and modeled by a licensed engineer. Skip to step 9.
8. For porous pavements that infiltrate rainfall, if the slowest infiltration rate measured is less than 0.3 inches per hour, consider relocating the porous pavement to a faster draining soil.

Figure C-2. A shovel was used to dig most of the way then a 6" diameter post hole digger was used to reach the proposed bottom elevation of a rain garden. Measure the drop in water from a known, stable marker.

Confirm Vertical Separation

Two conditions for vertical separation should be met:

9. After infiltration testing is complete, dig the hole another 2 feet of depth from the bottom of the BMP (*i.e.* the elevation where water will begin to pond) to uncover bedrock or other impermeable subsurface layers that may impede infiltration. If the soil is pretty consistent all the way down then one criteria for vertical separation is met.
10. If testing during the wet weather season (Nov. 1st to April 1st), dig the hole one foot deeper to discover groundwater. If water doesn't seep into the hole, then groundwater is sufficiently deep and the second vertical separation criteria is met. If not testing during the wet weather season, hire a registered soil scientist, licensed engineer, registered geologist, or other qualified licensed professional to assist with assessing the depth of the seasonal high groundwater table.
11. Fill the hole back up and leave the site in a safe condition (*i.e. prevent a tripping hazard)*.

OTHER TESTING METHODS

There are numerous other methods to test the rate at which water will pass through the soil. One method that may be suitable for larger scale infiltration BMPs is the Pilot Infiltration Test, developed and recommended by the Washington Department of Ecology[2].

[2] *Washington State Department of Ecology, Water Quality Program. Stormwater Management Manual for Western Washington. Volume V: Runoff Treatment BMPs. Page B-1. (Feb. 2005). Retrieved from:* https://fortress.wa.gov/ecy/publications/publications/0510033.pdf

SIMPLIFIED SIZING APPROACH INFILTRATION TESTING FORM

Owner's Name:	
Mailing Address:	
Site Address:	
Email:	**Phone:**
Signature:	**Date:**

Complete form for each BMP

Infiltration Testing Information			**Infiltration Testing Results**		
BMP type:			Test 1	Test 2	Test 3
BMP ID:		Start time (of day)			
Infiltration test ID:		Duration (hours) (1 hour minimum)			
Test method:		Initial water depth (inches)			
Date of test:		Final water depth (inches)			
Depth of excavation (inches):		**Infiltration rate*** (inches/hour)			

*Infiltration Rate = (Initial Depth (in.) - Final Depth (in.)) / Duration of Test (hours)

Infiltration Testing Conditions	YES	NO
Test conducted in the rain.		
Test conducted within 24 hours of a storm > 1/2 inch.		
Test conducted when ground is frozen.		
Data entry form attached		
Was the soil dry before testing?		

Confirm Vertical Separation	YES	NO
Was an impermeable layer found 2 feet below initial depth of hole?		
Was testing during wet weather months (Nov. 1st to April 1st)?		
Did groundwater seep into testing hole after digging a foot deeper than initial depth (within 2 hours)?		

Test pit location (site plan sketch)

Key information to include: 1) Site or parcel, 2) Adjacent road(s) or cross street(s), 3) Tests pit location with dimensions and ID, 4) BMP sketch with dimensions and ID.

N

****Attach a photo of the infiltration testing setup with water elevation marker clearly visible.****

DATA ENTRY FORM

Tester's Name:		
Company (if applicable):		
Contact Number:		
Location:	**Date:**	**BMP ID:** **Infiltration test ID:**
Depth to bottom of hole:	**Hole diameter (inch):**	**Test method:**

Depth (inch):	**Soil Texture:**

Dry weather test repetition #	Time	Time interval (minutes)	Measured drop in water elevation from marker (inch)	Infiltration rate (inch/hour)	Notes/Comments:
1					
2					
3					

APPENDIX D: SPECIFICATIONS

TABLE OF CONTENTS

APPENDIX D: SPECIFICATIONS

This appendix details suitable materials and installation methods (i.e. specifications) for a variety of BMPs including a description of the material, applicability to a particular BMP, criteria for selection, and/or installation recommendations.

SOIL AMENDMENT SPECIFICATIONS

Applicability. Soil amendment (Organic Matter Compost, Mycorrhizae, and Mulch as described below) specifications apply to the following BMPs:

- Depaving Existing Pavement BMP
- Restored Soils BMP
- Contained Planters BMP
- Dispersion BMPs (Standard Details BMP 4.01 to 4.02)
- Tree Planting BMP (Standard Details BMP 10.01 to 10.04)
- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Organic Matter Compost

Care should be taken to ensure that compost is clean and free of weeds, pollutants, or other deleterious materials that may impact plant health and water quality.

Organic matter compost shall meet the following criteria:

- Weed seed and pollutant free.
- 100% should pass a 1/2-inch screen.
- pH between 5.5 and 7.0. If the pH isn't quite right, it may be lowered by adding iron sulfate and sulfur or raised by adding lime. If lime is used, incorporate first into the compost, wet the compost down, and then fold mixture into the soil.
- Carbon nitrogen ratio between 30:1 and 35:1.
- Organic matter content between 40 and 50 percent.
- Fully composed. Earthy is good. Avoid compost that smells like ammonia.
- Metals should not exceed (mg/kg dry weight):
    - Arsenic ≤20 ppm
    - Cadmium ≤10 ppm
    - Copper ≤750 ppm
    - Lead ≤150 ppm
    - Mercury ≤8 ppm
    - Molybdenum ≤9 ppm
    - Nickel ≤210 ppm
    - Selenium1 ≤18 ppm
    - Zinc ≤1400 ppm

Organic matter compost may consist of the following:

- Mushroom Compost. The used bedding material from commercial mushroom production.
- US Compost Council Seal of Testing Assured compost. Visit http://compostingcouncil.org/participants to find a participating supplier near you. The STA

program is no guarantee of quality, only that the compost has been tested and those test results are available for the designer's review to compare against the criteria listed above.

- Any other organic matter meeting the criteria above except for those listed next.
- Peat Moss is not recommended since it is extracted from wetlands and has negative impacts on the watershed from which the peat moss was removed.

Mycorrhizae

Mycorrhizae are mushroom roots, and most plants in western Oregon have co-evolved with this material. Mushroom roots interact with the plant roots by feeding on the plant's waste and by bringing the plant nutrients, thereby expanding the effective root area of the plant by many fold. Plants receiving this kind of amendment consistently grow bigger and faster than plants without it.

Material Specifications. Many manufacturers/suppliers have mycorrhizae products specific to a particular BMP, such as for landscapes or eco-roofs with a variety of applications methods that may include hydromulching, broadcasting, tilling, or watering. You can buy amendments as pellets or water-soluble powder.

A non-BMP-specific mycorrhizae product with a mix of endo- and ectomycorrhizal species is acceptable for any plant-based BMP in this guidance.

Installation. Apply or incorporate per manufacturer's guidelines**.**

Mulch

Material Specifications. Mulch should be:

- Shredded wood chips (preferred for trees and shrubs)
  OR
- Coarse compost (not bark dust or bark chips) meeting the specifications in this section for "Organic Matter Compost"
- Spread in a 2-inch layer minimum over bare soil and between plantings to completely cover the soil and prevent erosion or weed intrusion.

Pull a few inches away from woody stems and trunks (*i.e.* shrubs and trees) to prevent rotting. Form a ring out of the material for holding extra water during the establishment period (see **Appendix E**). Materials to avoid include:

- Bark dust or bark chips. These tend to float more than the materials recommended above when water enters stormwater facilities. These should be avoided in other BMPs as well since they do not readily break down to provide nutritional support to the plants.
- Sawdust, grass clippings, and leaves. These will break down quickly, robbing the soil of nitrogen.

Installation. A 2 to 3-inch layer of coarse compost or shredded wood (not bark products) shall be used over the amended soil and between the plantings to completely cover the soil and prevent erosion and weed intrusion.

AGGREGATES

Applicability. The open-graded crushed aggregate specifications apply to the following BMPs:

- The underdrain assemblies included in the
  - Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
  - Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
  - LID Swale BMP (Standard Details BMP 3.01 to 3.09).
  - Water Quality Conveyance Swale (Standard Detail BMP 9.04)

- Porous Pavement BMP base rock and/or the rock trenches (Standard Details BMP 5.01 to 5.04)
- Soakage trench BMP (Standard Details BMP 6.01 to 6.03)
- Drywell BMP (Standard Details BMP 7.01 and 7.02)

Terminology. Rock and aggregate are used interchangeably throughout this guidance.

Material Specifications. Coarse aggregate shall meet the following requirements:

1. All aggregates shall be clean and washed rock. For BMPs with geotextile fabric (see specification below) below rock (*e.g.* Porous Pavement BMP, Soakage Trench BMP, and Drywell BMP), a maximum wash loss of 0.5% is required. Clean rock is generally delivered with a 2% wash loss, so rinsing in the truck or on-site, using appropriate erosion control methods, may be needed to prevent long-term geotextile clogging. For BMPs that do not incorporate a geotextile fabric, 2% wash loss as delivered is acceptable.
2. All aggregates in porous pavements shall meet the following requirements:
    a. Minimum Durability Index of 35
    b. Maximum Abrasion of 10% for 100 revolutions and maximum of 50% for 500 revolutions
3. Unless otherwise approved by the engineer, **base rock** shall be uniformly graded with the following gradation (AASHTO #3):

Table C-1. AASHTO #3 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
2 ½” (63 mm)	100
2” (50 mm)	90-100
1 ½” (37.5 mm)	35-70
1” (25 mm)	0-15
½” (12.5 mm)	0-5

If the above gradation cannot be met, the following gradation (AASHTO # 5) is acceptable with the approval of the licensed engineer and minimum voids of 40%:

Table C-2. AASHTO #5 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½” (37.5 mm)	100
1” (25 mm)	90-100
¾” (19 mm)	20-55
½” (12.5 mm)	0-10
3/8” (9.5 mm)	0-5

4. **Choker course aggregate** (porous pavement) or **storage rock (rock trench) aggregate** or **French drain rock** (vegetated stormwater facilities) shall have the following gradation (AASHTO # 57).

Table C-3. AASHTO #57 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½” (37.5 mm)	100
1” (25 mm)	95-100
½” (12.5 mm)	25-60
4 (4.75 mm)	0-10
8 (2.36 mm)	0-5

5. **Infill aggregate** and **bedding course** (permeable pavers) or **separation rock** (vegetated stormwater facilities) shall have the following gradation (AASHTO # 8).

Table C-4. AASHTO #4 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
½” (12.5 mm)	100
3/8” (9.5 mm)	85-100
4 (4.75 mm)	10-30
8 (2.36 mm)	0-10
16 (1.18 mm)	0-5

GEOTEXTILE FABRIC

Applicability. Geotextile fabric specifications apply to the following BMPs:

- Porous Pavement BMP base rock and/or the rock trenches (Standard Details BMP 5.01 to 5.04)
- Soakage trench BMP (Standard Details BMP 6.01 to 6.03)
- Drywell BMP (Standard Details BMP 7.01 and 7.02)

Material Specifications. Non-woven geotextile (drainage filter fabric) shall conform to the following criteria:

- Minimum flow rate of 95 gal/min/ft2 ASTM D-4491-85
- Grab tensile strength min 115 lb. ASTM D-4632-86
- Mullen Burst strength min 150 psi ASTM D-3786-80a
- Puncture resistance min 45 lb. ASTM D-4833-88
- Apparent opening size 60-90 U.S. Standard Sieve

Installation. Geotextile fabric shall be installed per the following guidance:

- Place geotextile in accordance with manufacturer’s standards and recommendations.
- Adjacent strips of geotextile shall overlap a minimum of sixteen (16) inches.
- Secure geotextile at least four (4) feet outside of excavated area over exposed soil and take any steps necessary to prevent runoff or sediment from entering the pavement rock base.
- After porous pavement surface is installed, cut excess geotextile fabric at the interface between the ground and the pavement, so that it cannot be seen any longer.

Very Clean Rock Required. The presence of a geotextile fabric requires that the base rock be delivered clean and washed on-site before placement, if necessary. Otherwise, as water moves through the cross section, it will carry dirt particles down to the fabric and clog it, creating an impervious layer beneath the area you intended to be porous. One successful method for this is to hose the rock off in the delivery truck when it arrives. Another method is to dump the rock and wash off the pile, pulling rock from the top and applying water again, depending on the size of the pile. Inspect it visually on a regular basis for small rocks and dirt to know at what point in the pile you should start washing again.

TREATMENT SOIL

A treatment soil is a naturally occurring or engineered mix which may include clay, silt, sand, gravel, compost, microorganisms, and mycorrhizae that has the desired physical and chemical properties needed to clean stormwater as it passes through it. It must have a variety of physical and chemical properties.

Treatment soils meeting the specifications below may include:

- Undisturbed native soil
- Amended Planting Soil (referred to in **Appendix F** Standard Details for rain gardens, stormwater planters and LID swales), which may be either:
    - Amended native soil

- Imported soil mix

Imported treatment soil mixes in Western Oregon have a variety of names, which may be marketed as bioretention soil mix (BSM), planting soil, amended soil, engineered soil, 3-way mix, or others.

Applicability. Treatment soil specifications apply to the following BMPs:

- Depave Existing Pavement BMP
- Restored Soils BMP
- Contained Planters BMP
- Dispersion BMPs (Standard Details BMP 4.01 to 4.02)
- Tree Planting BMP (Standard Details BMP 10.01 to 10.04)
- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Material Specifications for All Treatment Soils. All treatment soils should be:

- Tested and confirmed to infiltrate between 0.5 inches per hour and 12 inches per hour[1] per Appendix C.
- Be free of weed seeds. If soil is imported, the supplier should be able to certify this condition through industry standard best practices.
- Be free of contaminants & hazardous materials[1]

Material Specifications for Imported Soil Mixes. All imported soil mixes should be tested for and meet the following criteria to a minimum depth as shown on the standard details in Appendix F:

- An organic content matter (OM) from 8-10% by weight[1]
- A cation exchange capacity (CEC) greater than 5 millequivalents/100 grams of dry soil[1]
- Between 2 – 5% clayey fines[1]
- pH between 5.5 and 7.5[2]
- 60% Loamy sand[1]
- 40% organic matter compost[1]
- Conform to the following gradation:

Table C-5. Imported Soil Gradation Specifications.

U.S. Sieve Size	Percent Passing
3/8-inch	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

Additional Specifications for Amended Native Soil. Amended native soil is the soil on the site mixed with organic matter compost (required) and gravelly sand (optional).

[1] Test undisturbed native soil for both the undisturbed native soil and amended native soil conditions per Appendix C. Test imported soil mixes in a lab according to the guidance provided in this memo retrieved from the State of Washington's Water Quality Manual: *http://www.ecy.wa.gov/programs/wq/stormwater/bsmresultsguidelines.pdf*

[2] Low Impact Development Center specifications. Retrieved from: http://www.lowimpactdevelopment.org/epa03/biospec_left.htm

Organic Matter Compost. Material should meet the specifications described above for organic matter compost.

Gravelly Sand. Use of gravelly sand is optional. For clayey soils, gravelly sand must be blended into the soil simultaneously with organic matter compost. **Caution! Never fold sand alone into clayey soils.** With insufficient quantities of sand, this action is likely to cement the soil creating a barrier to infiltration.

Gravelly sand should be free of organic material, contaminants, and hazardous materials, and should conform to the following gradation, which should be compared against the gradation of material provided by your quarry:

Table C-6. Gravelly Sand Gradation Specifications.

U.S. Sieve Size	Percent Passing
2-inch	100
3/4-inch	70-100
1/4-inch	50-80
No. 40	15-40
No. 200	0-3

Mixing. Mix soil and amendments to a homogeneous (i.e. all the same) consistency. Do not mix compost, sand, and native soil in the rain or wet conditions. Even in dry weather, soils and amendments themselves should not be overly wet.

Choose from two different soil blends as follows:

- Organic matter compost only = 2 (soil):1 (organic matter compost)
- Organic matter compost and gravelly sand = 2(soil):1(organic matter compost):1(sand)

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

Placement. Place amended native soil mix in lifts not exceeding 8 inches in loose thickness. Compact lightly after each lift. Do not over compact soil mix with mechanical equipment after placement; following the construction steps in this guidance, soils have already been compacted by spraying water on them or boot tamping. After all lifts have been placed, grade soil to finish grades as specified on the plans.

IMPERMEABLE LINER

Applicability. Impermeable liners may be used to line the sides of infiltration rain gardens, stormwater planters, LID swales, and water quality conveyance swales (to prevent undercutting of adjacent structures during infiltration) or the sides and bottom of lined facilities. Specifications apply to the following BMPs:

- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Material Specifications. Impermeable liners may be a 45-mil (minimum) low density polyethylene (LDPE), 45-mil (minimum) ethylene propylene diene monomer (EPDM) or bentonite clay mat per manufacturer guidance.

Placement. Make sure that the liner is installed securely at a height equal to the depth of water that may be ponded or flowing during any storm, not just the design storm. If an outlet structure is present, attach the liner to the outlet structure with the appropriate adhesive or mechanically.

If an LDPE or EPDM liner will be used, make sure that it's a single, solid piece big enough to be installed underneath the entire facility area or that pieces are glued or otherwise waterproofed together per manufacturer guidelines. Overlapping sheets will not adequately prevent infiltration.
If the design calls for a bentonite clay mat, follow the manufacturer's guidance for installation.

POROUS ASPHALT PAVEMENT SPECIFICATION

This specification has been provided courtesy of Tom Cahill of Cahill Associates. This specification has been adapted for conditions throughout Western Oregon but should be further completed with specific information for your project.

Where project-specific changes to this specification are needed, information has been ***[bracketed, changed to italics, and in the color green similar to this text.]***

Blue information in a box is provided to give you more information on how to complete the project-specific changes. Except for the sentence "This specification has been provided courtesy of Tom Cahill of Cahill Associates.", delete the above paragraph and all blue text and incorporate these specifications into your construction documents and/or contract drawings.

Summary

The work of this Section includes subgrade preparation, and base course, choker base course, and porous bituminous paving.

Part 1: Submittals

- Submit a list of materials proposed for work under this Section including the name and address of the materials producer and the location from which the materials are to be obtained.
- Submit certificates, signed by the materials producer and the paving subcontractor, stating that materials meet or exceed the specified requirements.
- Submit samples of base rock and choker course aggregate, non-woven geotextile, and porous bituminous asphalt for review and approval by the Engineer.
- The asphalt mixing plant shall certify the aggregate mix, abrasion loss factor, polymer additive, binder draindown, tensile strength ratio, resistance to stripping by water and asphalt content in the mix.

Quality Assurance

- Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work in this section.
- Codes and Standards
    - All materials, methods of construction and workmanship shall conform to applicable requirements of Oregon Department of Transportation, unless otherwise specified.

ODOT has been using open graded HMAC as a top course over impervious pavement for years to reduce spray and hydroplaning.

Project Conditions

A. Protection of Existing Improvements

1. Protect adjacent work from splashing or paving materials. Remove all stains from exposed surfaces of paving, structures, and grounds. Remove all waste and spillage.
2. Do not damage or disturb existing improvements or vegetation. Provide suitable protection where required before starting work and maintain protection throughout the course of the work.
3. Restore damaged improvements, including existing pavement on or adjacent to the site that has been damaged as a result of construction work, to their original condition or repair as directed to the satisfaction of the Owner, and authority having jurisdiction at no additional cost.

B. Safety and Traffic Control
1. Notify and cooperate with local authorities and other organizations having jurisdiction when construction work will interfere with existing roads and traffic.
2. Provide temporary barriers, signs, warning lights, flaggers, and other protections as required to assure the safety of persons, vehicles, and bicycles around the construction area and to organize the smooth flow of traffic.

C. Weather Limitations
1. Do not place bituminous paving mixtures between *[November 1 and April 1]*, unless otherwise permitted in writing by the Engineer.

Change this to reflect the period where your region's average temperatures may be colder than 55 degrees.

2. Do not place porous bituminous paving mixtures when surfaces are wet or when the ambient temperature is 55 degrees Fahrenheit of lower.

D. Annual Book of ASTM Standards, 1997 or latest edition; American Society for Testing and Materials, West Conshohocken, PA.
E. Standard Specifications, latest edition; Oregon Department of Transportation (ODOT)
F. Standards of the American Association of State Highway and Transportation Officials (AASHTO), 1998 or latest edition.

Part 2: Products

Materials

A. Base Courses
1. All aggregates within reservoir course shall meet the following:

a. Maximum Wash Loss of 0.5%
b. Minimum Durability Index of 35
c. Maximum Abrasion of 10% for 100 revolutions and maximum of 50% for 500 revolutions

Our volcanic rocks like basalt are going to meet this durability index, so this shouldn't be hard to find in Oregon. Same with abrasion.

2. Unless otherwise approved by the Engineer, base rock shall be uniformly graded with the following gradation (AASHTO number 3):

Table C-7. AASHTO #3 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
2 ½" (63 mm)	100
2" (50 mm)	90-100
1 ½" (37.5 mm)	35-70
1" (25 mm)	0-15
½" (12.5 mm)	0-5

If the above gradation cannot be met, the following gradation (AASHTO size number 5) is acceptable with the approval of the Engineer and minimum void space of 40%:

Most uniformly graded rock has 40% voids, so this shouldn't be a big deal to find in Oregon.

Table C-8. AASHTO #5 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	90-100
¾" (19 mm)	20-55
½" (12.5 mm)	0-10
3/8" (9.5 mm)	0-5

3. Choker course aggregate shall have the following gradation (AASHTO size number 57).

Table C-9. AASHTO #57 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	95-100
½" (12.5 mm)	25-60
4 (4.75 mm)	0-10
8 (2.36 mm)	0-5

4. Non-woven geotextile (drainage filter fabric) shall conform to the following:
   a. Minimum flow rate of 95 gal/min/ft^2 ASTM D-4491-85
   b. Grab tensile strength min 115 lb ASTM D-4632-86
   c. Burst strength min 150 psi ASTM D-3786-80a
   d. Puncture resistance min 45 lb ASTM D-4833-88
   e. Apparent opening size 60-90 U.S. Standard Sieve
   f. Non-woven geotextile shall be Mirafi 160N, or approved equal.

5. 2-foot wide rock edge drain shall be 1 to 2 ½" diameter washed screen crushed aggregate with no fines.

This is a backup overflow system if the pavement surface clogs. Tip the pavement a minimum of 1% towards this edge drain and design and install the edge drain to connect/sit on top of the reservoir course. If the pavement is clogged, rainfall will turn into runoff, but will still be infiltrated.

B. Porous Bituminous Asphalt

1. In accordance with ODOT Section 00745, ½" Open Grade Level 3 HMAC mix except as modified by the following:

Click on this link to download Word doc with ODOT specs.

2. Bituminous surface course for porous paving shall be *[two and one-half (2.5) inches thick]* with a bituminous mix of 5.5% to 6% by weight dry aggregate. In accordance with ASTM D6390, draindown of the binder shall be no greater than 0.3%. If more absorptive aggregates, such as limestone, are used in the mix then the amount of bitumen is to be based on the testing procedures outlined in the National Asphalt Pavement Association's Information Series 131 – "Porous Asphalt Pavements" (2003) or ODOT equivalent.

Thickness of asphalt is often 2.5 to 3 inches thick, but this varies with the project. Get recommendation from geotechnical engineer for your soils and traffic loading.
The draindown is critical or the pavement will clog due to the binder being too viscous and draining down the interface between the asphalt and the rock and sealing the pavement at that interface.
Click on the purple text link to buy "Porous Asphalt Pavements" document.

3. For traffic bearing surfaces, use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of *[PG 70-22]* in accordance with ODOT Section 00744.11. The elastomeric polymer shall be styrene-butadiene-styrene (SBS), or approved equal, applied at a rate of 3% by total weight of the binder. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Varies with location. Get recommendation from geotechnical engineer or reference Chapter 3 of the Asphalt Association of Oregon publication "Asphalt Pavement Design Guide". This value SHOULD work for the Willamette Valley.

The contractor shall submit a certification letter from the polymer-modified asphalt supplier to the Engineer before the mix is placed on the project. The certification letter from the supplier will include the following:

a. Type of elastomer polymer used to modify the asphalt.
b. Quality control sampling and testing procedures used to certify the polymer modified asphalt prior to shipping to the Contractor's asphalt plant.
c. Information on the storage and stability of the polymer modified asphalt.
d. Recommended mixing and compaction temperatures.
e. A statement saying that the polymer modified asphalt will comply with these specifications.

4. Add hydrated lime at a dosage rate of 1.0% b weight of the total dry aggregate to mixes containing granite. Hydrated lime shall meet the requirements of ASTM C977. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

The asphaltic mix shall be tested for its resistance to stripping by water in accordance with ASTM D-3625. If the estimated coating area is not above 95 percent, anti-stripping agents shall be added to the asphalt.

Part 3: Execution

Installation

A. Base Course

1. Owner shall be notified at least 24 hours prior to all base courses and porous paving work.
2. Subgrade Preparation
   a. Existing subgrade under pavement areas shall NOT be compacted or subjected to excessive construction equipment traffic prior to geotextile and stone bed placement.

Your geotechnical engineer can recommend equipment that might be used for your soils. For instance, in sandy soils, track equipment may not cause excessive compaction. In clays soils, though, it is very likely to and some means of working from the side or building a deep haul road to spread the loads over the soils would be needed.

   b. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6" with a spring tooth rake or equivalent and a light tractor.

"Light equipment" means hand tools. Even foot traffic can compact clay soils!

   c. Bring subgrade of base course to line, grade, and elevations indicated. Fill and lightly re-grade with aggregate base course material any areas damaged by erosion, ponding, or traffic compaction before placing the aggregate. All bed bottoms are level grade.

3. Base Course Installation
   a. Upon completion of subgrade work, the Engineer shall be notified and shall inspect at his discretion before proceeding with reservoir and choker course installation.
   b. Geotextile and base course aggregate shall be placed immediately after approval of the subgrade preparation. Any accumulation of debris or sediment, which has taken place after approval of subgrade shall be removed prior to installation of geotextile at no cost to the Owner.
   c. Place geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile shall overlap a minimum of sixteen inches (16"). Secure geotextile at least four (4) feet outside of excavated area and take any steps necessary to prevent any runoff or sediment from entering the storage bed.
   d. Install reservoir base course in 8-inch maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregates to grades indicated on the drawings.
   e. Install choker base course aggregate evenly over surface of rock trench, sufficient to allow placement of pavement, and notify Engineer for approval. Choker base course shall be sufficient to allow for even placement of asphalt, but no thicker than 1 inch in depth.

This choker course evolved as a means to lock the lightly compacted, open-graded (i.e. no fines) reservoir course rocks into place so the porous asphalt can be rolled out evenly. If this course is too thin, the reservoir course will roll. Too thick, and the choker course will then be the rock that rolls around under the weight of the roller.
The reservoir course is made up of 1-1.5" diameter rock and the thickness of the choker course needed to lock the pavement in place is a function of what reservoir gradation you use. The 1-inch minimum depth is a guide and can vary somewhat.

   f. Following placement of base course aggregate, the geotextile shall be folded back along all bed edges to protect against sediment washout along bed edges. At least a four (4) foot strip shall be used to protect beds from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to the rock trenches are stabilized and vegetated or the porous bituminous asphalt is installed. In addition, take any necessary steps to prevent sediment from washing into beds during site development. When the site is fully stabilized, temporary sediment control devices may be removed.

"Fully stabilized" means 90% vegetative cover with deep roots, not just grass fuzz that's just come up. Fuzz/shallow roots aren't going to hold soil and the pavement can get clogged.

B. Porous Bituminous Asphalt
   1. Transporting Material
      a. Transporting of mix to the site shall be in vehicles with smooth, clean dump beds that have been sprayed with a non-petroleum release agent.
      b. The mix shall be covered during transport to control cooling.

   2. Porous bituminous asphalt shall not be stored more than 90 minutes before placement.
   3. Asphalt Placement
      a. The porous bituminous surface source shall be laid in one lift directly over the storage bed and stone base course to a *[2.5]* inch finished thickness.

Varies by project. Match to spec above.

      b. The laying temperature of the bituminous mix shall be between 300 degrees Fahrenheit and 350 degrees Fahrenheit (based on the recommendations of the asphalt supplier).
      c. Installation shall take place when ambient temperatures are 55 degrees Fahrenheit or above, when measured in the shade away from artificial heat.
      d. The use of a remixing material transfer device between the trucks and the paver is highly recommended to eliminate cold lumps in the mix.
      e. The polymer-modified asphalt is very difficult to rake; a well-heated screed should be used to minimize the need for raking, which can clog the pavement.
      f. Compaction of the surface course shall take place when the surface is cool enough to resist a 10-ton roller. One or two passes is all that is required for proper compaction. More rolling could cause a reduction in the surface porosity, which is unacceptable.

This is really important, so be on–site the first day to talk to the paving contract about this and observe the rolling. Otherwise, you could end up with a clogged pavement from the first day of its installation.

   4. After final rolling, no vehicular traffic of any kind shall be permitted on the surface until cooling and hardening has taken place, and in no case within the first 72 hours. Provide barriers as necessary to prevent vehicular use; remove at the direction of the Engineer.
   5. Transition to adjacent impervious bituminous paving shall be merged neatly with flush, clean lines. Finished paving shall be even, without pockets, and graded to elevations shown on drawing.
   6. Porous pavement area shall at no time be used for equipment or materials storage during construction, and under no circumstances shall vehicles be allowed to deposit landscape materials on paved porous surfaces.

Best practice: Lay a tarp down. This is a best practice for ALL pavements since most contractors are not fond of sweeping and organic material on impervious surfaces is often just power washed into the drain.
Another best practice: Put up a sign, so all your sub-contractors know what and where the porous pavement is and how they should change their practices. Mention this at the weekly meeting, too, since contractors come and go.

7. Repair of Damaged Paving
    a. Any existing pavement on or adjacent to the site that has been damaged because of construction work shall be repaired to the satisfaction of the Owner.

8. Field Quality Control
    a. The full permeability of the pavement surface shall be tested by application of clean water at the rate of 5 gallons per minute over the surface, using a hose or other distribution device. Water used for the test shall be clean, free of suspended solids and deleterious liquids. All applied water shall infiltrate directly without puddle formation or surface runoff and shall be observed by the Engineer and Owner.
    b. Testing and Inspection: Employ at Contractor's expense an inspection firm acceptable to the Engineer and Owner to perform soil inspection services, staking and layout control, and testing and inspection of site grading and pavement work. Inspection and list of tests shall be reviewed and approved in writing by the Engineer prior to starting construction. A licensed Engineer must sign all test reports.
    c. Test in-place base and surface course for compliance with requirements for thickness and surface smoothness. Repair or remove and replace unacceptable work as directed by the Owner.
    d. Surface Smoothness: Test finished surface for smoothness and even drainage, using a ten (10) foot to centerline of paved area. Surface will not be accepted if gaps or ridges exceed 3/16 of an inch.
9. Grade Control
    a. Establish and maintain required lines and elevations. The Engineer shall be notified for review and approval of final stake lines for the work before construction work is to begin. Finished surfaces shall be true to grade and even, free of roller marks and free of low spots to form puddles. All areas must drain.
    b. If, in the opinion of the Owner, based upon reports of the testing service and inspection, the quality of the work is below the standards, which have been specified, additional work and testing will be required until satisfactory results are obtained.

STRUCTURAL TREE SOIL MIX SPECIFICATIONS

Structural Soil

Structural soil shall consist of a mixture of gravel, soil and admixtures as described below. The following sources are approved to supply the materials. Other sources may be approved, based upon satisfactory test results however, it is the contractor's responsibility to provide the required information or testing needed to approve the source.

Engage a licensed engineer to provide site preparation specifications, pavement sections, and construction oversight as required by the following sections.

Materials

Structural Soil shall consist of the following materials:
1. Crushed rock (3/4" to 1 ¼" diameter)
2. Loam/organic Topsoil
3. Soil Binder such as "Stabilizer"
4. Water

Proportions of materials

The major components of the structural soil mixture are crushed rock and topsoil. Since when mixed together some of the topsoil fills in the voids of the crushed rock material the sum of the rock and topsoil volumes does not equal the volume of the structural soil material. There is approximately a 10% volume reduction due to mixing the materials together.

Material	Amount for 1 CY of Structural Soil	Amount for 4.6 CY of Structural Soil
Crushed Rock	23.2 cubic feet	4 cubic yards
Topsoil	5.9 cubic feet	1 cubic yard
Soil Binder	13.7 oz	4 pounds
Water	1.6 gallon	46 gallons

The target moisture content is 20% by weight of the topsoil weight. The above water content assumes the topsoil is dry. The amount of water that will need to be added depends on the moisture content of the raw materials. Actual amounts of water used will be determined during mixing based on observations of the material through the mixing procedure below.

Mixing procedure

1. Mix structural soil in batches of an appropriate size for the equipment being used. The result is to be a material that is uniformly blended together. Do not batch in quantities that will not allow the equipment to completely mix the material. Determine batch size and quantities of each material needed for the batch.
2. Start with half of the crushed rock material.
3. Add all the topsoil material.
4. Add the soil binder.
5. Add half of the estimated water.
6. Add the other half of the crushed rock material.
7. Mix the material together.
8. Slowly add water to the mixture and continue to mix. The final amount of water will vary with moisture content of the crushed rock and topsoil. Add water in incremental amounts and mix the material between the additions of water.
9. Stop adding water and mixing when there is a minute amount of free topsoil remaining. The topsoil will coat the crushed rock and not fall out of the material. All of the crushed rock should be uniformly coated with topsoil. There should be no clumps of topsoil or uncovered crushed rock in the mixture.
10. If too much water is added to the mixture water will drain out of the material and the topsoil will wash off the crushed rock. If this occurs this batch of material is to be discarded and shall not be incorporated into the completed work.

Placement

1. Protect soils and mixes from absorbing excess water and from erosion at all times. Do not store materials unprotected from rainfall events. Do not allow excess water to enter site prior to compaction. If water is introduced into the material after grading, allow material to drain or aerate to optimum compaction moisture content.
2. All areas to receive Structural Soil mixture shall be inspected by the licensed engineer before starting placement of mixture. All defects such as incorrect grading, compaction and inadequate drainage, etc., shall be corrected prior to beginning placement of Structural Soil.
3. Confirm that the sub-grade is at the proper elevation and compacted or uncompacted, as indicated by the plans and/or site preparation specifications. Sub-grade elevations shall slope parallel to the

finished grade. Clear the excavation of all construction debris, trash, rubble and foreign material. Fill any over excavation with approved fill and compact to the required sub-grade compaction.

4. Install Structural Soil in 6-inch lifts and compact each lift to 85 percent of maximum density using lightweight, handheld compaction equipment. Delay compaction 24 hours if moisture content exceeds maximum allowable and protect Structural Soil with plastic or plywood as directed by the Engineer. Do not overcompact. Engage a testing company to test field density of each lift, especially in the beginning when the contractor is “getting a feel” for compacting the material to the appropriate density.
5. The water service lines that cross the structural soil material fill area may be corroded and fragile. The contractor shall take care when working around the water service lines. If a service line is damaged, develops a leak or is bent, the service line shall be replaced as per City of Grants Pass standards at the contractor's expanse. The structural soil that will be the bedding for the water service lines shall compacted to conform to the grade of the water service line. The contractor shall not compact the immediate vicinity above a water service line until a fill depth of 12-inches above the water service line is reached.
6. Bring Structural Soils to finished grades as shown on the drawings. Immediately protect the Structural Soil material from contamination from water by covering with plastic or plywood as directed by the Engineer.
7. The Engineer may periodically check the material being delivered and installed at the site for mixture proportions and consistency with the material requirements of these specifications. If the installed material varies significantly from the specified material, the Contractor shall remove the material and replace with the specified Structural Soil material at no extra cost to the Contracting Agency.

Measurement

Structural Soil per cubic yard shall be measured by the neat lines as shown on the plans.

Payment

Payment of the bid item “Structural Soil” per cubic yard shall include all costs to supply, mix, haul, place and compact the structural soil material. All costs associated with subgrade preparation shall be included in this bid item.

Additional Information: Physical Tests

The following are the results of physical tests performed on materials used in a successful structural tree soil project in Olympia, WA. Materials should closely approximate the materials found here.

Rock. Crushed Rock, Gradation of 100% passing 1.25 inch, 26% passing 0.75 inch, 4% passing 0.25 inch and 0.5% passing No 40 sieve by weight.

Soil. ASTM D2487 Soils Classification SW-SC Well-graded Sand with Silty Clay. With a composition of 9% Gravel, 81% Sand, 8% Silt and 2% Clay. Organic Content of 8.3% dry weight.

Stabilizer. Stabilizer as supplied by Stabile Inc. 2218 E magnolia Street Phoenix Arizona 85034 USA (602) 225- 5900 & 1(800) 336-2468 Phone (602) 225-5902 Fax

Structural Soil. Compaction and bearing tests were performed on the structural soil mixture. The proctor density of the material was 138.7 pounds per cubic foot. The California Bearing Ratio (CBR) value at 100% density was 74.

Since a high voids content was desired, 85% compaction was the target for the project. This resulted in a CBR value of 30. Subgrades in Olympia are compacted to 95% under roads and 90% under non-traffic areas. Generally, if this compaction reaches a CBR value of 20 it would be adequate for supporting our standard 4-inch concrete sidewalk or standard roadway sections. A CBR value of 30 provided sufficient bearing capacity for the sidewalk and provided about one third voids content in the structural soil.

APPENDIX E: PLANT SPECIFICATIONS

TABLE OF CONTENTS

CRITERIA FOR CHOOSING PLANTS

Above all, plants should be chosen using the motto "Right Plant, Right Place". Plants in BMPs provide many ecological, hydraulic, and social functions, which must be considered. When choosing the best plants as stormwater managers, first consider water quality function of the facility. A diverse assembly of long-lived plants should be chosen according to the guidance provided throughout this appendix. Varying heights and rooting depths are also beneficial, if feasible.

Recommendations for Stormwater Management

Natives, non-natives, and invasives are not interchangeable terms. Their differences and the reasons for the following recommendations are provided in the "Background and Considerations" section below.

Suitable Plants Hierarchy. When choosing suitable plants, use the following hierarchy:

- Due to the availability of a variety of suitable species at nurseries[1], it is recommended to use native plants (groundcover, forbs (flowers), shrubs, and trees) wherever possible. In the case of street trees, if soils are highly degraded, avoid native trees.
- When selecting non-native plants, use the following research:
    - Avoid plants that reproduce readily. These are plants that spread by seeds (*e.g.* grasses), rhizomes (when a piece of broken off root will start a new plant, *e.g.* Yellow flag iris), or culms (when a piece of a stem is able to re-root, *e.g.* English Ivy), etc.
    - Avoid plants listed on the Native Plant Society's Emerald Chapter's website[2] for "Exotic Gardening and Landscaping Plants" that are emerging as problematic. Due to numerous similarities throughout Western Oregon, designated as a "bioregion", it's more likely that plants that are problematic could easily be problematic elsewhere in the bioregion. It's better to be cautious and avoid these plants in your region.
    - Avoid plants listed on the invasive plant lists of Washington[3] and California[4].
    - Consult with your local OSU Extension agent, watershed council, or soil and water conservation district.
- Avoid invasive plants listed on the Oregon Department of Agriculture "Oregon Noxious Weed List"[5].

Background and Considerations

Use Native Plants for Better Water Quality. Native plants are essential to healthy watersheds. They provide unique services and products in our region that other kinds of plants may not provide.
Native plants:

- Evolved over geologic time periods with other plants and animals in our watersheds. Native plants support the insects that feed the birds (Tallamey) that spread the seeds that grow the diverse landscapes that manage stormwater.
- Are generally easier to establish, which lessens maintenance, especially in the first two years of a BMP
- Often require less water and fertilizers.

---

[1] Native Plant Society of Oregon (NPSO) website. Retrieved from: http://www.npsoregon.org/landscaping5.php
[2] NPSO. Exotic Gardening and Landscaping Plants Invasive in Native Habitats of the Southern Willamette Valley. Retrieved from: http://emerald.npsoregon.org/inv_ornmtls.html
[3] Washington State Noxious Weed Control Board. Retrieved from: http://www.nwcb.wa.gov/
[4] Invasive Species Council of California. The California Invasive Species List. retrieved from: http://www.iscc.ca.gov/species.html
[5] Oregon Department of Agriculture. Oregon Noxious Weed Profiles. Retrieved from: http://www.oregon.gov/ODA/programs/Weeds/OregonNoxiousWeeds/Pages/AboutOregonWeeds.aspx

Avoid Invasive Plants. Invasives, or weeds, impact the watershed in many ways by:

- Overgrowing on trees and blocking solar access.
- Physically pulling limbs down.
- Filling niches in the watershed that would have been occupied by a variety of species and excluding them.
- Changing the composition of the soil organisms that provide our watershed's long-term permeability.
- Some invasives, like Himalayan Blackberry, increase erosion by shading out understory plants and exposing bare soils to rain.
- Reducing crop yield, which is why the Oregon Department of Agriculture maintains a list of invasive species, called the Oregon State Noxious Weed List[6].
- Impacting habitat. While many native insects and some amphibians find adequate habitat in any plant, many plants do not provide adequate habitat. Insects provide us with the long-term permeability of our watersheds and are the foundation of the food web for the wildlife that spreads the seeds that create forests. Just as humans are not adapted to eat a bowl of maple leaves, many native insects are adapted to eat only parts of native plants (see below for more information on native plants).

Figure E-1. Vinca minor, Himalayan Blackberry, and English Ivy are intermixed with natives along a popular hiking trail in the Columbia River Gorge, many miles from the nearest town. Seeds enter the forest on the wind, by birds and mammals, and are tracked in on shoes.

Use Non-Native Plants Carefully. Non-native plants are generally used by gardeners as ornamentals or edibles such as fruits, vegetables, and herbs. In many cases, non-natives are not harmful and are preferred as street trees, due to the many constraints of putting the right plant in the right place. On the other hand, non-native species may become invasive, and there's often no way to know which path a plant will take until it has been introduced into a watershed. Some non-natives have taken up to 80 years to become invasive after overplanting (*e.g.* kudzu planted on the East coast for erosion control); some spread quickly from just a few specimens (*e.g.* scotch broom dominates the Pacific NW landscape and originated from three plants introduced in the late 1800's). Follow the research guidelines provided above to ascertain whether a non-native is likely to become invasive.

[6] *Oregon Department of Agriculture. Oregon Noxious Weed Profiles. Retrieved from:* *http://www.oregon.gov/ODA/programs/Weeds/OregonNoxiousWeeds/Pages/Law.aspx*

There are additional reasons to avoid non-native, edible plants:

- Fertilizers, pesticides, and herbicides used to maximize yield could be easily exported to become pollutants from any BMP.
- In rain gardens, stormwater planters, swales, and vegetated filter strips, polluted runoff is directed to the plants for treatment. Plants may treat pollutants in a variety of ways. Microbes on the roots or other internal processes may break pollutants down into harmless materials or the pollutants may be absorbed and stored in the plant structure, including leaves, flowers, or fruits. While research is underway, there is very little science currently on which plants uptake which pollutants and where each plant stores those pollutants. It's possible that pollutants can become concentrated in an edible part of a plant, so regardless of whether they are native or non-native edible plants, they should be avoided in these facilities.

Native Cultivars ("Nativars"). "Nativar" is a relatively new term has been coined to describe cultivars of native plants. These are readily available and popular, because they offer a variety of sizes, shapes, and colors. Sometimes these plants offer the same benefits (see list above in "Use Native Plants for Better Water Quality") as their native relatives, which have not been crossbred; sometimes they do not. For this reason, as with non-native plants, there is currently no way to know whether "nativars" would be impacting the watershed in ways similar to invasive plants in that they are filling niches that could be occupied by non-crossbred native plants, changing the microbial soil composition, or not providing wildlife benefit. Use native cultivars carefully, researching information using guidance provided above for "Suitable Plants Hierarchy".

Soil Depth Influences Plant Choice

Generally, the more soil, the better it will be for the plant. Choose plants that, at maturity, will still have enough soil to be low maintenance. Too little soil can stunt the size of the plant or, in the case of trees, cause it to be unhealthy and drop limbs. For plants to reach their full size at maturity and be low maintenance, soil depth requirements vary with the plant type. Generally, soil depth minimums are as follows:

- Sedums: 2"
- Grasses: 12". Generally, the roots of grasses and grass-like plants will be as deep as the plant is tall so some species may benefit from deeper soil.
- Shrubs: 18", but 24" is preferable.
- Trees: 36", but depending on the species, trees also need a minimum volume of soil, 400 to 1,000 cubic feet. Since tree roots often don't extend much deeper than 3 feet, the minimum area needed is 133 to 333 square feet (see **Chapter 4** "*Tree Planting BMP*").

Lined Vegetated Stormwater Facilities. Lined vegetated stormwater facilities designed per this guidance require 30" of soil to provide water quality treatment before runoff flows out of the facility. This soil depth is enough for sedum, grasses, and shrubs. Trees are not suitable for lined facilities unless additional cost is incurred to incorporate adequate soil depths.

PLANT SPACING, DENSITY & CONTAINER SIZE

Applicability. The information in this section applies to the following BMPs:

- Restored Soils BMP
- Vegetated Roofs (Green Roofs) BMP
- Dispersion BMP
- Rain Garden BMP
- Stormwater Planter BMP
- LID Swale BMP

- Water Quality Conveyance Swale BMP

The BMPs above rely on good vegetative cover to optimize water quality treatment and reduce maintenance needs, such as weeding.

Plant spacing and pot size needed to achieve the coverage goals -- provided in the detailed guidance for each BMP in **Chapter 4** – vary based on the type of plant, as follows. This section does not apply to street tree planting. See Grants Pass, OR, Development Code 23 for spacing, container size and other requirements for street tree plantings.

Suggested Plant Tables for Combining Plant Types. Plant densities that exceed the following tables may be desired for initial aesthetic reasons. For a cost- and environmentally-effective facility, minimum plant quantities are as follows:

Table E-1. Primarily herbaceous plants, such as flowers, groundcover, grasses, sedges, rushes.

Number of plants	Vegetation type	Per square feet of BMP	Size	Spacing density (average on center)*
45	Herbaceous plants	100	1 gallon	1.5'***
OR				
37	Herbaceous plants	100	1 gallon	1.5'***
4	Small shrubs	100	1 gallon	3' to 4'**
OR				
100% Native seed coverage (follow supplier guidelines for density)				

* To reduce erosion and water flows from shortcutting in runoff reduction BMPs receiveing concentrated flows, plants should be randomly located per Standard Details BMP 1.07, 2.07, 3.09, and 9.05. The average on-center density is provided as general guidance.
** Depending on mature spread. Shrubs may be placed farther away than density indicated but not closer.
*** Usually ranges from 1 to 3 feet, depending on plant species.

Table E-2. If a mix of herbaceous, small and large shrubs is desired, the following minimum plant quanties may be used.

Number of plants	Vegetation type	Per square feet of BMP	Size	Spacing density (average on center)*
30	Herbaceous plants	100	1 gallon	1.5'***
4	Large shrubs	100	1 gallon	4' to 8'**
OR				
6	Medium to small shrubs	100	1 gallon	3' to 8'**
35	Small shrubs	100	1 gallon	3' to 4'**

* To reduce erosion, plants should be randomly located. The average on-center density is provided as general guidance.
** Depending on mature spread. Shrubs may be placed farther away than density indicated but not closer.

Table E-3. Trees may be added to any of the above planting configurations, if appropriate (per Chapter 4 "Tree Planting BMP" "Siting").The recommended minimum density for trees is as follows.

Number of plants	Vegetation type	Per square feet of BMP	Size	Additional Info
1	Evergreen tree	300	6' high minimum	See guidance in Chapter 4 "*Tree Planting BMP*"
OR				
1	Deciduous tree	300	1.5" minimum caliper**	See guidance in Chapter 4 "*Tree Planting BMP*"

* Measured at a height of 6 feet above the base

Plant Placement

Moisture is considered one of the most important factors in choosing successful plants for your BMPs. Consider the drying effects of sunlight and wind when determining the moisture available at your site. As a result of buildings and other shading infrastructure, even very small sites may have a combination of light and moisture availability. See Section, "*Recommended Plant List*", Figure E-3.

SOIL TEXTURE

Soil texture affects how quickly a soil drains and how much moisture is retained for the plant's use after a rain event. Sandy soils drain quickly and don't hold as much moisture as clayey soils. The facilities in this guidance are designed to empty within 30 hours and with their facility bottoms at least a few feet (see individual guidance) above the groundwater table. Regardless of the soil texture in your BMP location, any soil that won't cause plant roots to be in standing water for more than 30 hours can be considered to be in a "well-drained" condition.

Some plants are adapted to grow better with a particular soil texture. A qualified landscape architect, landscape designer, or horticulturist can assist with identifying suitable plants for your project site based on soil texture. You can also use the USDA PLANTS database (see tutorial below) to find plants adapted to certain soil textures.

For more information on field testing and interpretation, see Appendix C: Infiltration Testing.

AESTHETICS

Aesthetics, are a matter of opinion, but consideration of the following questions can help with public acceptance of stormwater management facilities and promote their wider use:

- What is the plant's height, width?
- Does the plant have attractive foliage, flowers or fruit?
- Does wildlife like it?
- Does it look good with its neighbors?
- Does it have seasonal interest?
- Is it fire resistant?

To achieve a traditional design aesthetic:

- Place short, small plants in the front (or sides) and big, tall plants in the back or middle
- Scale your plants for your site
- Mass color or foliage for effect
- Lacy, light foliage mixes well with course foliage
- Draw attention to features by placement with other plants or hard features
- Include natural elements such as rocks and logs

Aesthetics can greatly impact maintenance frequency and intensity. For instance, squared-off hedges are going to be more difficult and costly to maintain than a more natural look.

SAFETY & CRIME

Regardless of the land use, vegetation should not block ground floor views either to or from a property (sometimes referred to as "eyes on the street") or provide hiding places for unauthorized users. Shrubs that grow excessively dense and/or tall should be planted with care. Some questions to ask about chosen plants when they reach their mature height and spread are as follows.

Will this plant (or associated landscape elements such as rocks, benches, etc):

- Obstruct traffic or block road signs? Check for setbacks and height limitations in rights of ways.
- Create a hazard? Does the plant have weak branches or does it tend to create excessively slippery or otherwise hazardous debris?
- Block views of ground floor windows or doors?
- Provide a place for unauthorized users to hide?
- Provide unauthorized access to a roof?
- Redirect foot traffic away from access points with the use of short, impenetrable hedges or thorny shrubs?

PLANTING TECHNIQUES

Plants from nurseries can often be root-bound in their pots. If the roots aren't loosened and unwound, the roots will continue to twist around in the planting hole instead of growing downwards and outwards, causing poor plant establishment and high maintenance. Another key to low maintenance plants is to ensure that the roots have good contact with the soil.

To plant a tree, see **Chapter 4** "*Tree Planting BMP*" "*Construction*".

Planting in Containers

To properly install plants in Contained Planters:

1. Fill your container with soil to within 4 to 5 inches of the top of the container.
2. Dig a hole twice the size of the pot the plant comes in. Keep the soil pile nearby and clear of leaves and other surface debris.
3. Take note of where the potting soil from the nursery level is compared to the stem of the plant. Many plants have a different color and texture on the section that sits below the soil than on the sections that sit above ground.
4. Gently shake the potting soil off as much of the roots as possible. The nutrition from the potting soil is likely to be exhausted.
5. For balled and burlapped trees, the soil may be left in. However, ensure that burlap or any other confining material will not impede root growth by removing at least the bottom half of the material.
6. Loosen the roots. For 4" root-bound plugs, use hand clippers to cut an X into the bottom of the root wad, then pull it apart to loosen the roots.
7. Taking some of the soil you dug out, create a mound at the bottom of the hole and lightly tamp it down.
8. Drape the plant roots around the mound so that they're touching the mound on the bottom and pointing downwards. There are two kinds of roots, larger structural roots and tiny feeder roots, which is where the plant "drinks" and "eats". In pot-bound plants, some roots may be really long and will just continue winding around the other plant roots. If they're very small feeder roots, shorten them by pulling them off to be a similar length as the other roots. A few of the bigger structural roots can be cut, but it's better to dig a deeper hole and get them pointed downward.

9. As you backfill the hole by pushing soil in around the tops of the roots, hold the plant so that the point at which the plant came out of the soil in its original pot will be the level where the final grade of soil in the contained planter will be (level of soil on the stem is the same). Plants that are planted too deep may drown or the stem may rot. Plants that are too high may not have enough feeder roots in the soil to survive.
10. When finished, tamp down the soil. If the container is very large, step around the stem of the plant. This, combined with previous steps, will ensure good root contact with the soil.
11. Place an organic mulch that meets the specifications in Appendix D, Compost Specifications to a depth of 2 to 3 inches. For woody stems on shrubs or trees, push the mulch a few inches away or the stems could rot.

Planting in the Ground

To properly install plants in a Restored Soils BMP area, or in a Rain Garden BMP, Stormwater Planter BMP, LID Swale, Dispersion BMP, or Conveyance Swale, follow steps 2-11 for installing plants in a Contained Planter BMP described above.

ESTABLISHMENT PERIOD MAINTENANCE

Native plants should be allowed to reseed before cutting the plant. When reseeding will occur depends on the chosen plant palette. As a general rule, most spring and summer blooming plants have seeded by August, and fall and winter blooming plants will have set their seed by January. Generally, most plants don't respond well when cut down to less than 6 inches high.

Timing of pruning is important. While common and correct horticultural practices might prune a shrub in the fall, when this is done to a shrub used for stormwater management, the shrub no longer has leaves to evapotranspire stormwater. This reduces the effectiveness of the BMP in reducing runoff.

Irrigation

Watering and weeding may be needed frequently within the first 1 to 3 years during Oregon's very dry summers, but this should taper off dramatically if you choose native perennial plants. The goal during the establishment period is to make plants as "drought proof" as possible by watering deeply and infrequently. Shallow, frequent watering will only make plants dependent on continued watering.

To establish perennial plants, you'll need to irrigate more in the first year and less to much less in subsequent years. In addition, plants benefit from varying irrigation seasonally. At the beginning of summer, after the rains stop, water a little. Increase irrigation volume as the summer/dry season continues. Taper off irrigation as the rains start to come back. Depending on your area and rainfall patterns, irrigation may be needed from May to October.

The volume of water and frequency of watering varies with the type of plant:

- Trees: 5-10 gallons, once/week
- Shrubs: 3-5 gallons once/week
- Groundcover: 1-2 gallons, once or twice/week
- Perennial herbs: ½ gallon, twice/week.

After the 2 – 3-year establishment period, irrigation would theoretically not be needed; however plantings surrounded by impervious pavement or hot roofs will probably require occasional irrigation beyond the establishment period, indefinitely.

Tips for hand watering. If hand watering with a hose, it may be difficult to know how much time it will take to apply the amounts described above to each plant. In this case, find a one-gallon container and time how long it takes to fill up. Multiply this time by the number of gallons above and water each plant for this amount of time. In some cases, water may begin to run off before the full time has been achieved, so water another plant for a little while and come back to the first plant after the original water has soaked in.

Plastic containers with a few holes in the bottom are one quick way to know how much water is being applied. The containers can fill up quickly (and repeatedly, as needed to achieve the above volumes) and water will drain out the holes without eroding soil or overloading the infiltration capacity. Clean the containers out very well and choose containers that contained something non-toxic like laundry detergent, but not something like bleach.

Reducing Water Demand & Improving Establishment

Watering techniques. Consider reducing your water demand by patient hand watering, using water efficient irrigation systems (i.e. drip), and harvesting rainwater. To make hand watering faster and more effective -- most people are not patient enough to water deeply enough to harden plants for drought -- find a gallon or two gallon container and poke a few small holes in the bottom and place it next to the stem of the plant. Commercially available watering bags are available for trees and large shrubs. This method allows you to deliver ideal water volumes to the plants quickly without causing erosion. Having a number of them already placed around the plants allows you to quickly move from one plant to another without having to wait for the water to soak in.

Mycorrhizae. Mycorrhizae are mushrooms that can interact in beneficial ways with plants to improve health and reduce water demand, through mycelium, or mushroom roots. These mycelia intertwine around plant roots and both mushroom and plant roots trade nutrients that the other cannot make. In addition, mycelium greatly expand the area for plants to access water and nutrition from the soil. Mushrooms will not necessarily sprout from the mycelium for the mycelium to work. Mycorrhizae treatments are very effective at reducing irrigation demand and supporting the long-term health of your plants through our tough summer droughts.

There are a number of commercial products available that can be surface applied or blended into the soil. See Appendix D for mycorrhizae specifications.

INTEGRATED PEST MANAGEMENT

Short and long-term maintenance of all landscape areas should be done using integrated pest management techniques.

According to the Oregon Department of Agriculture:

“Integrated pest management (IPM) refers to a coordinated decision-making and action process that uses the most appropriate pest control methods and strategies in an environmentally and economically sound manner to meet agency pest management objectives.

The elements of integrated pest management include the following:

- Preventing pest problems by focusing on developing healthy plant environments (fostering healthy soils, maintaining air flow and utilizing right plant right place techniques
- Monitoring for the presence of pests and pest damage
- Establishing the density of the pest population, which may be set at zero, that can be tolerated or correlated with a damage level sufficient to warrant treatment of the problem based on health, public safety, economic, or aesthetic thresholds
- Treating pest problems to reduce populations below those levels established by damage thresholds using strategies that may include biological, cultural, mechanical, and chemical control methods and that shall consider human health, ecological impact, feasibility, and cost effectiveness
- Evaluating the effects and efficacy of pest treatments

Pest refers to any vertebrate or invertebrate animal, pathogen, parasitic plant, weed, or similar organism that can cause disease or damage to crops, trees, shrubs, grasses or other plants, humans, animals, or property.[7]"

For additional resources including the PNW Insect Handbook, PNW Plant Disease Handbook, and the PNW Weed Handbook, visit the Oregon Department of Agriculture website: http://www.oregon.gov/ODA/programs/Pesticides/RegulatoryIssues/Pages/IPM.aspx.

Weeding. Invasive plants are invasive because they are more vigorous and grow faster than native and ornamental plants. While thoughtful irrigation, as described above, can reduce weeding effort, weeding is a continuous maintenance activity. During the establishment period, when desirable plants are still small, there will be many patches of open area where weeds will grow. Weeds and weed seed may also be brought in on the surface of plants grown in organic gardens where herbicides are not used.

Weeding frequency is generally recommended to be a minimum of twice a year in May and October, but should also be timed to pull whatever invasive plants are on-site before they go to seed. Hand pulling or other mechanical removal technique is preferred. In particular, pesticides, herbicides, and fertilizers should generally be avoided in maintaining any of the BMPs in this guidance, especially facilities that receive runoff and that infiltrate and/or have overflows. These are pollutants that are easily conveyed in stormwater runoff.

Figure E-2. Since weeds need water in the summer but the right natives won't, substantial irrigation beyond the establishment period will only increase maintenance.

SOURCING PLANTS

Plants may be sourced from a variety of nurseries. Choosing healthy, appropriate specimens is key to high functioning facilities. Some tips for sourcing plants are as follows:

- A list of native plant nurseries can be found online: http://www.npsoregon.org/landscaping5.php
- Plants should be from seeds adapted to either clayey or sandy soil type, according to the on-site soils.
- Plants should be from seeds gathered as locally as possible. For instance, a native alder grown from seed collected in Tillamook County will not be as well adapted to the Willamette Valley.

RECOMMENDED PLANT LIST

The following plants list and planting guide was prepared by the Rogue Valley Council of Governments in their *Stream & Wetland Enhancement Guide*, prepared in May, 2004. This plant list is considered

[7] *Oregon Department of Agriculture. Integrated Pest Management. retrieved from: http://www.oregon.gov/ODA/programs/Pesticides/RegulatoryIssues/Pages/IPM.aspx*

appropriate for stormwater management applications as set forth in this manual due to the hydrophilic nature of the plants listed. The City of Grants Pass is adopting this list along with a list of recommended plants for ecoroofs from the City of Portland SWMM.

Vegetated Roof (green roofs) recommended plants

Ecoroof vegetation should be:

- Drought-tolerant, requiring little or no irrigation after establishment.
- Self-sustaining, without the need for fertilizers, pesticides, or herbicides.
- Able to withstand heat and cold.
- Very low-maintenance, needing little or no mowing or trimming.
- Perennial or self-sowing.
- Fire-resistant.

A mix of sedum/succulent plant communities is recommended because these plants possess many of the attributes listed above. Although herbs, forbs, grasses and other low groundcovers can provide stormwater and aesthetic benefits, plants that require irrigation beyond what is allowed in this section for survival are not permitted.

Table E-4. Ecoroof plant list.

	Scientific Name	Common Name	Potential Height	Full Sun	Partial Shade
Succulents	*Delosperma cooperi*	Ice Plant	4”	X	X
	Delosperma nubigenum	Ice Plant	2”	X	X
	Opuntia spp.	Prickly-Pear Cactus	5”	X	X
	Sedum acre	Biting Stonecrop	2”	X	X
	Sedum album	White Stonecrop	3”	X	X
	Sedum divergens	Pacific Stonecrop	3”	X	X
	Sedum hispanicum	Spanish Stonecrop	3”	X	X
	Sedum kamtschaticum	Kirin-so	6”	X	X
	Sedum lanceolatum	Lance-leaved Stonecrop	4”	X	X
	Sedum oreganum	Oregon Stonecrop	4”	X	X
	Sedum oregonense	Creamy Stonecrop	4”	X	X
	Sedum rupestre	Crooked Stonecrop	6”	X	X
	Sedum sexangulare	Tasteless Stonecrop	4”	X	X
	Sedum spathulifolium	Broad-leaved Stonecrop	4”	X	X
	Sedum spurium	Two-row Stonecrop	6”	X	X
	Sedum takesimense	Gold Carpet Stonecrop	9”	X	X
	Sedum telephium	Autumn Joy	24”	X	X
	Sempervivum tectorum	Hens and Chicks	6”	X	X
Herbaceous Plants	*Achillea millefolium*	Common Yarrow	36”	X	X
	Allium acuminatum	Hooker’s Onion	6”	X	X
	Allium cernuum	Nodding Onion	12”	X	X
	Antennaria neglecta	Field Pussytoes	4”	X	X
	Arenaria montana	Sandwort	4”	X	X
	Aurinia saxatilis	Basket-of-Gold	6”	X	X
	Campanula rotundifolia	Common Harebell	8”	X	X
	Dianthus spp.	Dianthus	12”	X	X
	Erigeron compositus	Fleabane	12”	X	X

Table E-5. Ecoroof plant list (continued).

	Scientific Name	Common Name	Potential Height	Full Sun	Partial Shade
Herbaceous Plants	*Erigeron glaucus*	Beach Aster	6”	X	X
	Festuca idahoensis	Idaho Fescue	12”	X	X
	Fragaria virginiana	Wild Strawberry	6”	X	X
	Gaillardia aristata	Blanket Flower	20”	X	X
	Gazania linearis	Gazania	6”	X	X
	Koeleria macrantha	Junegrass	24”	X	X
	Lobularia maritima	Sweet Alyssum	12”	X	X
	Phlox douglasii	Tufted Phlox	4”	X	X
	Polypodium glycyrrhiza	Licorice Fern	12”	X	X
	Polystichum munitum	Sword Fern	24”	X	X
	Potentilla nepalensis	Nepal Cinquefoil	14”	X	X
	Potentilla neumanniana	Cinquefoil	14”	X	
	Prunella vulgaris	lanceolata Self-Heal	4”	X	X
	Silene acaulis	Moss Campion	3”	X	X
	Thymus serphyllum	Creeping Thyme	3”	X	
	Veronica liwanensis	Turkish speedwell	2”	X	X
Accent Plants	*Camassia quamash*	Common Camas	8”	X	X
	Clarkia amoena	Farewell-to-Spring	7”	X	X
	Gilia capitata	Globe Gilia	18”	X	X
	Linaria reticulata	Purplenet Toadflax	20”	X	X
	Linum perenne	Blue Flax	8”	X	X
	Lupinus bicolor	Two-Colored Lupine	5”	X	X
	Madia elegans	Elegant Tarweed	18”	X	X
	Nemophila menziesii	Baby Blue Eyes	5”	X	X
	Phacelia campanularia	Desert Bluebells	10”	X	X
	Plectritis congesta	Sea Blush	5”	X	X
	Triteleia ixoides	Golden Star	10”	X	X

Recommended plants for BMPs

Refer to earlier sections of Appendix E for planting specifications. Consult a landscape architect, arborist, and/or wetland scientist to properly place vegetation (Chapter 3, "*Steps to Planning an LID Site*"). Two facility planting zones are defined to guide the designer in placing plants within a BMP.

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 must 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.

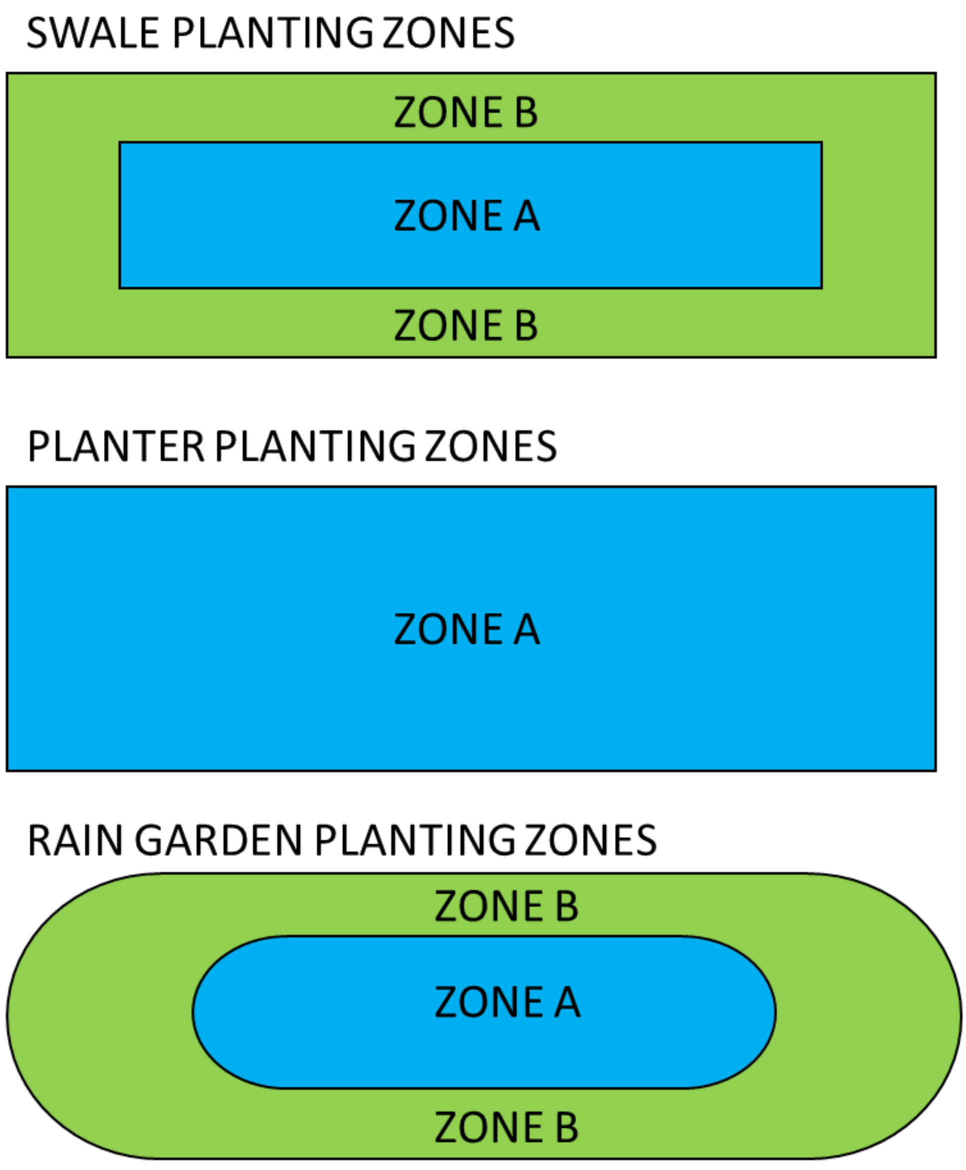


Figure E-3. Planting zones.

Table E-6. Recommended grasses and riparian woodland plants.

	Scientific Name	Common Name	Zone	Potential Height
Grasses	Dactylis glomerata	Orchardgrass	-	-
	Calamagrostis canadensis	Bluejoint Reedgrass	-	-
	Festuca idahoensis	Idaho Fescue	-	12”
	Hordeum brachyantherum	Meadow Barley	-	-
Riparian Woodland	Amelanchier alnifolia	Serviceberry	-	-
	Cornus stolonifera	Red Osier Dogwood	-	-
	Holodiscus discolor	Ocean Spray	-	-
	Oemleria cerasiformis	Indian Plum	-	-
	Physocarpus capitatus	Pacific Ninebark	-	-
	Rosa nutkana	Nootka Rose	-	-
	Rubus parviflorus	Thimbleberry	-	-
	Ribes aureum	Golden Currant	-	-
	Sambucus cerulea	Blue Elderberry	-	-
	Vaccinium parvifolium	Red Huckleberry	-	-
	Mahonia aquifolium	Oregon Grape	-	-
	Polystichum munitum	Sword Fern	-	-
	Symphoricarpos albus	Common Snowberry	-	-
	Philadelphus lewistii	Wild Mock Orange	-	-

Table E-7. Recommended trees, wildflowers, and riparian wetland plants.

	Scientific Name	Common Name	Zone	Potential Height
Trees	**Acer macrophyllum*	Big Leaf Maple	B	60'
	**Calocedrus decurrens*	Incense Cedar	A/B	100’
	**Fraxinus latifolia*	Oregon Ash	A/B	30'
	Alnus rubra	Red Alder	B	-
	Cornus nuttallii	Western Dogwood	-	-
	Crataegus douglasii	Black Hawthorne	-	-
	Populus balsamifera v. trichocarpa	Black Cottonwood	B	-
	Prunus virginiana	Common Chokecherry	-	-
	Pyrus fusca	Western Crabapple	-	-
	Salix lasiandra	Pacific Willow	A	-
	Salix scouleriana	Scoulers Willow	-	-
	Salix exigua ssp. melanopsis	Dusky Willow	-	-
Wildflowers	Aquilegia formosa	Columbine	-	-
	Aster chilensis ssp. hallii, A.	Asters	B	-
	Asarum caudatum	Wild Ginger	-	-
	Epilobium angustifolia	Fireweed	-	-
	Veratrum californicum	Corn Lily	-	-
	Xerophyllum tenax	Bear Grass	-	-
	Fragaria chiloensis	Wild Strawberry	-	-
	Petasites frigidus	Colt.s Foot	-	-
	Lupinus rivularis, L. polyphyllus	Lupines	-	-
	Dicentra formosa	Western Bleeding Heart	-	-
	Penstemon rupicola	Cliff Penstemon	-	-
	Camassia quamash ssp. Quamash	Common Camas	-	-
	Vancouveria hexandra	Insideout Flower	-	-
Riparian Wetland Plants	Equisetum hyemale	Scouring Rush	-	-
	Juncus effuses	Soft Rush	-	-
	Carex obnupta	Slough Sedge	A	4'
	Eleocharis palustris	Creeping Spike-rush	-	-
	Glyceria occidentalis	Western Manna Grass	A	18"
	Juncus balticus	Baltic Rush	A	20"
	Scirpus accutus	Hardstem Bulrush	-	-
	Scirpus microcarpus	Small-fruited Bulrush	-	-
	Veronica americana	American Brookline	-	-
	Sagittaria latifolia	Wapato	-	-

APPENDIX F: DETAILS

Details are currently available in pdf and AutoCAD format and may be downloaded from the City of Grants Pass website (https://www.grantspassoregon.gov/).

LIST OF DETAILS

BMP 1.01 Infiltration Rain Garden

BMP 1.02 Infiltration Rain Garden with Area Drain

BMP 1.03 Infiltration Rain Garden with Imported or Amended Soil

BMP 1.04 Lined Filtration Rain Garden

BMP 1.05 Infiltration Rain Garden with Rock Trench

BMP 1.06 Infiltration Rain Garden with Planting Soil

BMP 1.07 Rain Garden Planting Schematic

BMP 2.01 Infiltration Stormwater Planter with Area Drain

BMP 2.02 Infiltration Stormwater Planter with Amended or Imported Soil and Area Drain

BMP 2.03 Lined Filtration Stormwater Planter

BMP 2.04 Infiltration Stormwater Planter with Rock Trench

BMP 2.05 Infiltration Stormwater Planter with Amended or Imported Soil

BMP 2.06 Infiltration Stormwater Planter

BMP 2.07 Stormwater Planter Planting Schematic

BMP 3.01 Lined Filtration LID Swale

BMP 3.02 Infiltration LID Swale - Lowest Elevation Cell with Area Drain

BMP 3.03 Infiltration LID Swale

BMP 3.04 Infiltration LID Swale with Amended Planting Soil

BMP 3.05 Infiltration LID Swale with Amended Planting Soil and Rock Trench

BMP 3.06 Infiltration LID Swale with Amended or Imported Soil and Rock Trench – Lowest Elevation Cell with Area Drain

BMP 3.07 Infiltration LID Swale -- Lowest Elevation Cell with Area Drain

BMP 3.08 Infiltration LID Swale with Planting Soil -- Lowest Elevation Cell with Area Drain

BMP 3.09 LID Swale Planting Schematic

BMP 4.01 Vegetated Filter Strip

BMP 4.02 Vegetated Filter Strip with Amended Planting Soil

BMP 5.01 Pervious Concrete Pavement

BMP 5.02 Porous Asphalt Pavement

BMP 5.03 Manufactured Permeable Pavers

BMP 5.04 Salvaged & Poured Concrete Permeable Pavers

BMP 5.05 Vehicular Permeable Paver Edges

BMP 6.01 Soakage Trench in Landscape Area

BMP 6.02 Soakage Trench under Impervious Pavement Surface

BMP 6.03 Soakage Trench at Surface

BMP 7.01 Drywell in Landscape Area

BMP 7.02 Drywell in Paved Area

BMP 8.01 Catch Basin Outlet Control Structure for Infiltration Facilities

BMP 8.02 Pavement Undercut Protection for Infiltration Facilities

BMP 8.03 Curb Cut / Curb Opening

BMP 8.04 Inlet Pretreatment & Energy Dissipater

BMP 9.01 Water Quality Conveyance Swale

BMP 9.02 Water Quality Conveyance Swale with Amended Planting Soil

BMP 9.03 Partially Lined Water Quality Conveyance Swale

BMP 9.04 Fully Lined Water Quality Conveyance Swale

BMP 9.05 Water Quality Conveyance Swale Planting Schematic

BMP 10.01 Tree with Berm

BMP 10.02 Tree with Berm (Existing Soils Restored)

BMP 10.03 Tree on Slope

BMP 10.04 Tree on Slope (Existing Soils Restored)

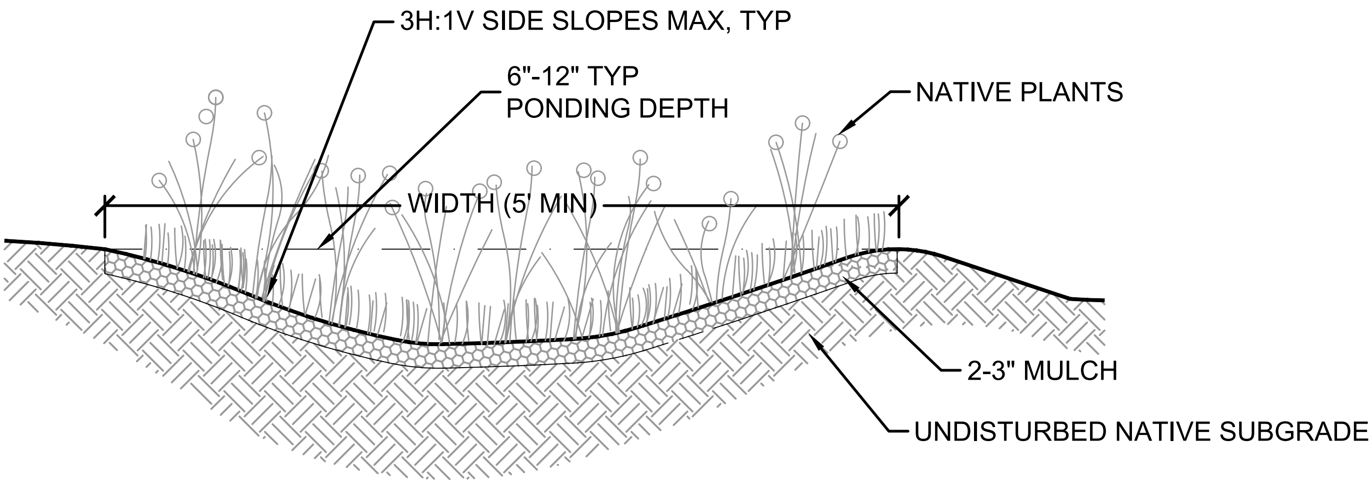
BMP 11.01 Tree Protection

BMP 11.02 Tree Protection – Boring Under Dripline

BMP 11.03 Tree Protection – Temporary Access Road

ABBREVIATIONS

CF	CUBIC FEET
DIA	DIAMETER
EL	ELEVATION
GAL/MIN	GALLONS PER MINUTE
H	HORIZONTAL
HDPE	HIGH DENSITY POLYETHYLENE
HMAC	HOT MIX ASPHALT CONCRETE
IE	INVERT ELEVATION
MAX	MAXIMUM
NO.	NUMBER
ODEQ	OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY
ODOT	OREGON DEPARTMENT OF TRANSPORTATION
OPT	OPTIONAL
PE	POLYETHYLENE
PVC	POLYVINYL CHLORIDE
SF	SQUARE FOOT
S	SLOPE
TYP	TYPICAL
UIC	UNDERGROUND INJECTION CONTROL
V	VERTICAL



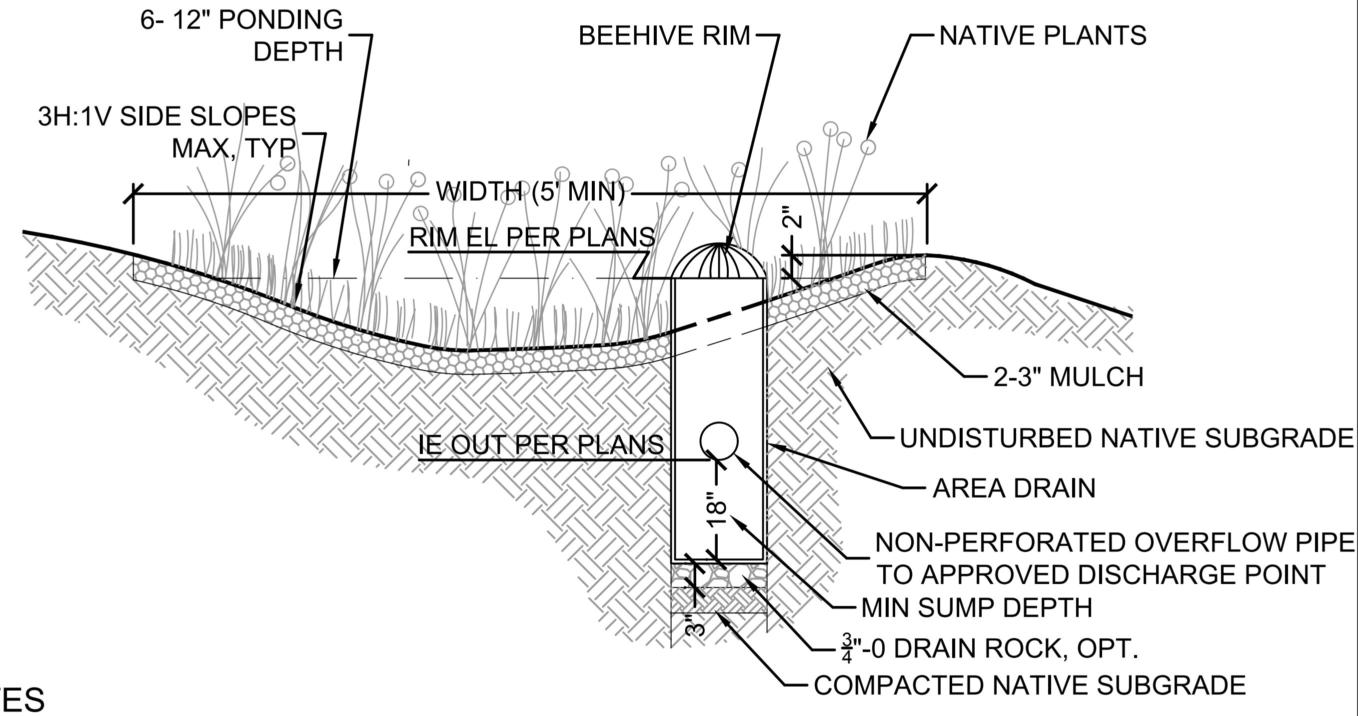
NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM TO DAMAGE HABITAT AND CHANGE HYDROLOGY. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM WATERWAYS.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF BARE SOIL IN THE RAIN GARDEN FOOTPRINT IS EXPOSED TO RAINFALL DURING CONSTRUCTION, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.



NOTES

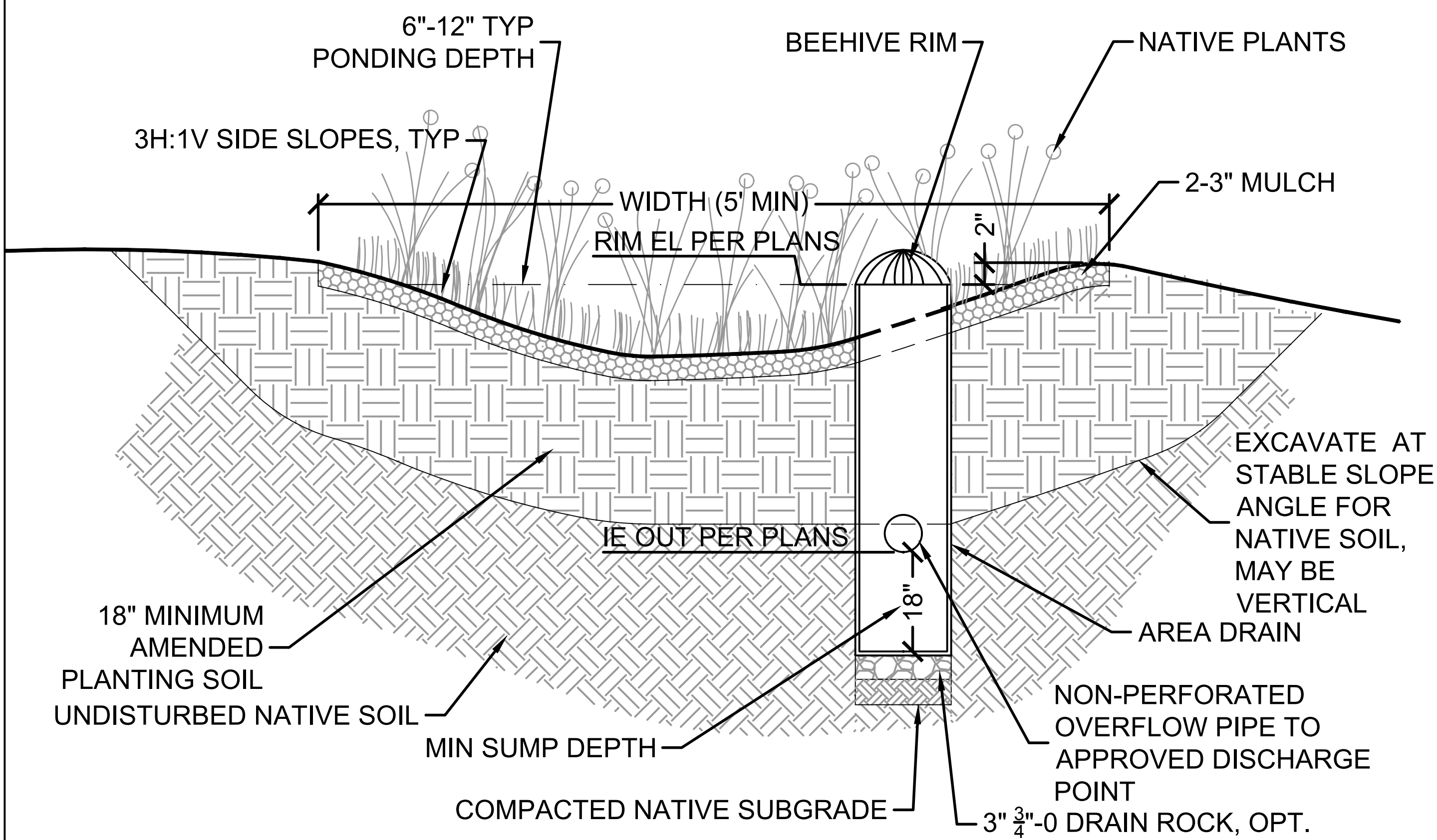
DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT, OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF BARE SOIL IN THE RAIN GARDEN FOOTPRINT HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Rain Garden with Area Drain	BMP 1.02 1 of 1 Scale: NTS Date: 2-09-18



NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF BARE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

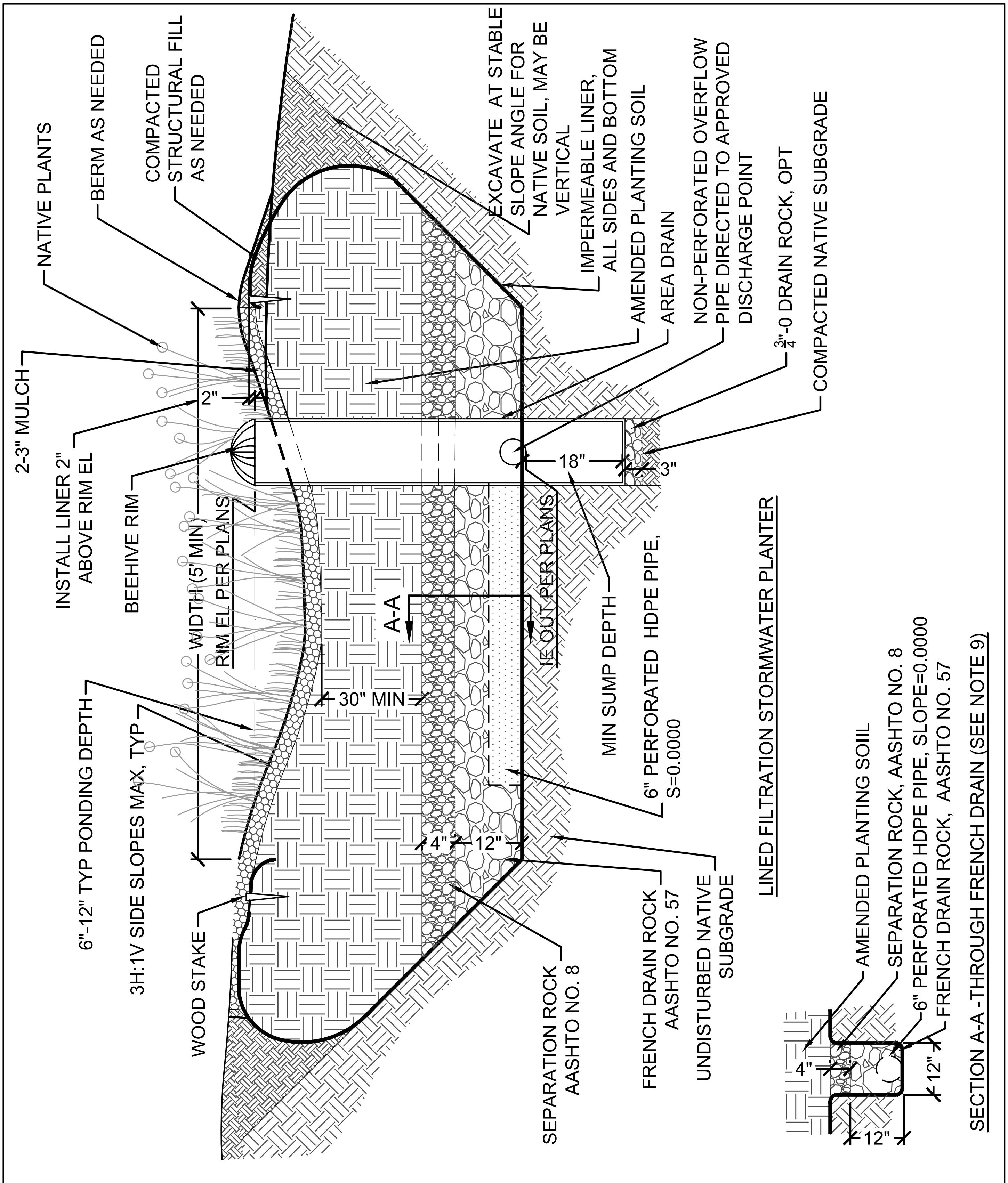
Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Rain Garden with Imported or Amended Soil	BMP 1.03 1 of 2 Scale: NTS Date: 2-09-18

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



City of Grants Pass, Oregon
Stormwater Management
Typical Details

Lined Filtration Rain Garden

BMP 1.04
1 of 3
Scale: NTS
Date: 2-09-18

NOTES

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. IMPERMEABLE LINER MAY BE 30 MIL PE OR PVC POND LINER OR BENTONITE CLAY MAT.
3. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS.
4. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.
7. DO NOT PUNCTURE LINER ANYWHERE EXCEPT AT THE TOP AS SHOWN. IF AN ALTERNATE LINER CONFIGURATION IS USED, ENSURE THAT DURING EVERY STORM FOR EVERY DEPTH OF WATER THAT MAY BE RETAINED, THE LINER PROTECTS STRUCTURES FROM WATER DAMAGE.
8. DO NOT EXTEND SEPARATION AND FRENCH DRAIN ROCK ACROSS ENTIRE FACILITY BOTTOM. THIS CAUSES SHORTCUTTING AND REDUCES THE WATER QUALITY EFFECTIVENESS OF THE FACILITY.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, FRENCH DRAIN ROCK SHALL MEET THE FOLLOWING GRADATION (AASHTO #57):

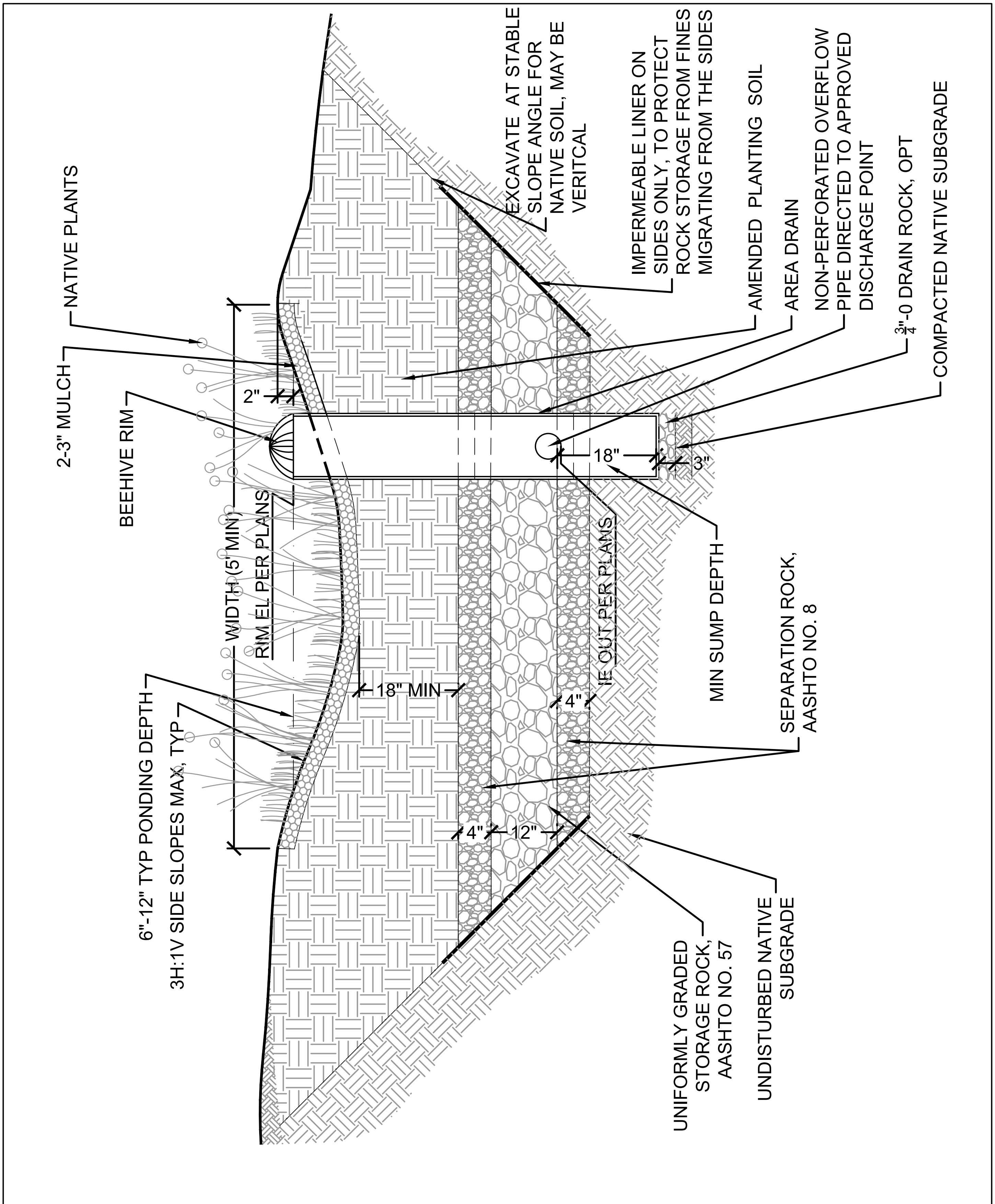
US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

IMPERMEABLE LINER SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. IMPERMEABLE LINERS MAY BE A 45-MILLIMETER (MINIMUM) LOW DENSITY POLYETHYLENE (LDPE), 45-MILLIMETER (MINIMUM) ETHYLENE PROPYLENE DIENE MONOMER (EPDM) OR BENTONITE CLAY MAT PER MANUFACTURER GUIDANCE.

2. PLACEMENT. INSTALL THE LINER SECURELY AT A HEIGHT EQUAL TO THE DEPTH OF WATER THAT MAY BE PONDED OR FLOWING DURING ANY STORM, NOT JUST THE DESIGN STORM. IF AN OUTLET STRUCTURE IS PRESENT, ATTACH THE LINER TO THE OUTLET STRUCTURE WITH ADHESIVE OR MECHANICAL METHOD PER MANUFACTURER'S GUIDELINES.

   IF AN LDPE OR EPDM LINER WILL BE USED, USE A SINGLE, SOLID PIECE BIG ENOUGH TO BE INSTALLED AS SHOWN ON PLANS AND DIRECTED ABOVE SO THAT PIECES ARE GLUED OR OTHERWISE WATERPROOFED TOGETHER PER MANUFACTURER GUIDELINES. OVERLAPPING SHEETS WILL NOT ADEQUATELY PREVENT INFILTRATION, IF THIS IS THE INTENT OF THE DESIGN. IF THE DESIGN CALLS FOR A BENTONITE CLAY MAT, FOLLOW THE MANUFACTURER'S GUIDANCE FOR INSTALLATION.



Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Rain Garden with Rock Trench	BMP 1.05 1 of 3 Scale: NTS Date: 2-09-18

NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS.
3. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

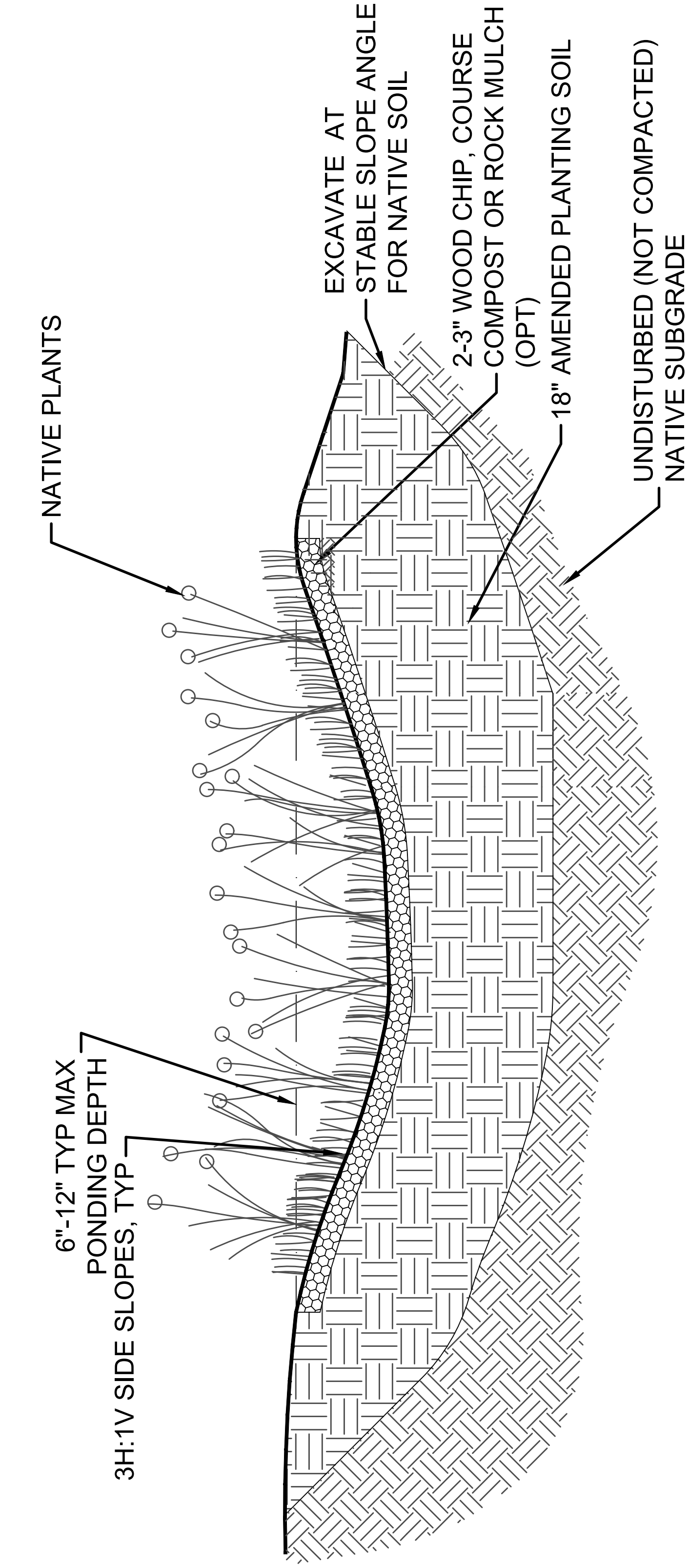
ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL MEET HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5



	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Rain Garden with Planting Soil	BMP 1.06 1 of 2 Scale: NTS Date: 2-09-18

NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 1.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

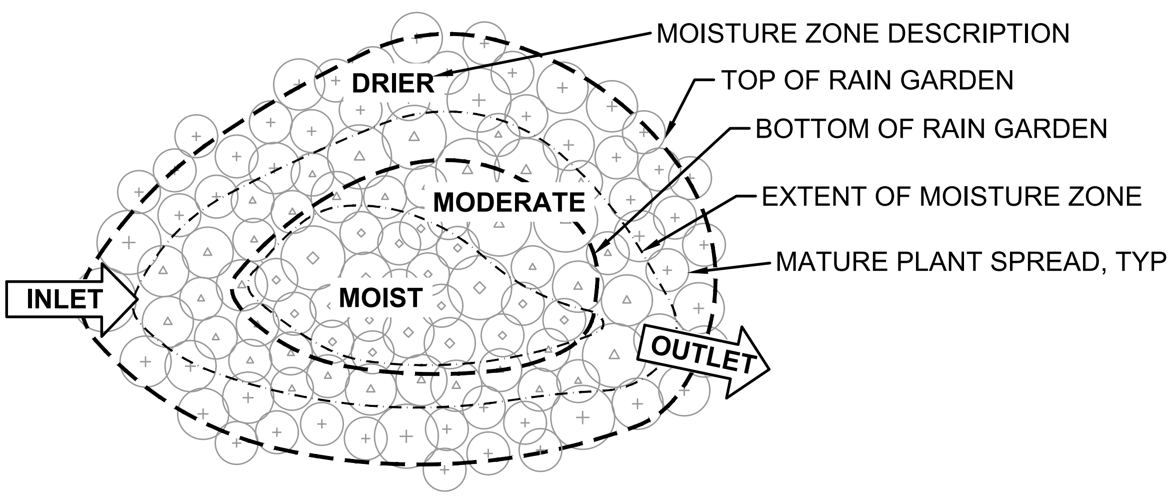
2. BUILD AND VEGETATE RAIN GARDEN AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



LEGEND:

— — CONTOUR LINE

— · — MOISTURE ZONE

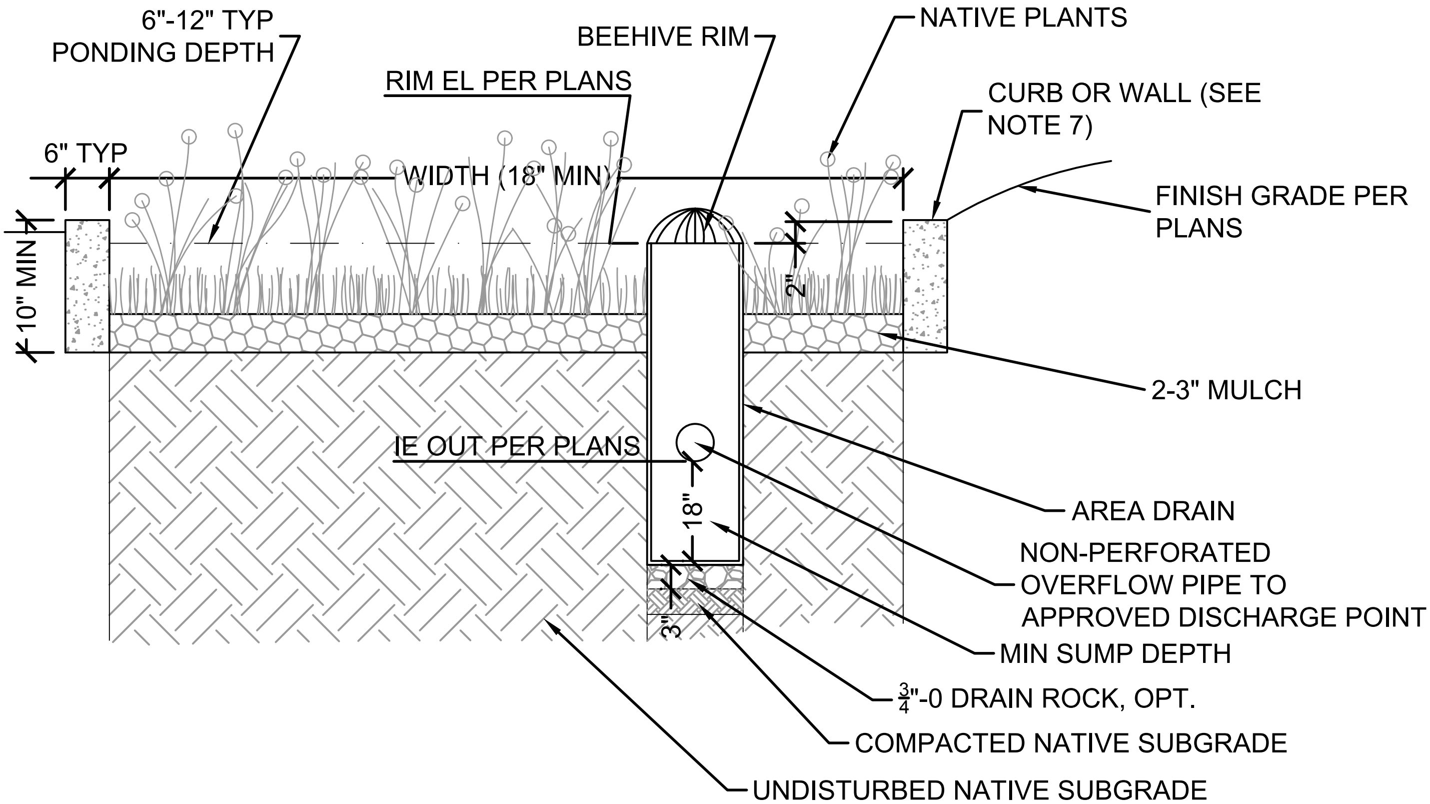
PLANT SPECIES APPROPRIATE FOR MOISTURE ZONE:

- DRIER
- MODERATE
- MOIST

NOTES:

1. THIS DETAIL IS PROVIDED AS A SCHEMATIC EXAMPLE OF THE RANDOM PLANT PLACEMENT AND 95% COVERAGE AFTER ESTABLISHMENT PERIOD DESIRED TO REDUCE EROSION AND WEEDS.
2. INSTALL PLANTS PER PLANS, ACCORDING TO LANDSCAPE DESIGN PLANT TABLE , WHICH SHOULD INCLUDE PLANT SPECIES, SPACING, AND QUANTITIES IN EACH MOISTURE ZONE.
3. MOISTURE ZONES VARY FROM THOSE SHOWN DEPENDING ON GRADING PLAN, LOCATION OF INLET (S) AND OUTLET(S) AND FACILITY SHAPE.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Rain Garden Planting Schematic	BMP 1.07 1 of 1 Scale: NTS Date: 2-09-18



NOTES

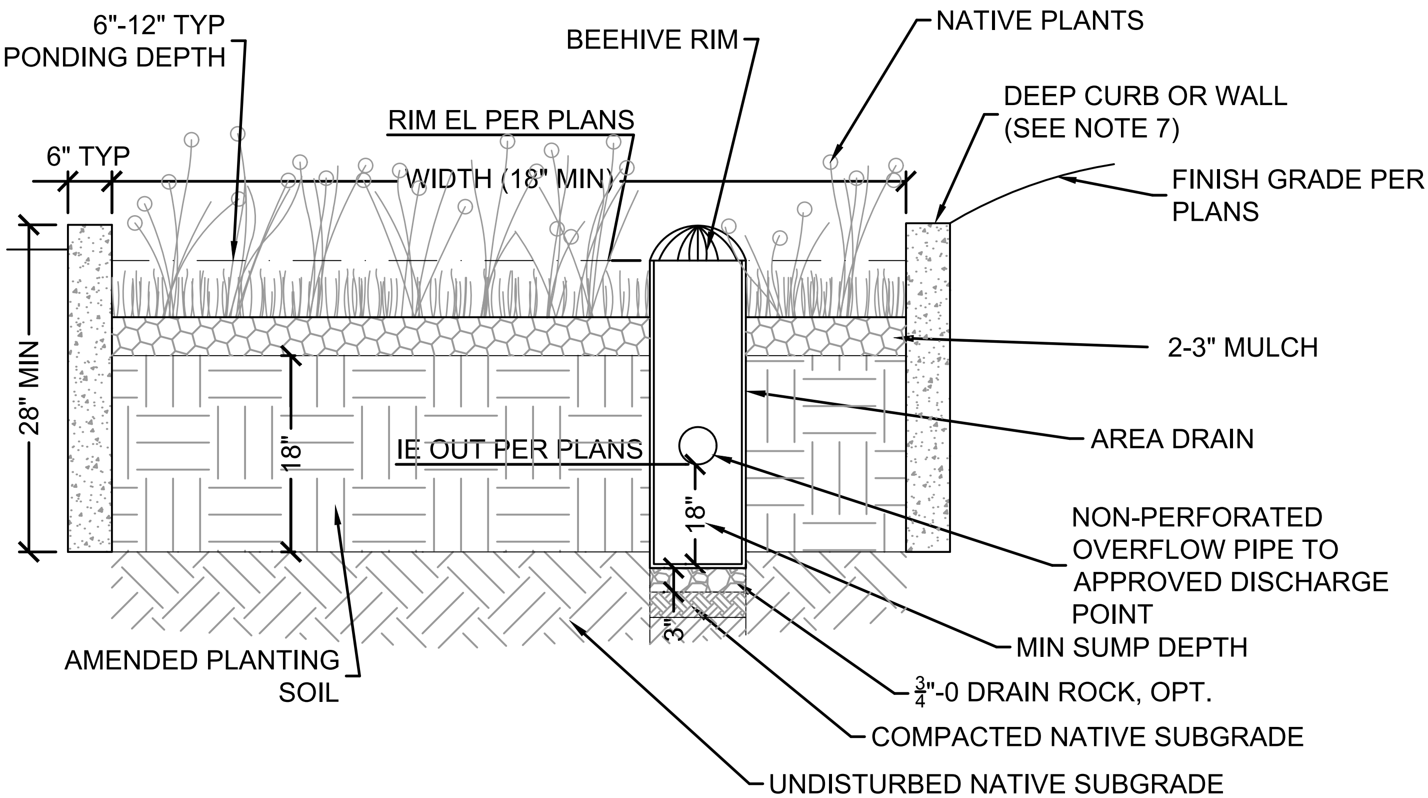
DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE PLANTERS AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS.
3. INFILTRATION AREAS (THE AREA OF THE PLANTER AS DEFINED BY THE TOP ELEVATION OF THE DEEP CURBS OR WALLS) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Stormwater Planter with Area Drain	BMP 2.01 1 of 1 Scale: NTS Date: 2-09-18



NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

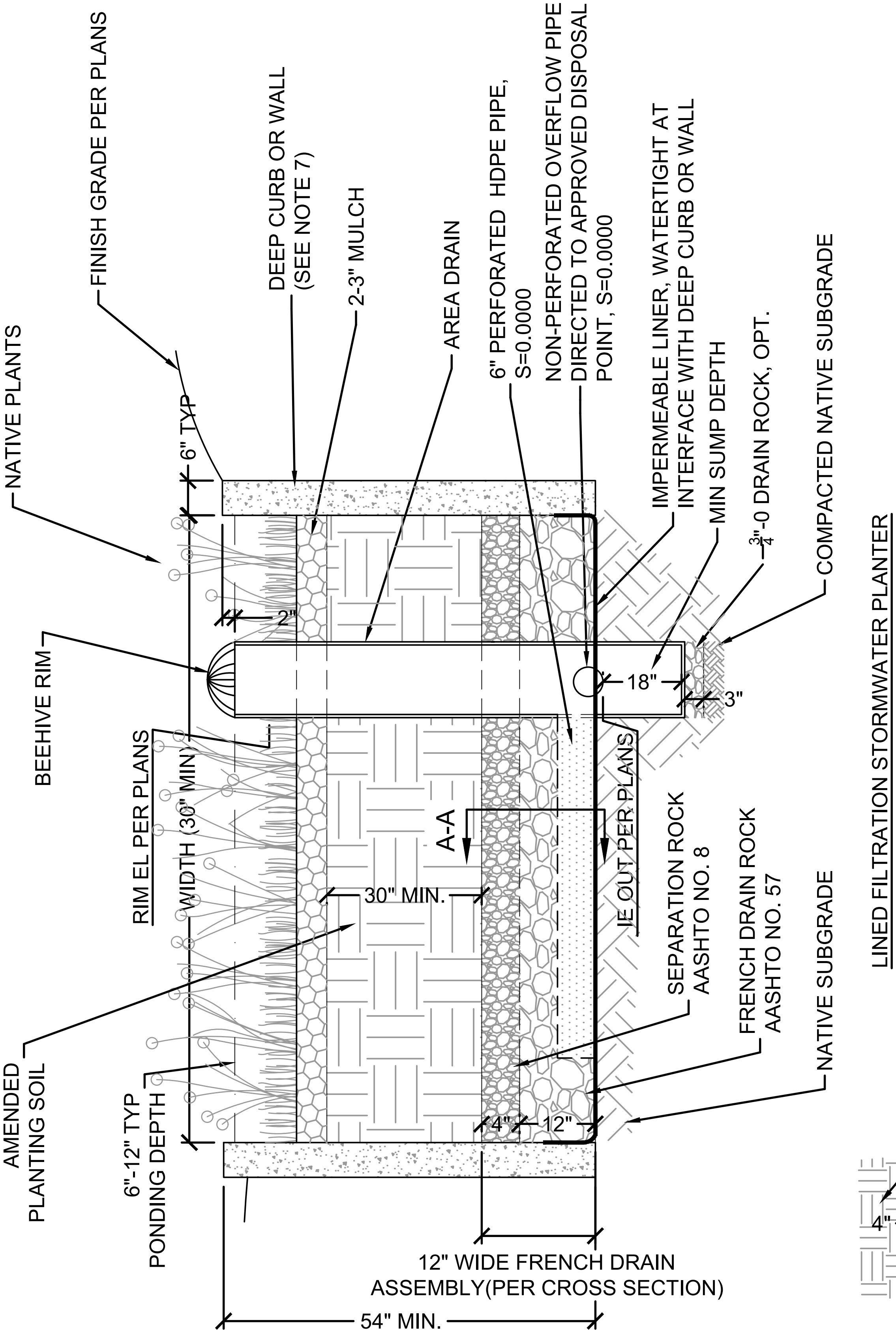
2. BUILD AND VEGETATE PLANTER AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS.
3. INFILTRATION AREAS (THE AREA OF THE PLANTER AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

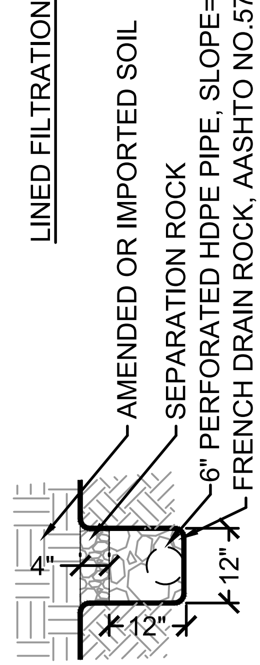
1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



LINED FILTRATION STORMWATER PLANTER



SECTION A-A - THROUGH FRENCH DRAIN (SEE NOTE 6)

	City of Grants Pass, Oregon Stormwater Management Typical Details	Lined Filtration Stormwater Planter	BMP 2.03 1 of 3 Scale: NTS Date: 2-09-18

NOTES

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. IMPERMEABLE LINER MAY BE 30 MIL PE OR PVC POND LINER OR BENTONITE CLAY MAT.
3. BUILD AND VEGETATE PLANTER AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS..
4. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.
5. DO NOT EXTEND FRENCH DRAIN AND SEPARATION ROCK ACROSS ENTIRE FACILITY BOTTOM. THIS CAUSES SHORTCUTTING AND REDUCES THE WATER QUALITY EFFECTIVENESS OF THE FACILITY.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, FRENCH DRAIN ROCK SHALL MEET THE FOLLOWING GRADATION (AASHTO #57):

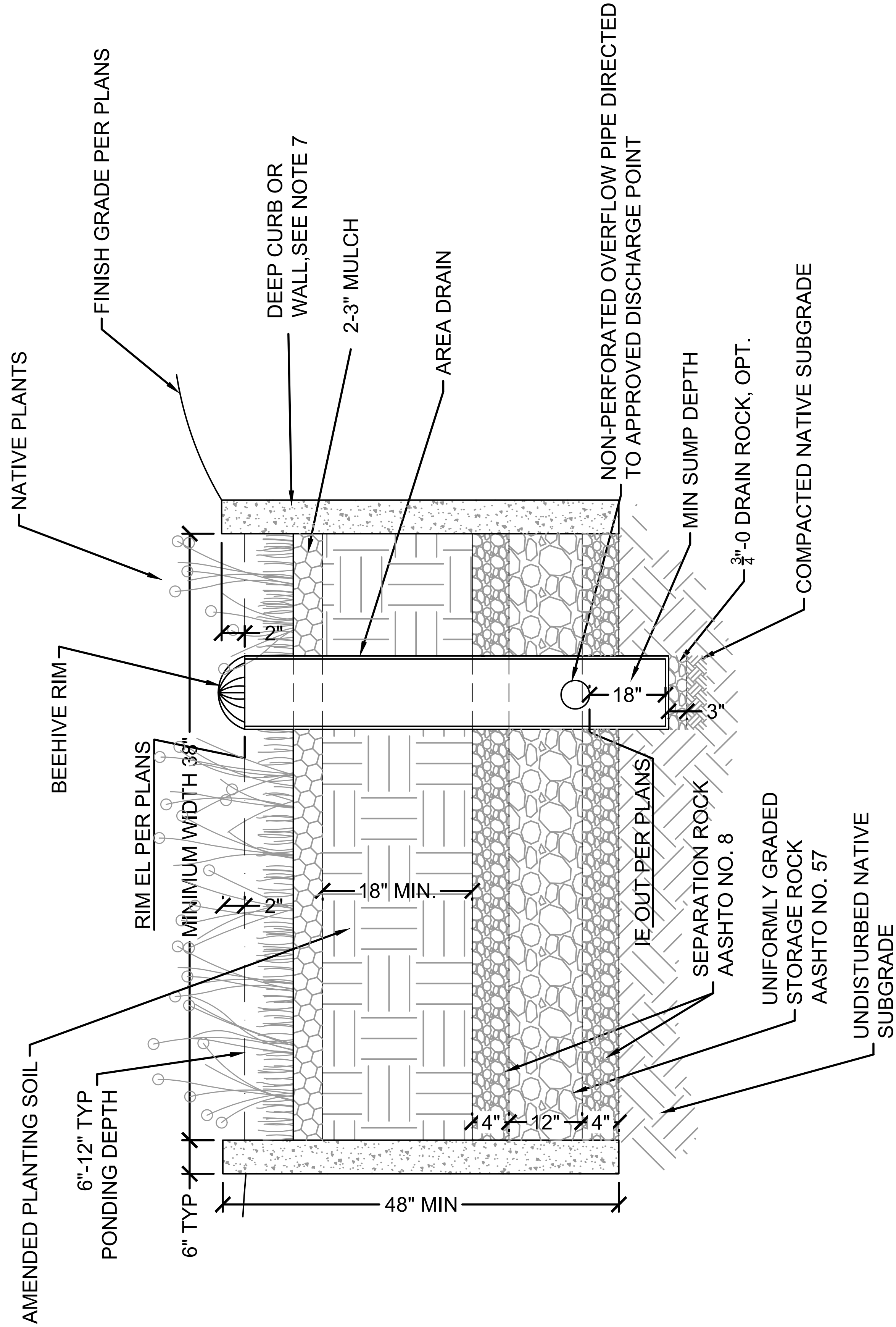
US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

IMPERMEABLE LINER SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. IMPERMEABLE LINERS MAY BE A 45-MILLIMETER (MINIMUM) LOW DENSITY POLYETHYLENE (LDPE), 45-MILLIMETER (MINIMUM) ETHYLENE PROPYLENE DIENE MONOMER (EPDM) OR BENTONITE CLAY MAT PER MANUFACTURER GUIDANCE.

2. PLACEMENT. INSTALL THE LINER SECURELY AT A HEIGHT EQUAL TO THE DEPTH OF WATER THAT MAY BE PONDED OR FLOWING DURING ANY STORM, NOT JUST THE DESIGN STORM. IF AN OUTLET STRUCTURE IS PRESENT, ATTACH THE LINER TO THE OUTLET STRUCTURE WITH ADHESIVE OR MECHANICAL METHOD PER MANUFACTURER'S GUIDELINES.

   IF AN LDPE OR EPDM LINER WILL BE USED, USE A SINGLE, SOLID PIECE BIG ENOUGH TO BE INSTALLED AS SHOWN ON PLANS AND DIRECTED ABOVE SO THAT PIECES ARE GLUED OR OTHERWISE WATERPROOFED TOGETHER PER MANUFACTURER GUIDELINES. OVERLAPPING SHEETS WILL NOT ADEQUATELY PREVENT INFILTRATION, IF THIS IS THE INTENT OF THE DESIGN. IF THE DESIGN CALLS FOR A BENTONITE CLAY MAT, FOLLOW THE MANUFACTURER'S GUIDANCE FOR INSTALLATION.



City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Stormwater Planter with Rock Trench	BMP 2.04 1 of 3 Scale: NTS Date: 2-09-18

NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.

CONSTRUCTION NOTES:

2. BUILD AND VEGETATE PLANTER AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL MEET HAVE THE FOLLOWING GRADATION (AASHTO #8):

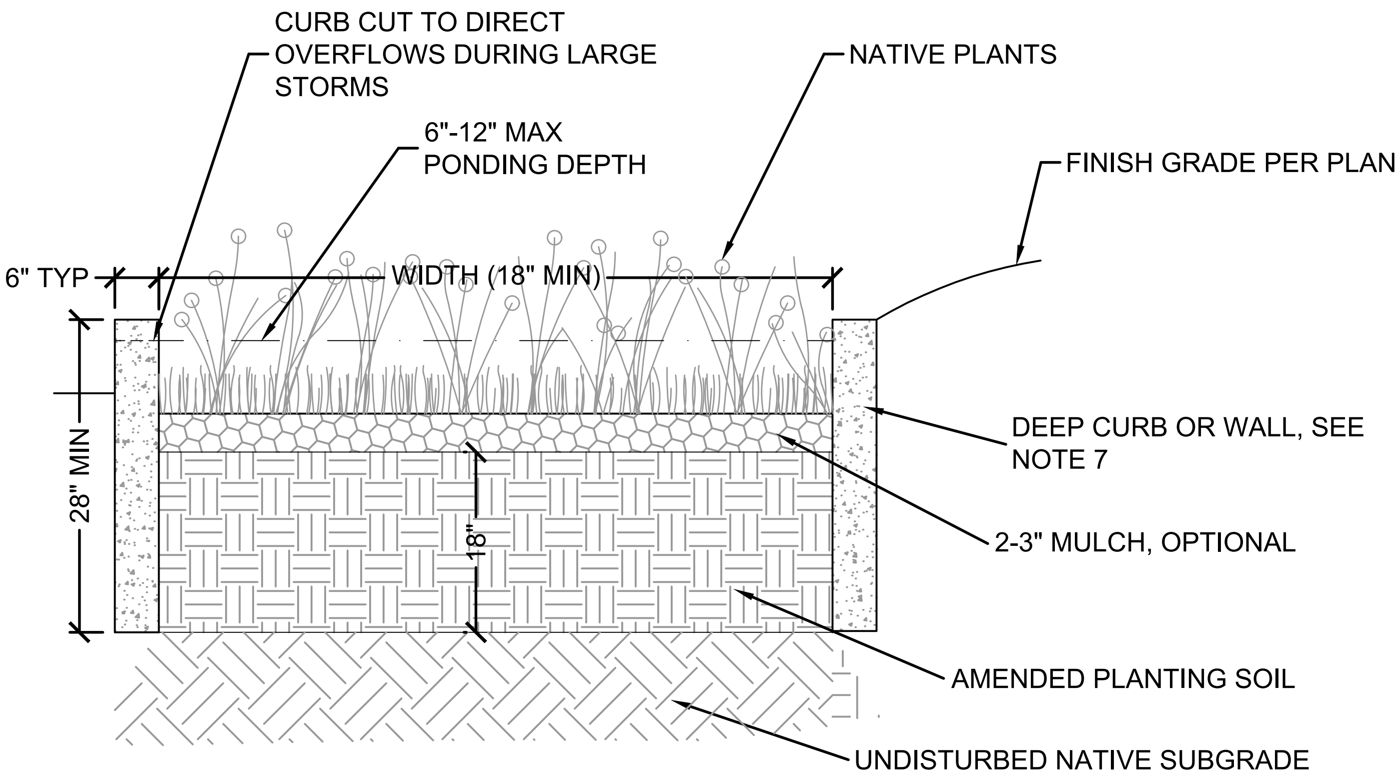
US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

IMPERMEABLE LINER SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. IMPERMEABLE LINERS MAY BE A 45-MILLIMETER (MINIMUM) LOW DENSITY POLYETHYLENE (LDPE), 45-MILLIMETER (MINIMUM) ETHYLENE PROPYLENE DIENE MONOMER (EPDM) OR BENTONITE CLAY MAT PER MANUFACTURER GUIDANCE.

2. PLACEMENT. INSTALL THE LINER SECURELY AT A HEIGHT EQUAL TO THE DEPTH OF WATER THAT MAY BE PONDED OR FLOWING DURING ANY STORM, NOT JUST THE DESIGN STORM. IF AN OUTLET STRUCTURE IS PRESENT, ATTACH THE LINER TO THE OUTLET STRUCTURE WITH ADHESIVE OR MECHANICAL METHOD PER MANUFACTURER'S GUIDELINES.

   IF AN LDPE OR EPDM LINER WILL BE USED, USE A SINGLE, SOLID PIECE BIG ENOUGH TO BE INSTALLED AS SHOWN ON PLANS AND DIRECTED ABOVE SO THAT PIECES ARE GLUED OR OTHERWISE WATERPROOFED TOGETHER PER MANUFACTURER GUIDELINES. OVERLAPPING SHEETS WILL NOT ADEQUATELY PREVENT INFILTRATION, IF THIS IS THE INTENT OF THE DESIGN. IF THE DESIGN CALLS FOR A BENTONITE CLAY MAT, FOLLOW THE MANUFACTURER'S GUIDANCE FOR INSTALLATION.



NOTES

DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. RUNOFF EXCEEDING THE VOLUME THAT CAN BE INFILTRATED WILL OVERFLOW FROM THE LOWEST POINT. APPROPRIATE CONVEYANCE THAT WILL NOT CAUSE EROSION OR DAMAGE TO DOWNHILL STRUCTURES MUST BE PROVIDED.

CONSTRUCTION NOTES:

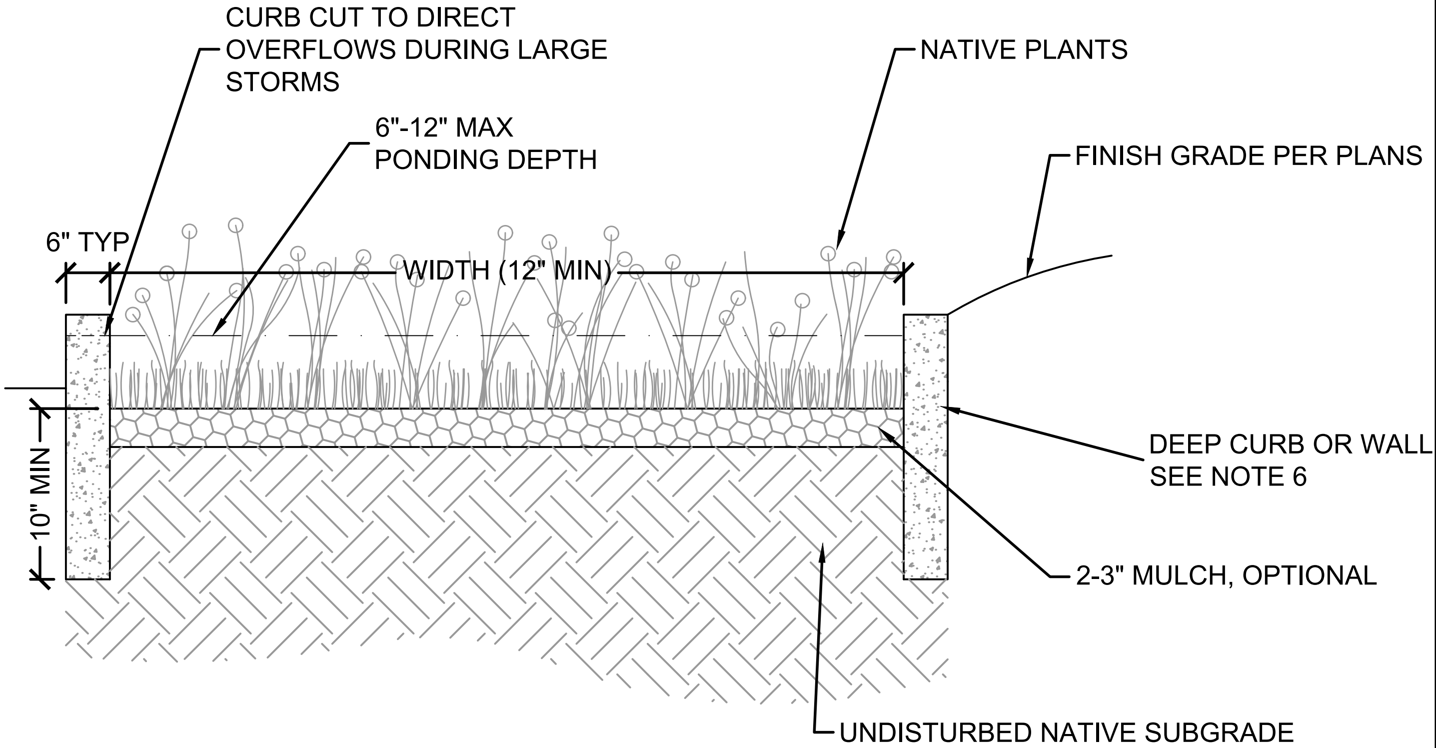
3. BUILD AND VEGETATE PLANTER AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
4. INFILTRATION AREAS (THE AREA OF THE PLANTER AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



NOTES

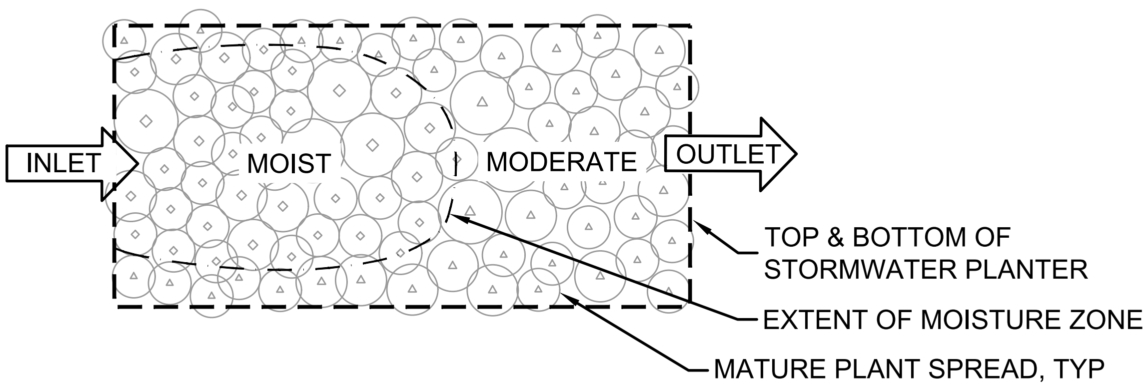
DESIGN NOTES:

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 2.07. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. RUNOFF EXCEEDING THE VOLUME THAT CAN BE INFILTRATED WILL OVERFLOW FROM THE LOWEST POINT. APPROPRIATE CONVEYANCE THAT WILL NOT CAUSE EROSION OR DAMAGE TO DOWNHILL STRUCTURES MUST BE PROVIDED.

CONSTRUCTION NOTES:

3. BUILD AND VEGETATE PLANTER AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
4. INFILTRATION AREAS (THE AREA OF THE PLANTER AS DEFINED BY THE TOP ELEVATION OF THE DEEP CURBS OR WALLS) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. CONSULT STRUCTURAL ENGINEER FOR OVERTURNING ANALYSIS IF WALL WILL BE UNSUPPORTED/FREE STANDING FOR A HEIGHT EQUAL TO OR GREATER THAN 4 FEET.

Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration Stormwater Planter	BMP 2.06 1 of 1 Scale: NTS Date: 2-09-18



LEGEND:

— — CONTOUR LINE

— · — MOISTURE ZONE

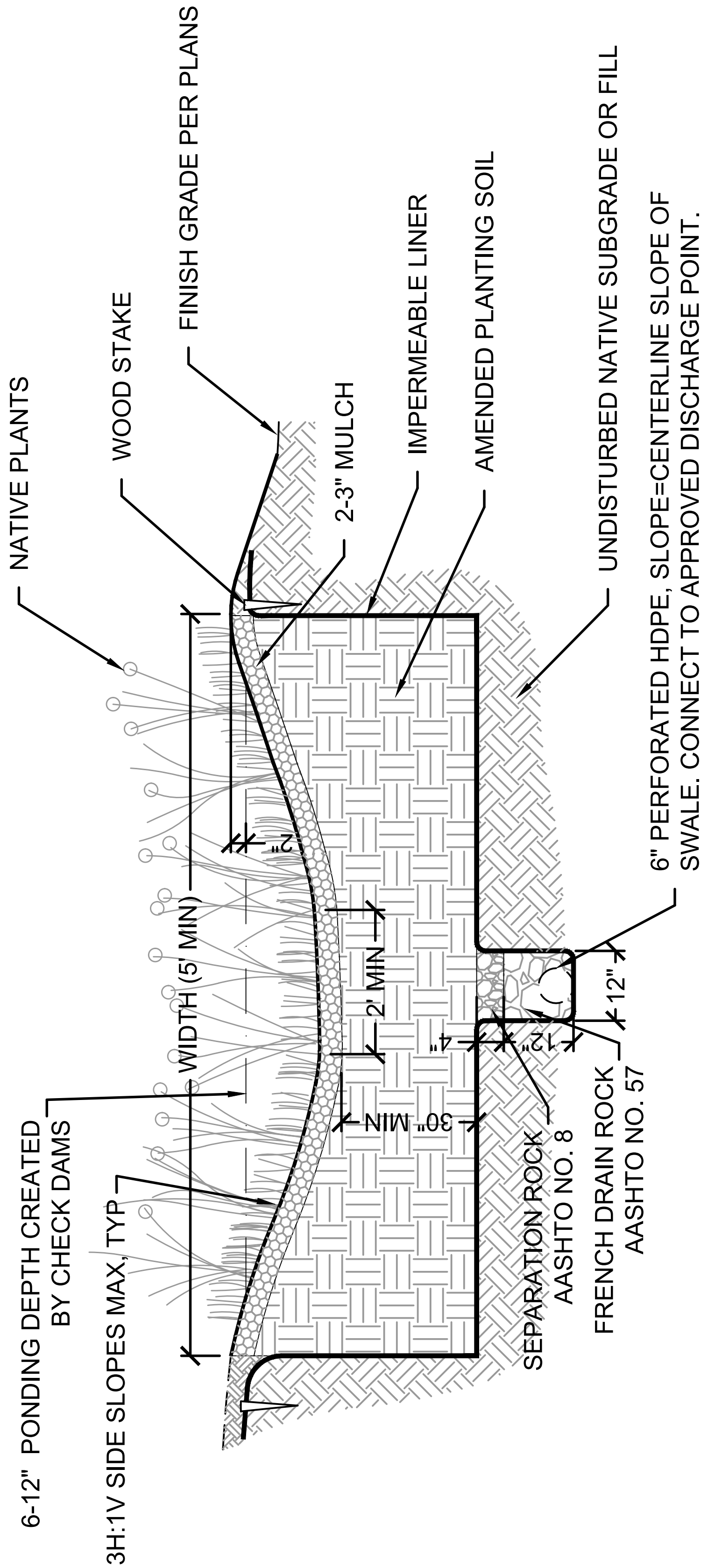
PLANT SPECIES APPROPRIATE FOR MOISTURE ZONE:

- DRIER
- MODERATE
- MOIST

NOTES:

1. THIS DETAIL IS PROVIDED AS A SCHEMATIC EXAMPLE OF THE RANDOM PLANT PLACEMENT AND 95% COVERAGE AFTER ESTABLISHMENT PERIOD DESIRED TO REDUCE EROSION AND WEEDS.
2. INSTALL PLANTS PER PLANS, ACCORDING TO LANDSCAPE DESIGN PLANT TABLE , WHICH SHOULD INCLUDE PLANT SPECIES, SPACING, AND QUANTITIES IN EACH MOISTURE ZONE.
3. MOISTURE ZONES VARY FROM THOSE SHOWN DEPENDING ON GRADING PLAN, LOCATION OF INLET (S) AND OUTLET(S) AND FACILITY SHAPE.

	City of Grants Pass, Oregon Stormwater Management Typical Details	Stormwater Planter Planting Schematic	BMP 2.07 1 of 1 Scale: NTS Date: 2-09-18



	City of Grants Pass, Oregon Stormwater Management Typical Details	Lined Filtration LID Swale	BMP 3.01 1 of 3 Scale: NTS Date: 2-09-18

NOTES

1. SEE RECOMMENDED PLANTING PLANS IN DETAIL BMP 3.09. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY & HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT IMPACT THE DOWNSTREAM WATERWAYS.
2. IF CHECK DAMS ARE USED, DESIGN CHECK DAMS TO DISTRIBUTE AND POND REQUIRED INFILTRATION VOLUMES EVENLY ACROSS ENTIRE FACILITY.
3. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
4. PROVIDE A CLEANOUT AT THE TOP END OF THE PERFORATED PIPE.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

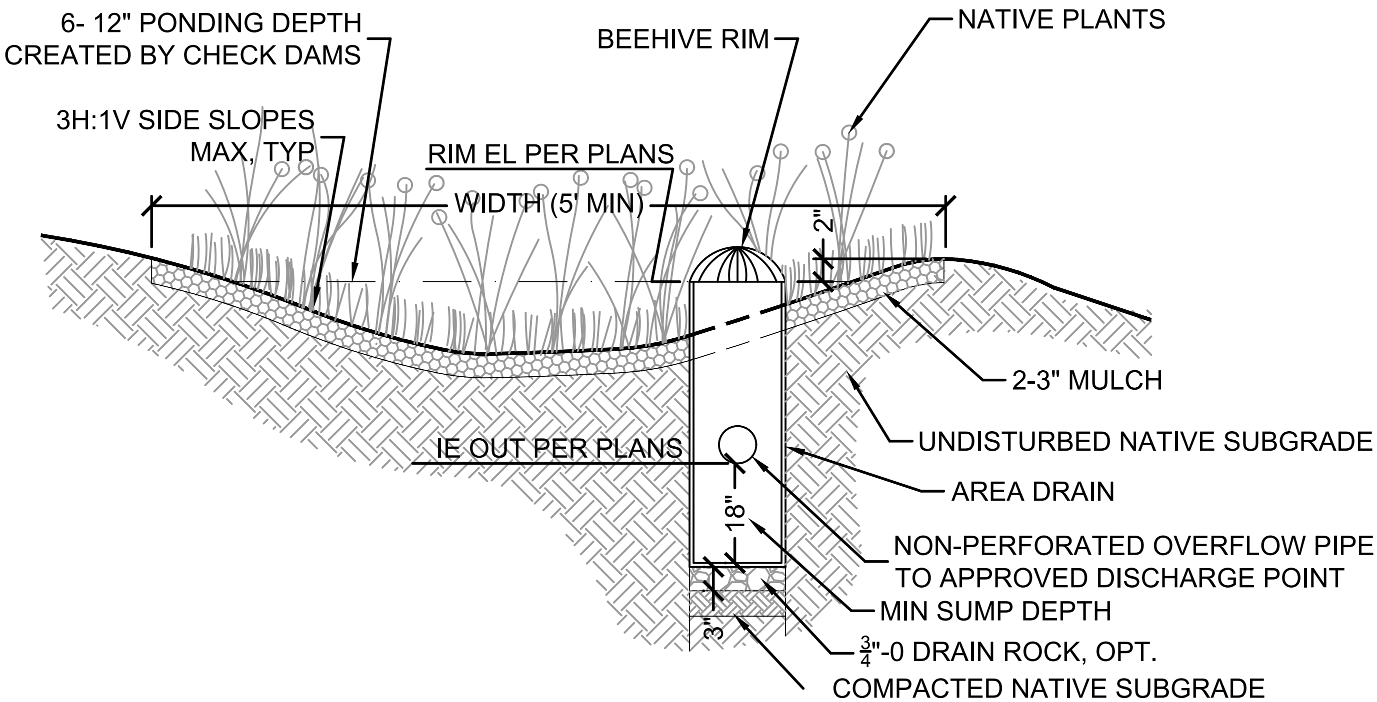
ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, FRENCH DRAIN ROCK SHALL MEET THE FOLLOWING GRADATION (AASHTO #57):

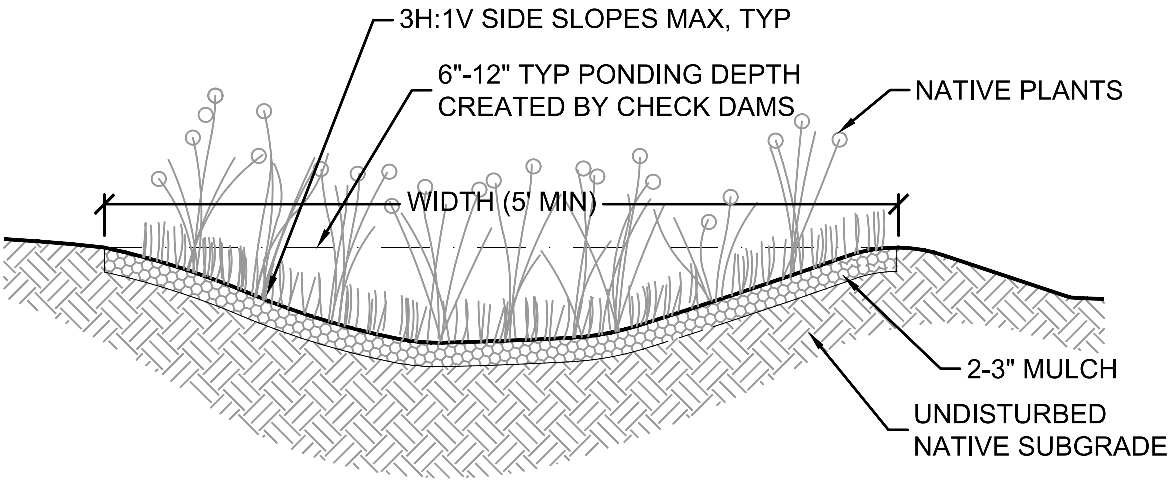
US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5



NOTES

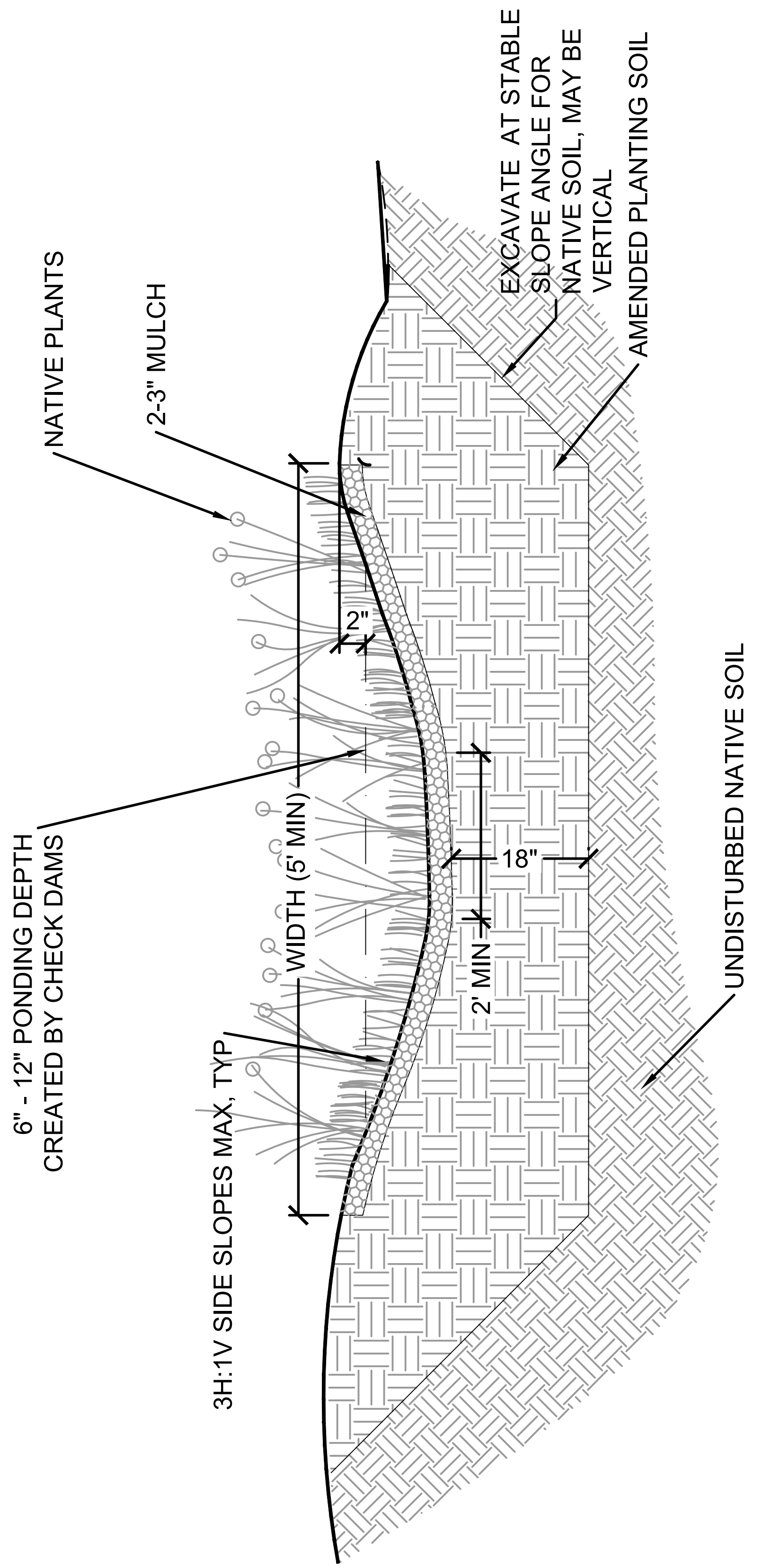
1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 3.09. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY AND HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE SWALE AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale - Lowest Elevation Cell with Area Drain	BMP 3.02 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 3.09. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY AND HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. INFILTRATION AREAS (THE AREA OF THE SWALE AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.



Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale with Amended Planting Soil	BMP 3.04 1 of 2 Scale: NTS Date: 2-09-18

NOTES

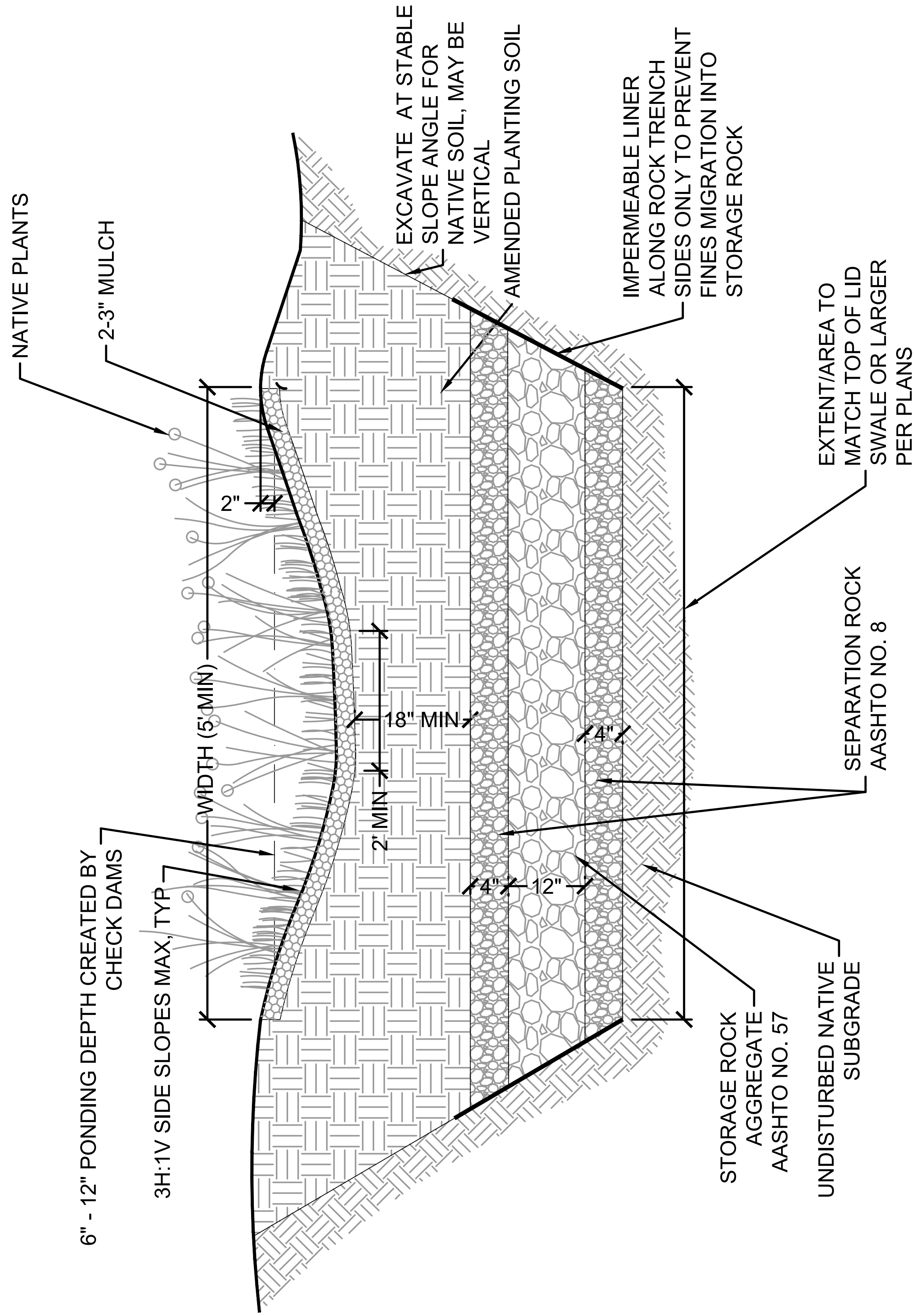
1. SEE RECOMMENED PLANTING PLAN IN DETAIL BMP 3.09. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. DESIGN CHECK DAMS TO DISTRIBUTE AND POND REQUIRED INFILTRATION VOLUMES EVENLY ACROSS ENTIRE FACILITY.
3. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
4. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale with Amended Planting Soil and Rock Trench	BMP 3.05 1 of 2 Scale: NTS Date: 2-09-18

NOTES

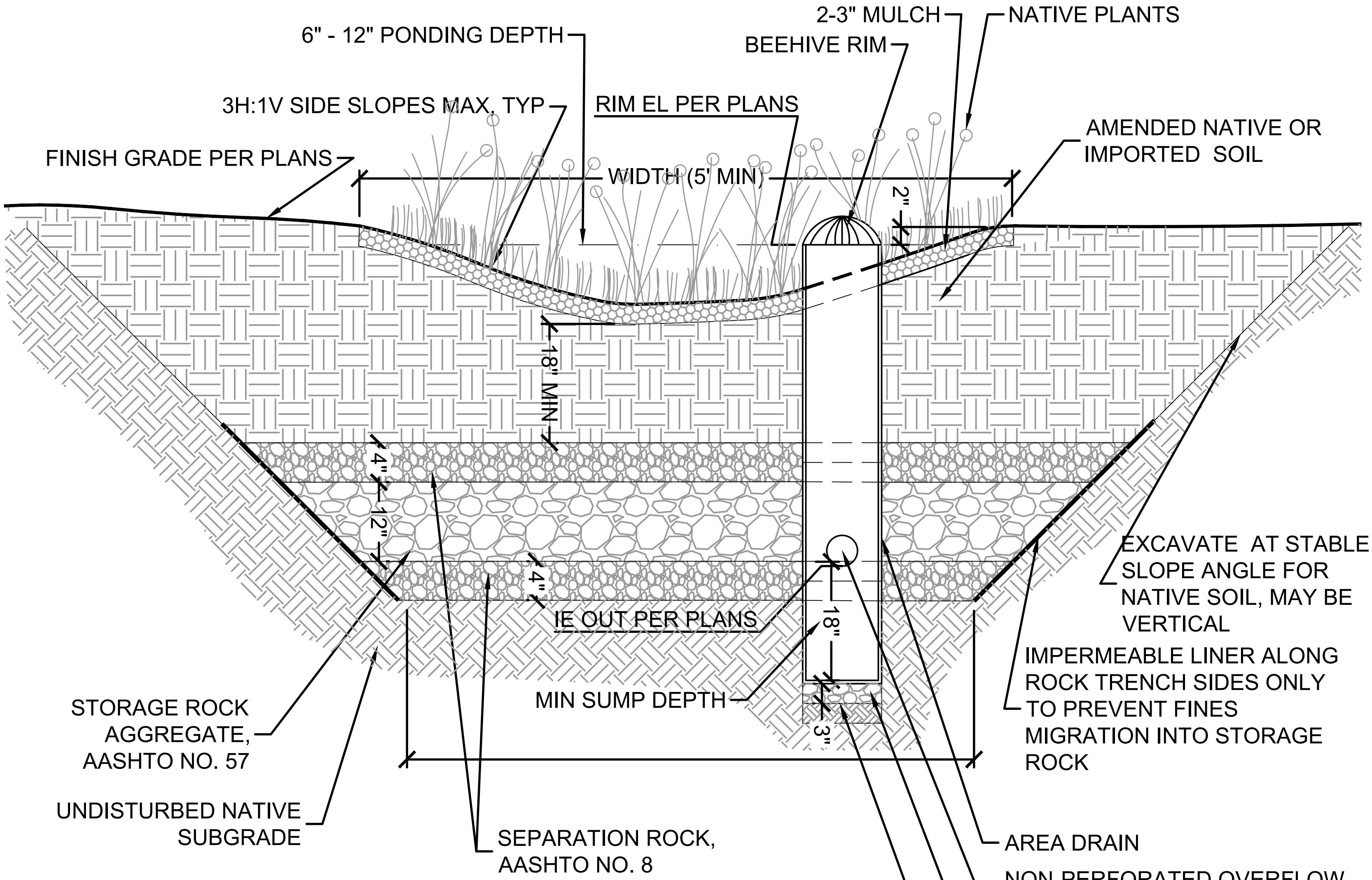
1. SEE RECOMMENDED PLANTING PLAN IN DETAIL BMP 3.09. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN MOVE DOWNSTREAM AND DAMAGE HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM HABITAT.
2. DESIGN CHECK DAMS TO DISTRIBUTE AND POND REQUIRED INFILTRATION VOLUMES EVENLY ACROSS ENTIRE FACILITY.
3. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
4. INFILTRATION AREAS (THE AREA OF THE RAIN GARDEN AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

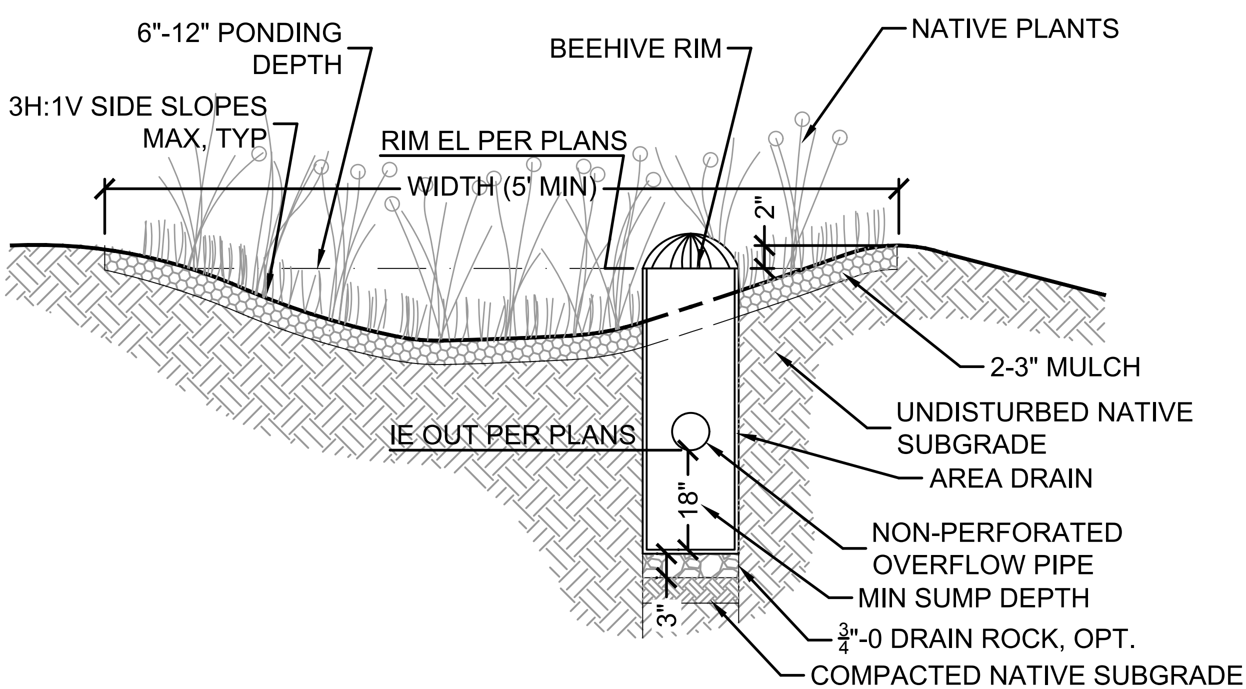
US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



1. THIS DETAIL SHOULD BE USED TO CONSTRUCT THE LOWEST ELEVATION CELL OF THE INFILTRATION LID SWALE WITH AMENDED OR IMPORTEDD SOIL AND ROCK TRENCH SHOWN ON THESE PLANS AND DETAILS. REFER TO THE INFILTRATION LID SWALE WITH AMENDED OR IMPORTED SOIL AND ROCK TRENCH DETAIL FOR ADDITIONAL NOTES.
2. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

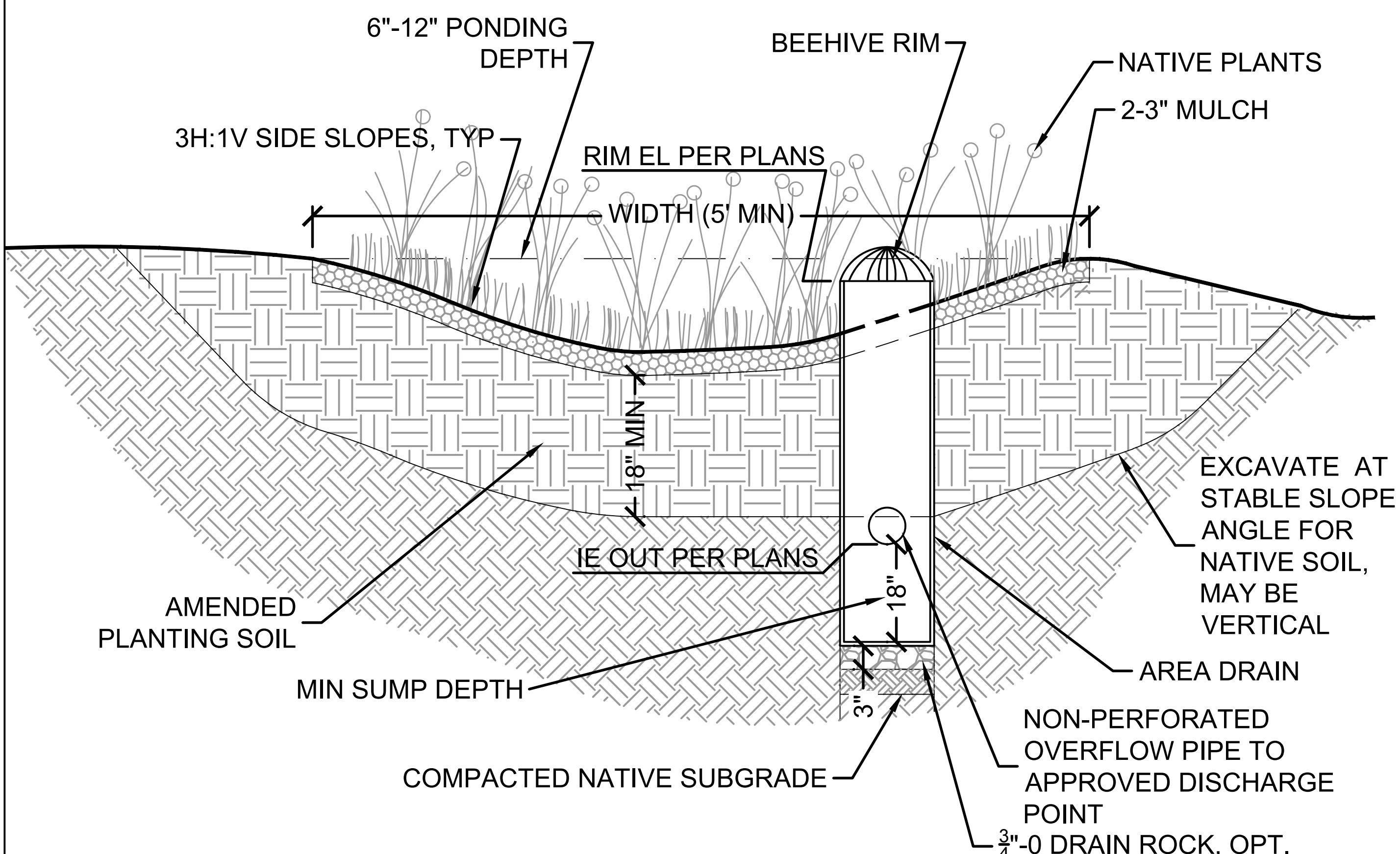
City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale with Amended or Imported Soil and Rock Trench – Lowest Elevation Cell with Area Drain	BMP 3.06 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. THIS DETAIL SHOULD BE USED TO CONSTRUCT THE LOWEST ELEVATION CELL OF THE SIMPLE INFILTRATION LID SWALES SHOWN ON THESE PLANS AND DETAILS. REFER TO SIMPLE INFILTRATION LID SWALE DETAIL FOR ADDITIONAL NOTES.
2. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

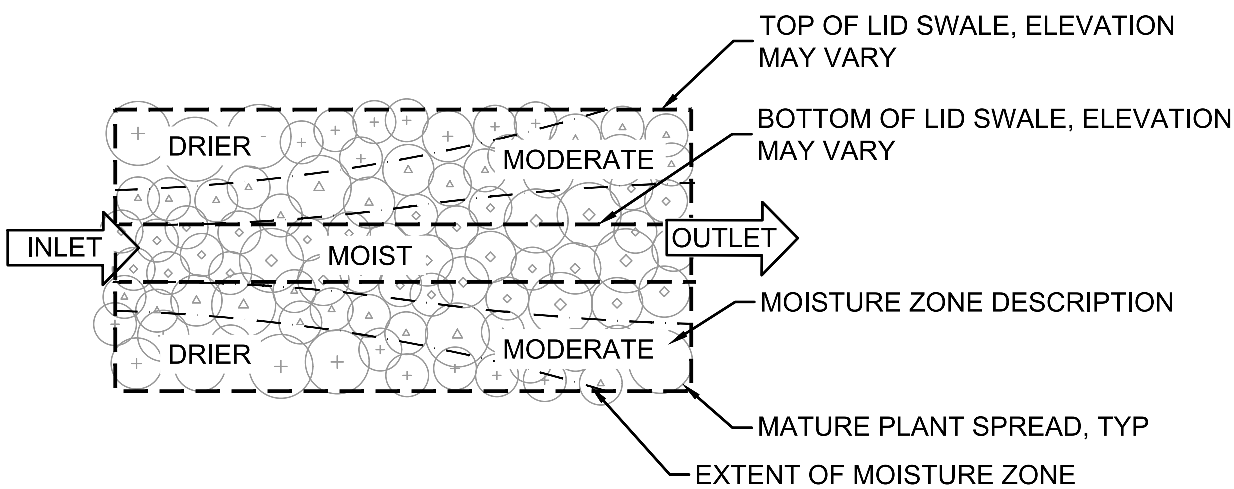
	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale -- Lowest Elevation Cell with Area Drain	BMP 3.07 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. THIS DETAIL SHOULD BE USED TO CONSTRUCT THE LOWEST ELEVATION CELL OF THE INFILTRATION LID SWALES WITH PLANTING SOIL SHOWN ON THESE PLANS AND DETAILS. REFER TO THE INFILTRATION LID SWALE WITH PLANTING SOIL DETAIL FOR ADDITIONAL NOTES.
2. DURING AREA DRAIN INSTALLATION, DISTURB NATIVE SOILS AS LITTLE AS POSSIBLE.

Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Infiltration LID Swale with Planting Soil -- Lowest Elevation Cell with Area Drain	BMP 3.08 1 of 1 Scale: NTS Date: 2-09-18



LEGEND:

CONTOUR LINE

MOISTURE ZONE

PLANT SPECIES APPROPRIATE FOR MOISTURE ZONE:

DRIER

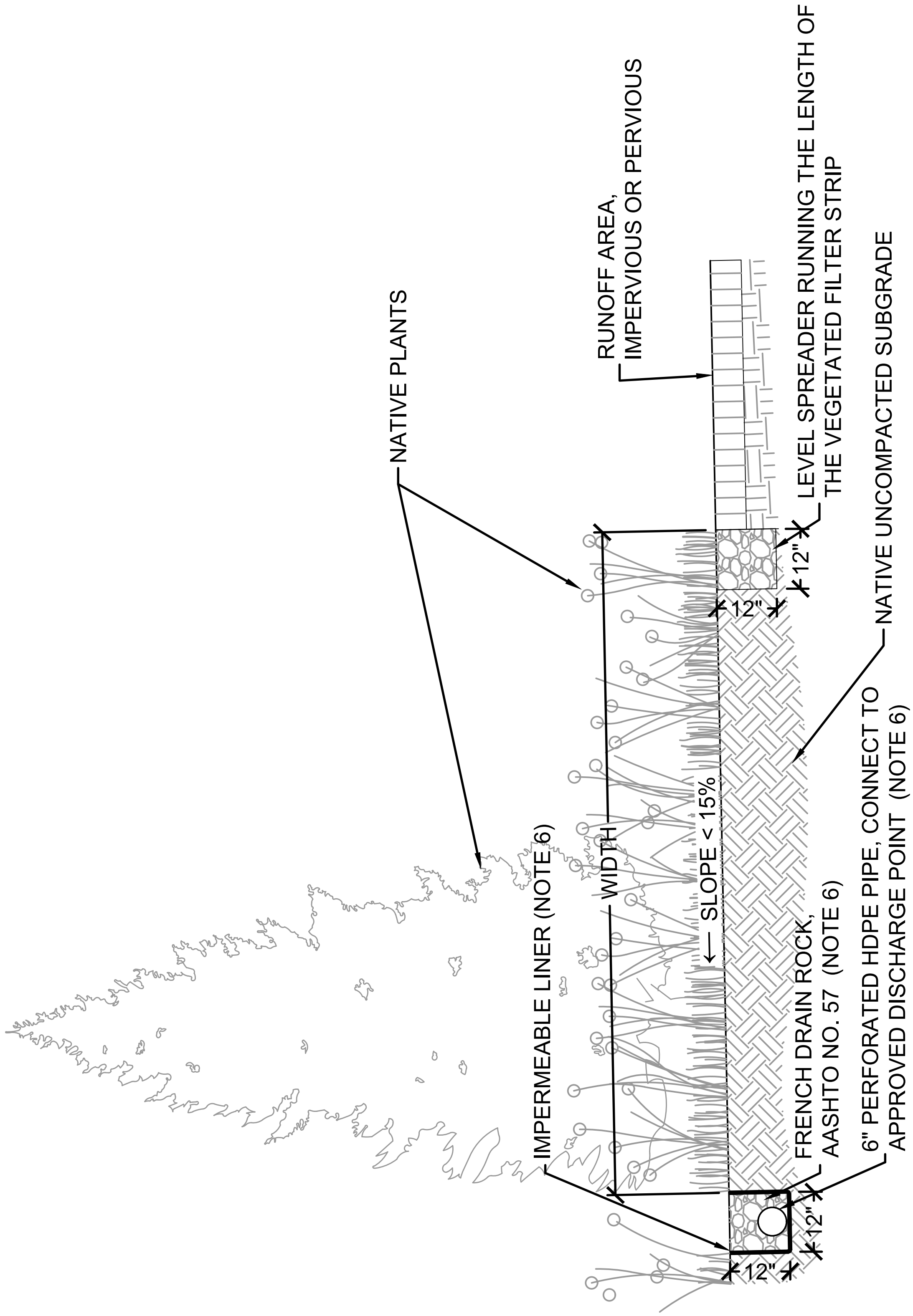
MODERATE

MOIST

NOTES:

1. THIS DETAIL IS PROVIDED AS A SCHEMATIC EXAMPLE OF THE RANDOM PLANT PLACEMENT AND 95% COVERAGE AFTER ESTABLISHMENT PERIOD DESIRED TO REDUCE EROSION AND WEEDS.
2. INSTALL PLANTS PER PLANS, ACCORDING TO LANDSCAPE DESIGN PLANT TABLE , WHICH SHOULD INCLUDE PLANT SPECIES, SPACING, AND QUANTITIES IN EACH MOISTURE ZONE.
3. MOISTURE ZONES VARY FROM THOSE SHOWN DEPENDING ON GRADING PLAN, LOCATION OF INLET (S) AND OUTLET(S) AND FACILITY SHAPE.

City of Grants Pass, Oregon Stormwater Management Typical Details	LID Swale Planting Schematic	BMP 3.09 1 of 1 Scale: NTS Date: 2-09-18



Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Vegetated Filter Strip	BMP 4.01 1 of 2 Scale: NTS Date: 2-09-18

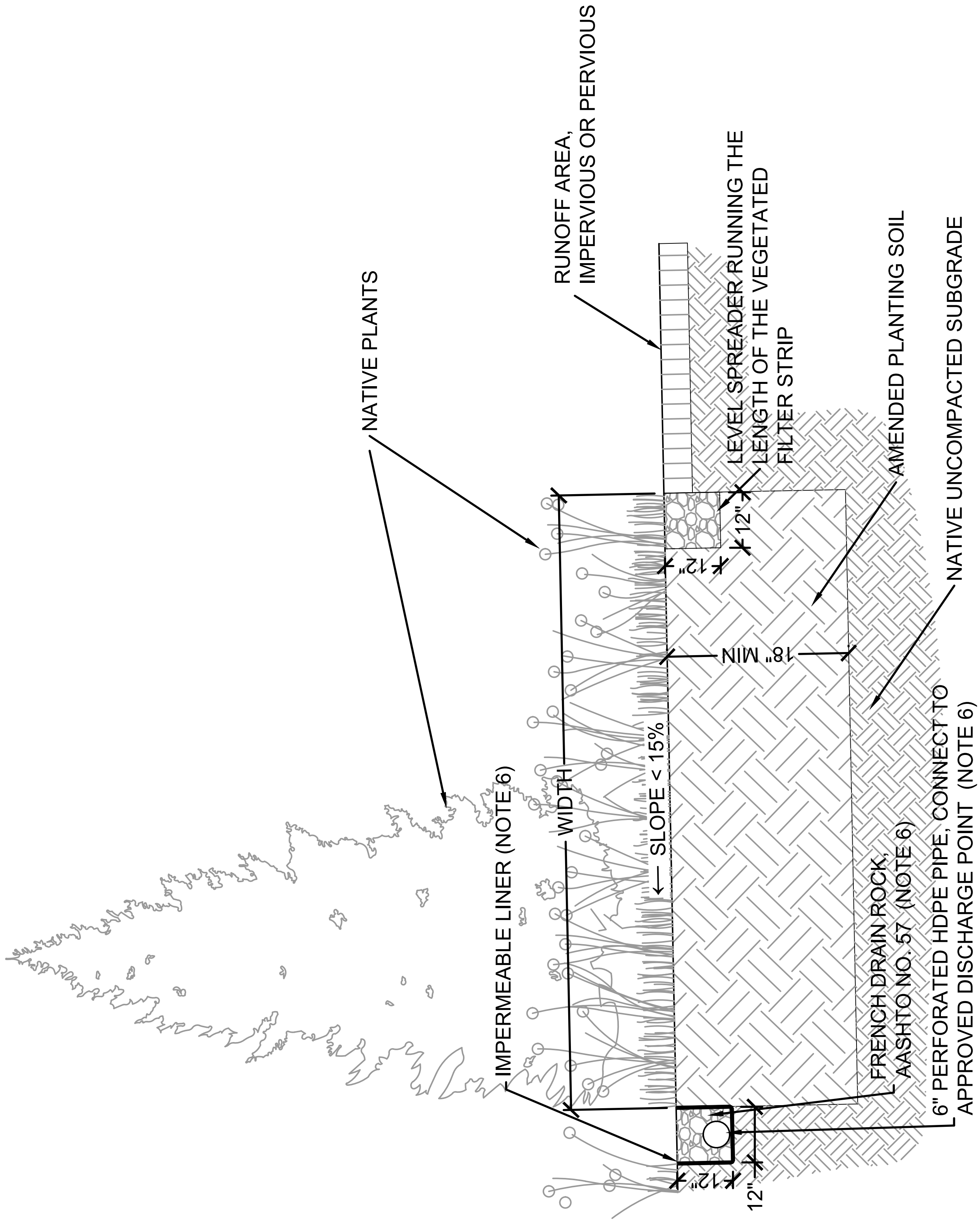
NOTES

1. BUILD AND VEGETATE FACILITY AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
2. TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE, FENCE INFILTRATION AREA (THE AREA OF THE PLANTER AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION.
3. LEVEL SPREADER COARSE AGGREGATE GRADATION IS AS FOLLOWS:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
2 ½” (63 MM)	100
2” (50 MM)	90-100
1 ½” (37.5 MM)	35-70
1” (25 MM)	0-15
½” (12.5 MM)	0-5

IF THE ABOVE GRADATION CANNOT BE MET, ANY OPEN-GRADED CRUSHED AGGREGATE WITH A MAXIMUM ROCK SIZE OF 3 INCHES OR LESS AND 30% MINIMUM VOID RATIO IS ACCEPTABLE.

5. VEGETATED FILTER STRIP LENGTH TO MATCH THE LENGTH OF THE AREA DRAINING TO IT.
6. THE FRENCH DRAIN OVERFLOW IS OPTIONAL AND SHOULD BE USED WHEN LARGE STORMS MAY DAMAGE DOWNHILL INFRASTRUCTURE. IF A FRENCH DRAIN OVERFLOW IS USED, AN IMPERMEABLE LINER IS REQUIRED TO AVOID AN UNDERGROUND INJECTION CONTROL.



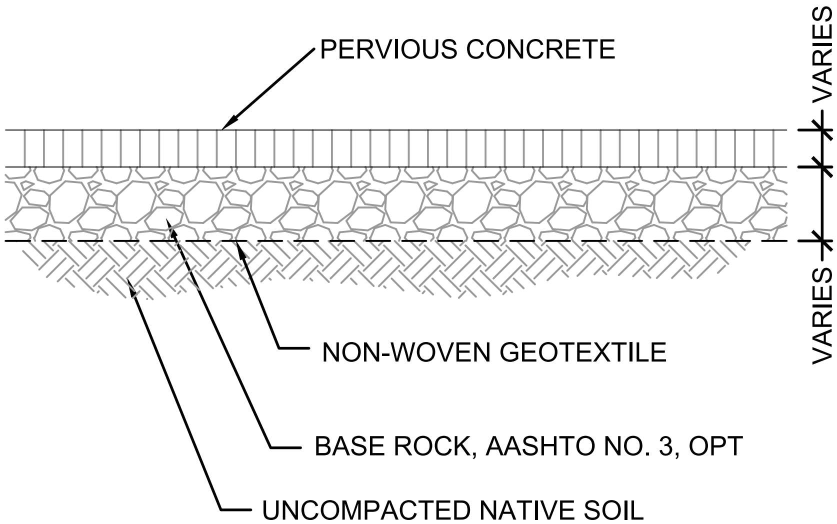
Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Vegetated Filter Strip with Amended Planting Soil	BMP 4.02 1 of 2 Scale: NTS Date: 2-09-18

NOTES

1. BUILD AND VEGETATE FACILITY AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
2. APPLY RESTORED SOILS BMP TO ENTIRE VEGETATED FILTER STRIP AREA TO RESTORE PERMEABILITY OR PROVIDE ADEQUATE ORGANIC MATTER.
3. LEVEL SPREADER COARSE AGGREGATE SUGGESTED GRADATION IS AS FOLLOWS:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
2 ½” (63 MM)	100
2” (50 MM)	90-100
1 ½” (37.5 MM)	35-70
1” (25 MM)	0-15
½” (12.5 MM)	0-5

IF THE ABOVE GRADATION CANNOT BE MET, ANY OPEN-GRADED CRUSHED AGGREGATE WITH A MAXIMUM ROCK SIZE OF 3 INCHES OR LESS AND 30% MINIMUM VOID RATIO IS ACCEPTABLE.



NOTES

1. INSTALLATION OF PERVIOUS CONCRETE SHALL BE PERFORMED BY A NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA) PERVIOUS CONCRETE TECHNICIAN WITH SUCCESSFUL INSTALLATION EXPERIENCE.
2. TO PREVENT LONG-TERM CLOGGING, GRADING PLAN SHALL REFLECT THAT LANDSCAPE AREAS DO NOT DRAIN TOWARDS PERVIOUS PAVEMENT AREA.
3. A FIELD TEST SHOWING THAT NATIVE SOILS WILL HAVE MINIMUM DESIGN INFILTRATION RATE OF 0.1 INCHES/HOUR SHALL BE SUBMITTED.
4. CONSULT A GEOTECHNICAL ENGINEER TO RECOMMEND A THICKNESS OF CONCRETE AND BASE ROCK BASED ON THE NATIVE SOILS IN A WET, UNCOMPACTED STATE AND THE TRAFFIC LOADING AND VOLUME.
5. THE GENERAL CONTRACTOR SHALL SUBMIT A NARRATIVE IDENTIFYING ANY ADDITIONAL SITE-SPECIFIC METHODS FOR PROTECTING PERVIOUS PAVEMENT SURFACES FROM RECEIVING SEDIMENT DURING THE ENTIRE CONSTRUCTION PROJECT.
6. THE FULL EXTENT OF THE POROUS PAVEMENT SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, TRACKING OF DIRT ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
7. DURING EXCAVATION OF NATIVE SOILS TO THE BOTTOM OF THE FACILITY, DO NOT ALLOW NATIVE SOILS TO BE EXPOSED TO RAINFALL, WHICH MAY CAUSE FINES TO CLOG THE NATIVE SOIL SURFACE OF THE FACILITY. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY AND CONTACT A QUALIFIED PROFESSIONAL TO INSPECT SOILS FOR PERMEABILITY.
8. BASE ROCK SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES WILL MIGRATE TO LOWER LEVELS OF THE PILE, OTHERWISE GEOTEXTILE FABRIC IS LIKELY TO CLOG.

	City of Grants Pass, Oregon Stormwater Management Typical Details	Pervious Concrete Pavement	BMP 5.01 1 of 2 Scale: NTS Date: 2-09-18

AGGREGATE SPECIFICATIONS

1. ALL AGGREGATES BENEATH THE PAVEMENT SURFACE SHALL MEET THE FOLLOWING:
   a. MAXIMUM WASH LOSS OF 0.5%
   b. MINIMUM DURABILITY INDEX OF 35
   c. MAXIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS
2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, BASE ROCK SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NUMBER 3):

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
2 ½” (63 MM)	100
2” (50 MM)	90-100
1 ½” (37.5 MM)	35-70
1” (25 MM)	0-15
½” (12.5 MM)	0-5

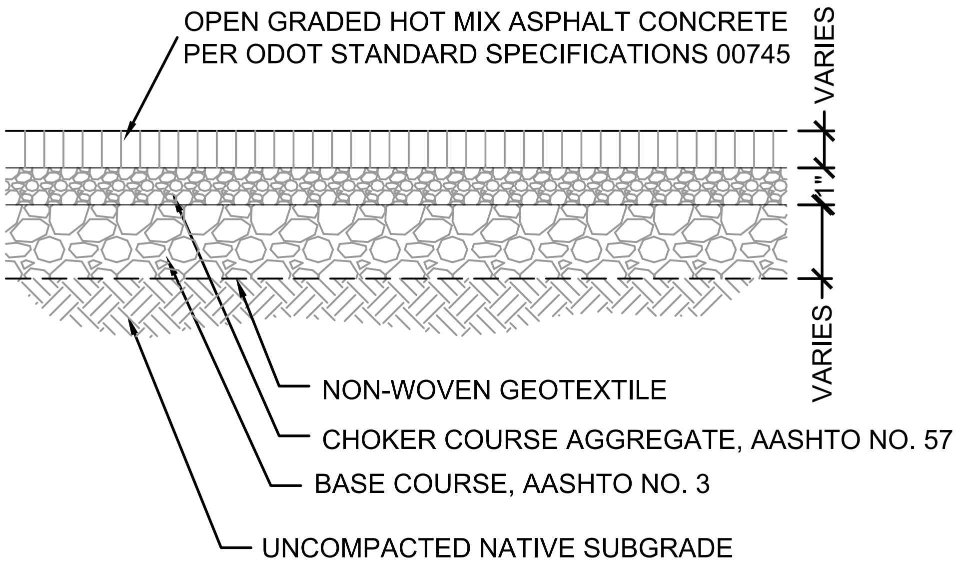
IF THE ABOVE GRADATION CANNOT BE MET, THE FOLLOWING GRADATION (AASHTO SIZE NUMBER 5) IS ACCEPTABLE WITH THE APPROVAL OF THE ENGINEER AND MINIMUM VOID SPACE OF 40%:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
1 ½” (37.5 MM)	100
1” (25 MM)	90-100
¾” (19 MM)	20-55
½” (12.5 MM)	0-10
3/8” (9.5 MM)	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER’S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.



NOTES

1. TO PREVENT LONG-TERM CLOGGING, GRADING PLAN SHALL REFLECT THAT LANDSCAPE AREAS DO NOT DRAIN TOWARDS PERVIOUS PAVEMENT AREA.
2. A FIELD TEST SHOWING THAT NATIVE SOILS WILL HAVE MINIMUM DESIGN INFILTRATION RATE OF 0.1 INCHES/HOUR SHALL BE SUBMITTED.
3. CONSULT A GEOTECHNICAL ENGINEER TO RECOMMEND A THICKNESS OF ASPHALT AND AGGREGATE BASE COURSE BASED ON THE NATIVE SOILS IN A WET, UNCOMPACTED STATE AND THE TRAFFIC LOADING AND VOLUME.
4. DESIGN AND INSTALLATION OF PERVIOUS ASPHALT SHALL BE PER ODOT STANDARD SPECIFICATIONS SECTION 00745 FOR OPEN GRADED HMAC.
5. THE GENERAL CONTRACTOR SHALL SUBMIT A NARRATIVE IDENTIFYING ANY ADDITIONAL SITE-SPECIFIC METHODS FOR PROTECTING PERVIOUS PAVEMENT SURFACES FROM RECEIVING SEDIMENT DURING THE ENTIRE CONSTRUCTION PROJECT.
6. THE FULL EXTENT OF THE POROUS PAVEMENT SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, TRACKING OF DIRTY ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
7. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY AND CONTACT A QUALIFIED PROFESSIONAL TO INSPECT SOILS FOR PERMEABILITY.
8. AGGREGATE BASE COURSE SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES WILL MIGRATE TO LOWER LEVELS OF THE PILE.
9. SEE POROUS ASPHALT SPECIFICATION FOR ADDITIONAL REQUIREMENTS, MATERIALS, AND METHODS FOR CONSTRUCTING ENTIRE POROUS ASPHALT PAVEMENT SECTION.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Porous Asphalt Pavement	BMP 5.02 1 of 3 Scale: NTS Date: 2-09-18

AGGREGATE SPECIFICATIONS

1. ALL AGGREGATES BENEATH THE PAVEMENT SURFACE SHALL MEET THE FOLLOWING:
   a. MAXIMUM WASH LOSS OF 0.5%
   b. MINIMUM DURABILITY INDEX OF 35
   c. MAXIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS
2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, BASE ROCK SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NUMBER 3):

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
2 ½" (63 MM)	100
2" (50 MM)	90-100
1 ½" (37.5 MM)	35-70
1" (25 MM)	0-15
½" (12.5 MM)	0-5

IF THE ABOVE GRADATION CANNOT BE MET, THE FOLLOWING GRADATION (AASHTO SIZE NUMBER 5) IS ACCEPTABLE WITH THE APPROVAL OF THE ENGINEER AND MINIMUM VOID SPACE OF 40%:

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
1 ½" (37.5 MM)	100
1" (25 MM)	90-100
¾" (19 MM)	20-55
½" (12.5 MM)	0-10
3/8" (9.5 MM)	0-5

3. CHOKER COURSE AGGREGATE SHALL HAVE THE FOLLOWING GRADATION (AASHTO NUMBER 57)

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
1 ½" (37.5 MM)	100
1" (25 MM)	95-100
½" (12.5 MM)	25-60
4 (4.75 MM)	0-10
8 (2.36 MM)	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

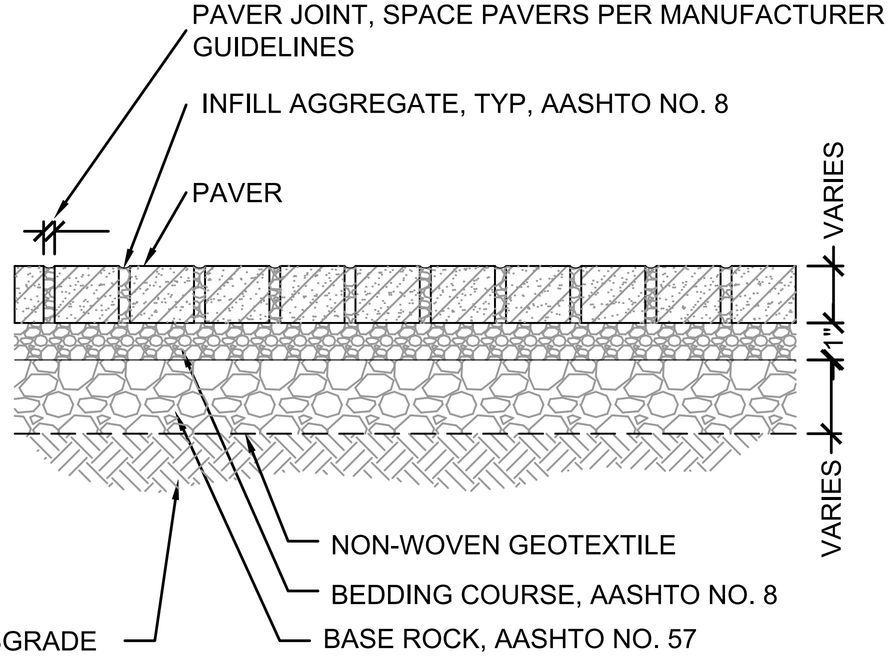
2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.

MATERIALS SPECIFICATIONS CONT...

POROUS BITUMINOUS ASPHALT

1. IN ACCORDANCE WITH ODOT SECTION 00745, ½" OPEN GRADE LEVEL 3 HMAC MIX EXCEPT AS MODIFIED BY THE FOLLOWING:
2. BITUMINOUS SURFACE COURSE FOR POROUS PAVING SHALL BE TWO AND ONE-HALF (2.5) INCHES THICK WITH A BITUMINOUS MIX OF 5.5% TO 6% BY WEIGHT DRY AGGREGATE. IN ACCORDANCE WITH ASTM D6390, DRAINDOWN OF THE BINDER SHALL BE NO GREATER THAN 0.3%. IF MORE ABSORPTIVE AGGREGATES, SUCH AS LIMESTONE, ARE USED IN THE MIX THEN THE AMOUNT OF BITUMEN IS TO BE BASED ON THE TESTING PROCEDURES OUTLINED IN THE NATIONAL ASPHALT PAVEMENT ASSOCIATION'S INFORMATION SERIES 131 – "POROUS ASPHALT PAVEMENTS" (2003) OR ODOT EQUIVALENT.
3. FOR TRAFFIC BEARING SURFACES, USE NEAT ASPHALT BINDER MODIFIED WITH AN ELASTOMERIC POLYMER TO PRODUCE A BINDER MEETING THE REQUIREMENTS OF PG 70-22 IN ACCORDANCE WITH ODOT SECTION 00744.11. THE ELASTOMERIC POLYMER SHALL BE STYRENE-BUTADIENE-STYRENE (SBS), OR APPROVED EQUAL, APPLIED AT A RATE OF 3% BY TOTAL WEIGHT OF THE BINDER. THE COMPOSITE MATERIALS SHALL BE THOROUGHLY BLENDED AT THE ASPHALT REFINERY OR TERMINAL PRIOR TO BEING LOADED INTO THE TRANSPORT VEHICLE. THE POLYMER MODIFIED ASPHALT BINDER SHALL BE HEAT AND STORAGE STABLE.
4. THE CONTRACTOR SHALL SUBMIT A CERTIFICATION LETTER FROM THE POLYMER-MODIFIED ASPHALT SUPPLIER TO THE ENGINEER BEFORE THE MIX IS PLACED ON THE PROJECT. THE CERTIFICATION LETTER FROM THE SUPPLIER WILL INCLUDE THE FOLLOWING:

    a. TYPE OF ELASTOMER POLYMER USED TO MODIFY THE ASPHALT.
    b. QUALITY CONTROL SAMPLING AND TESTING PROCEDURES USED TO CERTIFY THE POLYMER MODIFIED ASPHALT PRIOR TO SHIPPING TO THE CONTRACTOR'S ASPHALT PLANT.
    c. INFORMATION ON THE STORAGE AND STABILITY OF THE POLYMER MODIFIED ASPHALT.
    d. RECOMMENDED MIXING AND COMPACTION TEMPERATURES.
    e. A STATEMENT SAYING THAT THE POLYMER MODIFIED ASPHALT WILL COMPLY WITH THESE SPECIFICATIONS.
5. ADD HYDRATED LIME AT A DOSAGE RATE OF 1.0% WEIGHT OF THE TOTAL DRY AGGREGATE TO MIXES CONTAINING GRANITE. HYDRATED LIME SHALL MEET THE REQUIREMENTS OF ASTM C977. THE ADDITIVE MUST BE ABLE TO PREVENT THE SEPARATION OF THE ASPHALT BINDER FROM THE AGGREGATE AND ACHIEVE A REQUIRED TENSILE STRENGTH RATIO (TSR) OF AT LEAST 80% ON THE ASPHALT MIX.
6. THE ASPHALTIC MIX SHALL BE TESTED FOR ITS RESISTANCE TO STRIPPING BY WATER IN ACCORDANCE WITH ASTM D-3625. IF THE ESTIMATED COATING AREA IS NOT ABOVE 95 PERCENT, ANTI-STRIPPING AGENTS SHALL BE ADDED TO THE ASPHALT.



NOTES

1. A FIELD TEST SHOWING THAT NATIVE SOILS WILL HAVE MINIMUM DESIGN INFILTRATION RATE OF 0.1 INCHES/HOUR SHALL BE SUBMITTED.
2. CONSULT A GEOTECHNICAL ENGINEER TO RECOMMEND AN AGGREGATE BASE COURSE THICKNESS BASED ON THE NATIVE SOILS IN A WET, UNCOMPACTED STATE AND THE TRAFFIC LOADING AND VOLUME.
3. THE GENERAL CONTRACTOR SHALL SUBMIT A NARRATIVE IDENTIFYING ANY ADDITIONAL SITE-SPECIFIC METHODS FOR PROTECTING PERVIOUS PAVEMENT SURFACES FROM RECEIVING SEDIMENT DURING THE ENTIRE CONSTRUCTION PROJECT.
4. THE FULL EXTENT OF THE POROUS PAVEMENT SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, TRACKING OF DIRT ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY AND CONTACT A QUALIFIED PROFESSIONAL TO INSPECT SOILS FOR PERMEABILITY.
6. BASE ROCK SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES WILL MIGRATE TO LOWER LEVELS OF THE PILE.

Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Manufactured Permeable Pavers	BMP 5.03 1 of 2 Scale: NTS Date: 2-09-18

AGGREGATE SPECIFICATIONS

1. ALL AGGREGATES BENEATH THE PAVEMENT SHALL MEET THE FOLLOWING:
   a. MAXIMUM WASH LOSS OF 0.5%
   b. MINIMUM DURABILITY INDEX OF 35
   c. MAXIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS
2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, BASE ROCK SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NO. 57)

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
1 ½” (37.5 MM)	100
1” (25 MM)	95-100
½” (12.5 MM)	25-60
4 (4.75 MM)	0-10
8 (2.36 MM)	0-5

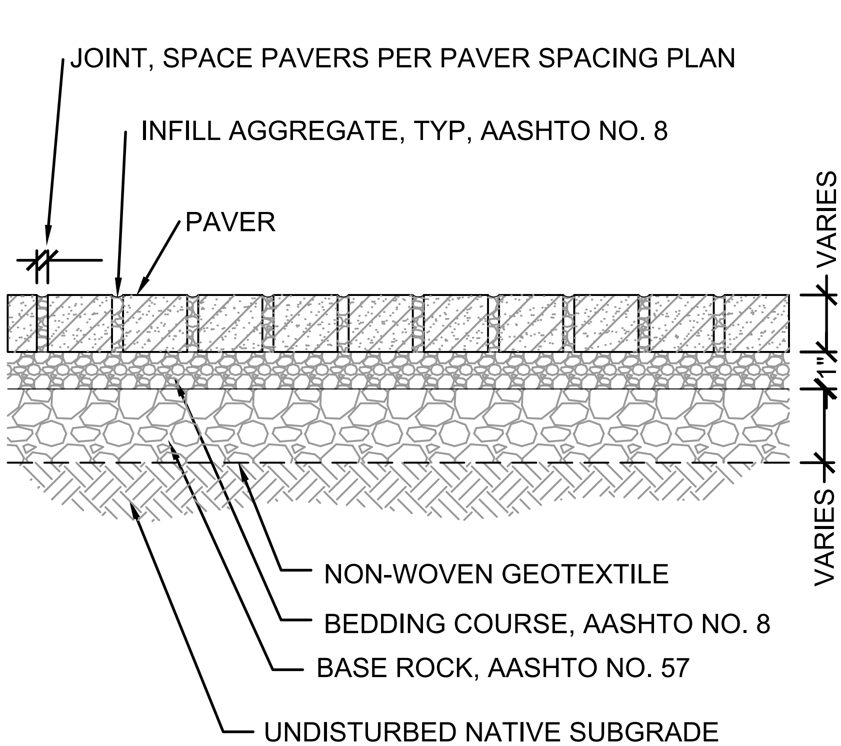
3. UNLESS OTHERWISE APPROVED BY THE ENGINEER, THE BEDDING COURSE SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NO. 8):

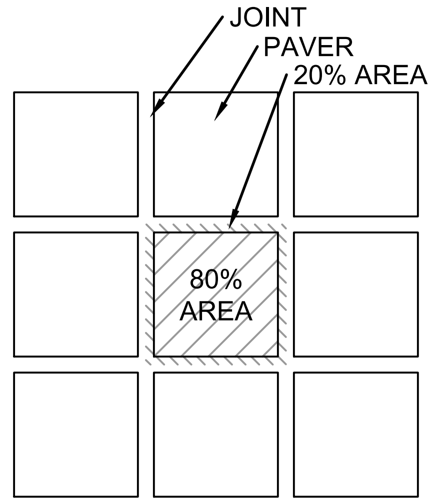
U.S. STANDARD SIEVE SIZE	PERCENT PASSING
½” (12.5 MM)	100
3/8" (9.5MM)	85-100
4 (4.75 MM)	10-30
8 (2.36 MM)	0-10
16 (1.18 MM)	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER’S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.





Paver Spacing Plan

NOTES

1. A FIELD TEST SHOWING THAT NATIVE SOILS WILL HAVE MINIMUM DESIGN INFILTRATION RATE OF 0.1 INCHES/HOUR SHALL BE SUBMITTED.
2. CONSULT A GEOTECHNICAL ENGINEER TO RECOMMEND A THICKNESS OF PAVER AND AGGREGATE BASE COURSE BASED ON THE NATIVE SOILS IN A WET, UNCOMPACTED STATE AND THE TRAFFIC LOADING AND VOLUME. CONFIRM THAT THE PAVER MATERIAL AND CONDITION IS SUITABLE FOR IT'S INTENDED USE.
3. THE GENERAL CONTRACTOR SHALL SUBMIT A NARRATIVE IDENTIFYING ANY ADDITIONAL SITE-SPECIFIC METHODS FOR PROTECTING PERVIOUS PAVEMENT SURFACES FROM RECEIVING SEDIMENT DURING THE ENTIRE CONSTRUCTION PROJECT.
4. THE FULL EXTENT OF THE PERMEABLE PAVERS SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, TRACKING DIRT ONTO ANY LAYER OF THE FACILITY, AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY AND CONTACT A QUALIFIED PROFESSIONAL TO INSPECT SOILS FOR PERMEABILITY.
6. BASE ROCK SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES WILL MIGRATE TO LOWER LEVELS OF THE PILE.

Grants Pass LIVE ROGUE	City of Grants Pass, Oregon Stormwater Management Typical Details	Salvaged & Poured Concrete Permeable Pavers	BMP 5.04 1 of 2 Scale: NTS Date: 2-09-18

AGGREGATE SPECIFICATIONS

1. ALL AGGREGATES BENEATH THE PAVEMENT SHALL MEET THE FOLLOWING:
   a. MAXIMUM WASH LOSS OF 0.5%
   b. MINIMUM DURABILITY INDEX OF 35
   c. MAXIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS
2. UNLESS OTHERWISE APPROVED BY THE ENGINEER, BASE ROCK SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NO. 57)

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
1 ½” (37.5 MM)	100
1” (25 MM)	95-100
½” (12.5 MM)	25-60
4 (4.75 MM)	0-10
8 (2.36 MM)	0-5

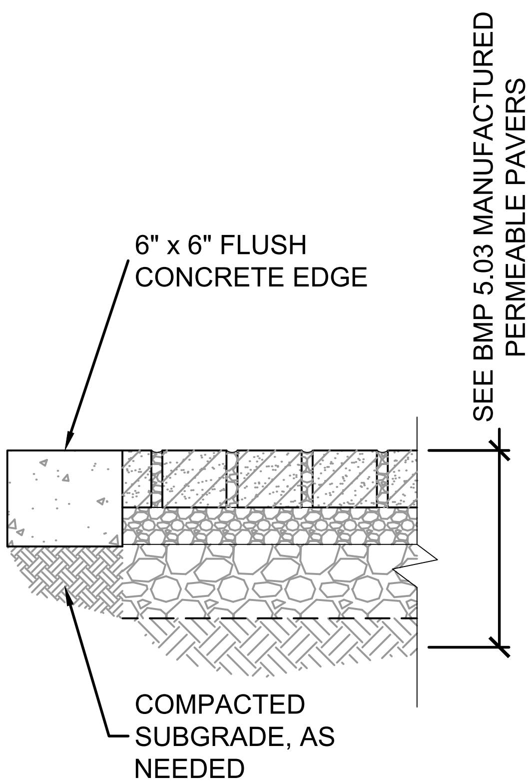
3. UNLESS OTHERWISE APPROVED BY THE ENGINEER, THE BEDDING COURSE SHALL BE UNIFORMLY GRADED WITH THE FOLLOWING GRADATION (AASHTO NO. 8):

U.S. STANDARD SIEVE SIZE	PERCENT PASSING
½” (12.5 MM)	100
3/8" (9.5MM)	85-100
4 (4.75 MM)	10-30
8 (2.36 MM)	0-10
16 (1.18 MM)	0-5

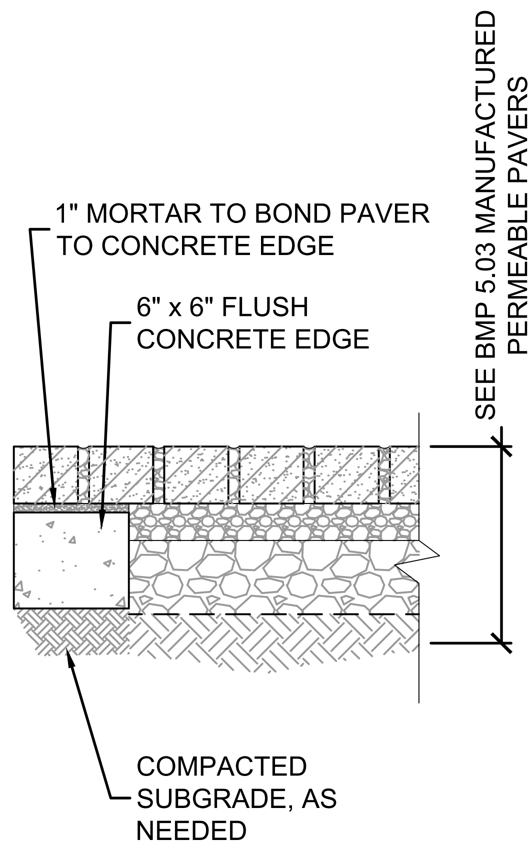
GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER’S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.



FLUSH CURB

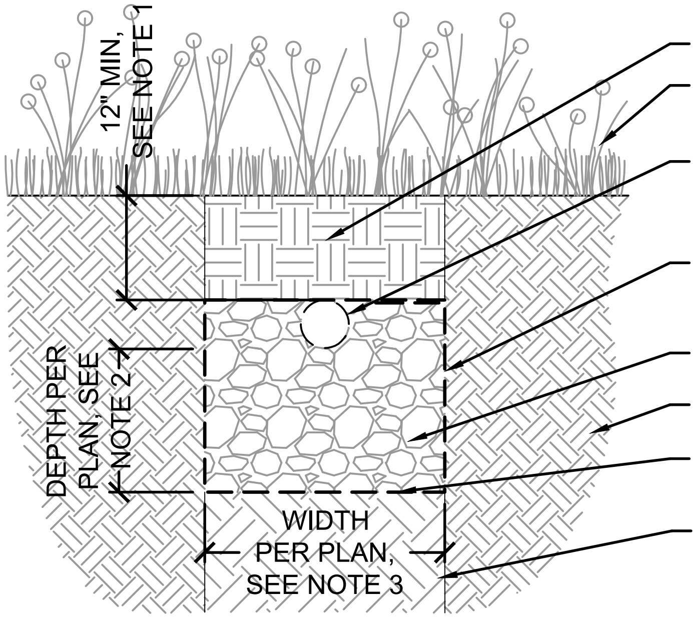


HIDDEN CURB

NOTES

1. DURING INSTALLATION OF CURB, PROTECT PERMEABLE PAVER AREA FROM COMPACTION.

City of Grants Pass, Oregon Stormwater Management Typical Details	Vehicular Permeable Paver Edges	BMP 5.05 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. DEPTH TO PIPE MUST BE 12" MINIMUM FOR ADEQUATE SOIL DEPTH PER PLANT CHOICES:
   12" FOR LAWN
   18" FOR TALL GRASSES
   24" FOR SHRUBS
   36" FOR MOST TREES
   DEPTH TO PIPE NEEDED TO PROVIDE ADEQUATE COVER VARIES WITH PIPE MANUFACTURER AND MAY EXCEED THE DEPTH OF SOIL AS DESCRIBED ABOVE NEEDED TO SUPPORT PLANTS.
2. DEPTH AND AREA OF UNIFORMLY GRADED STORAGE ROCK PER DIMENSIONS PROVIDED ON PLANS.
3. INFILTRATION AREAS (THE AREA OF THE SOAKAGE TRENCH AS DEFINED BY THE BOTTOM AREA OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. CONTRACTOR TO CREATE A STAGING AND STOCKPILING PLAN STAMPED BY A GEOTECHNICAL ENGINEER SHOWING HOW THE FACILITY WILL BE PROTECTED FROM CONSTRUCTION IF FENCING WILL NOT BE USED.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. AGGREGATE BASE COURSE SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES (VERY SMALL SOIL PARTICLES) WILL MIGRATE TO LOWER LEVELS OF THE PILE. USE APPROPRIATE EROSION PREVENTION & SEDIMENT CONTROL MEASURES DURING THIS PROCESSING.
7. ALL RUNOFF ENTERING THE PERFORATED DISTRIBUTION PIPE MUST BE PRE-TREATED TO REDUCE TOTAL SUSPENDED SOLIDS (TSS).
8. 4" OF SEPARATION ROCK (AASHTO NO. 8) INSTALLED CONTINUOUSLY ALONG THE BOTTOM OF THE SOAKAGE TRENCH MAY BE SUBSTITUTED FOR GEOTEXTILE FABRIC ON THE BOTTOM. GEOTEXTILE FABRIC IS STILL REQUIRED ON THE TOPS AND SIDES.

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

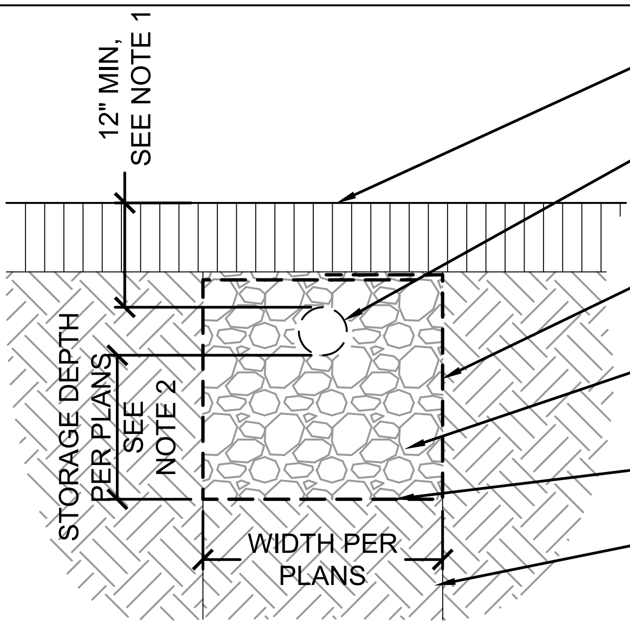
3. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL MEET HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.



NOTES

1. PROVIDE DEPTH TO PIPE NEEDED FOR ADEQUATE COVER BASED ON VEHICULAR LOADING, WHICH VARIES WITH PIPE MANUFACTURER.
2. DEPTH AND AREA OF UNIFORMLY GRADED STORAGE ROCK PER DIMENSIONS PROVIDED ON PLANS.
3. INFILTRATION AREAS (THE AREA OF THE SOAKAGE TRENCH AS DEFINED BY THE BOTTOM AREA OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. CONTRACTOR TO CREATE A STAGING AND STOCKPILING PLAN STAMPED BY A GEOTECHNICAL ENGINEER SHOWING HOW THE FACILITY WILL BE PROTECTED FROM CONSTRUCTION IF FENCING WILL NOT BE USED.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. AGGREGATE BASE COURSE SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES (VERY SMALL SOIL PARTICLES) WILL MIGRATE TO LOWER LEVELS OF THE PILE. USE APPROPRIATE EROSION PREVENTION & SEDIMENT CONTROL MEASURES DURING THIS PROCESSING.
7. ALL RUNOFF ENTERING THE PERFORATED DISTRIBUTION PIPE MUST BE PRE-TREATED TO REDUCE TOTAL SUSPENDED SOLIDS (TSS).
8. PAVEMENT SECTION (DEPTH AND TYPE OF IMPERVIOUS PAVEMENT SURFACE, OPEN GRADED BASE ROCK) TO BE DESIGNED BY A GEOTECHNICAL ENGINEER TO SUPPORT PREDICTED TRAFFIC LOADING BASED ON UNDERLYING NATIVE SOILS IN A WET, UNCOMPACTED CONDITION. DO NOT COMPACT SUBGRADE.
9. IF PERFORATED DISTRIBUTION PIPE WILL BE LOCATED ON THE BOTTOM OF THE TRENCH TO ACHIEVE ADEQUATE COVER, INCORPORATE A CATCH BASIN CONTROL STRUCTURE (SEE BMP 8.01) OR EQUIVALENT DEVICE TO ENSURE WATER BACKS UP INTO STORAGE ROCK DEPTH.
10. 4 INCHES OF SEPARATION ROCK (AASHTO NO. 8) INSTALLED CONTINUOUSLY ALONG THE BOTTOM OF THE SOAKAGE TRENCH MAY BE SUBSTITUTED FOR GEOTEXTILE FABRIC ON THE BOTTOM . GEOTEXTILE FABRIC IS STILL REQUIRED ON THE TOPS AND SIDES.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Soakage Trench under Impervious Pavement Surface	BMP 6.02 1 of 2 Scale: NTS Date: 2-09-18

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

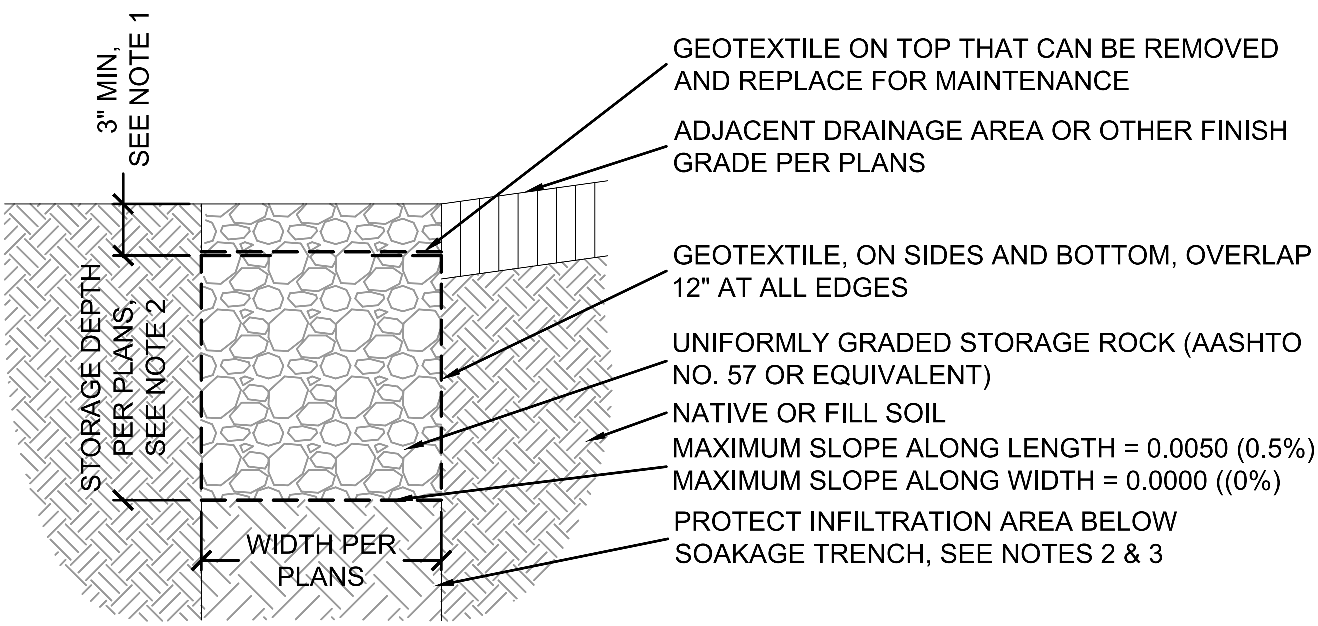
3. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL MEET HAVE THE FOLLOWING GRADATION (AASHTO #8):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.



NOTES

1. DEPTH OF AGGREGATE COVERING GEOTEXTILE SHOULD BE SUFFICIENT TO PROTECT GEOTEXTILE FROM SUNLIGHT, SINCE ULTRAVIOLET (UV) LIGHT DEGRADES GEOTEXTILE FABRICS.
2. DEPTH AND AREA OF UNIFORMLY GRADED STORAGE ROCK PER DIMENSIONS PROVIDED ON PLANS.
3. INFILTRATION AREAS (THE AREA OF THE SOAKAGE TRENCH AS DEFINED BY THE BOTTOM AREA OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SUBGRADE, DIRT TRACKING ONTO ANY LAYER OF THE FACILITY AND STOCKPILING OF CONSTRUCTION MATERIALS THAT MAY CLOG THE SURFACE.
4. IF FENCING WILL NOT BE USED, CONTRACTOR TO SUBMIT A STAGING AND STOCKPILING PLAN SHOWING HOW THE FACILITY WILL BE PROTECTED FROM CONSTRUCTION.
5. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
6. AGGREGATE BASE COURSE SHALL BE DELIVERED CLEAN (2% WASH LOSS) AND WASHED ON-SITE TO REDUCE WASH LOSS TO 0.5%. THIS MAY BE DONE BY HOSING THE ROCK OFF WHILE STILL IN THE DELIVERY TRUCK OR AFTER STOCKPILING. SCOOP FROM THE TOP AND PLACE ROCK. HOSE OFF AS NEEDED AS THE PILE DIMINISHES SINCE FINES (VERY SMALL SOIL PARTICLES) WILL MIGRATE TO LOWER LEVELS OF THE PILE. USE APPROPRIATE EROSION PREVENTION & SEDIMENT CONTROL MEASURES DURING THIS PROCESSING.
7. 4 INCHES OF SEPARATION ROCK (AASHTO NO. 8) INSTALLED CONTINUOUSLY ALONG THE BOTTOM OF THE SOAKAGE TRENCH MAY BE SUBSTITUTED FOR GEOTEXTILE FABRIC ON THE BOTTOM . GEOTEXTILE FABRIC IS STILL REQUIRED ON THE TOPS AND SIDES.

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL HAVE THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

3. UNLESS OTHERWISE APPROVED BY ENGINEER, SEPARATION ROCK SHALL MEET HAVE THE FOLLOWING GRADATION (AASHTO #8):

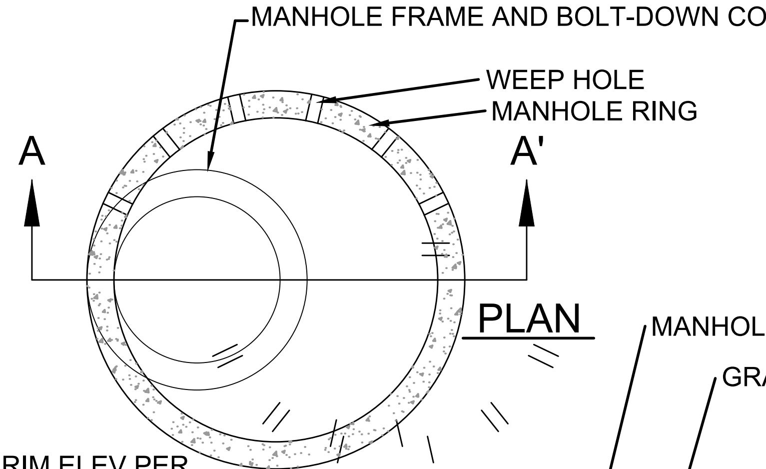
US. STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{1}{2}$"	100
$\frac{3}{8}$"	85-100
#4	10-30
#10	0-10
#8	0-10
#16	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

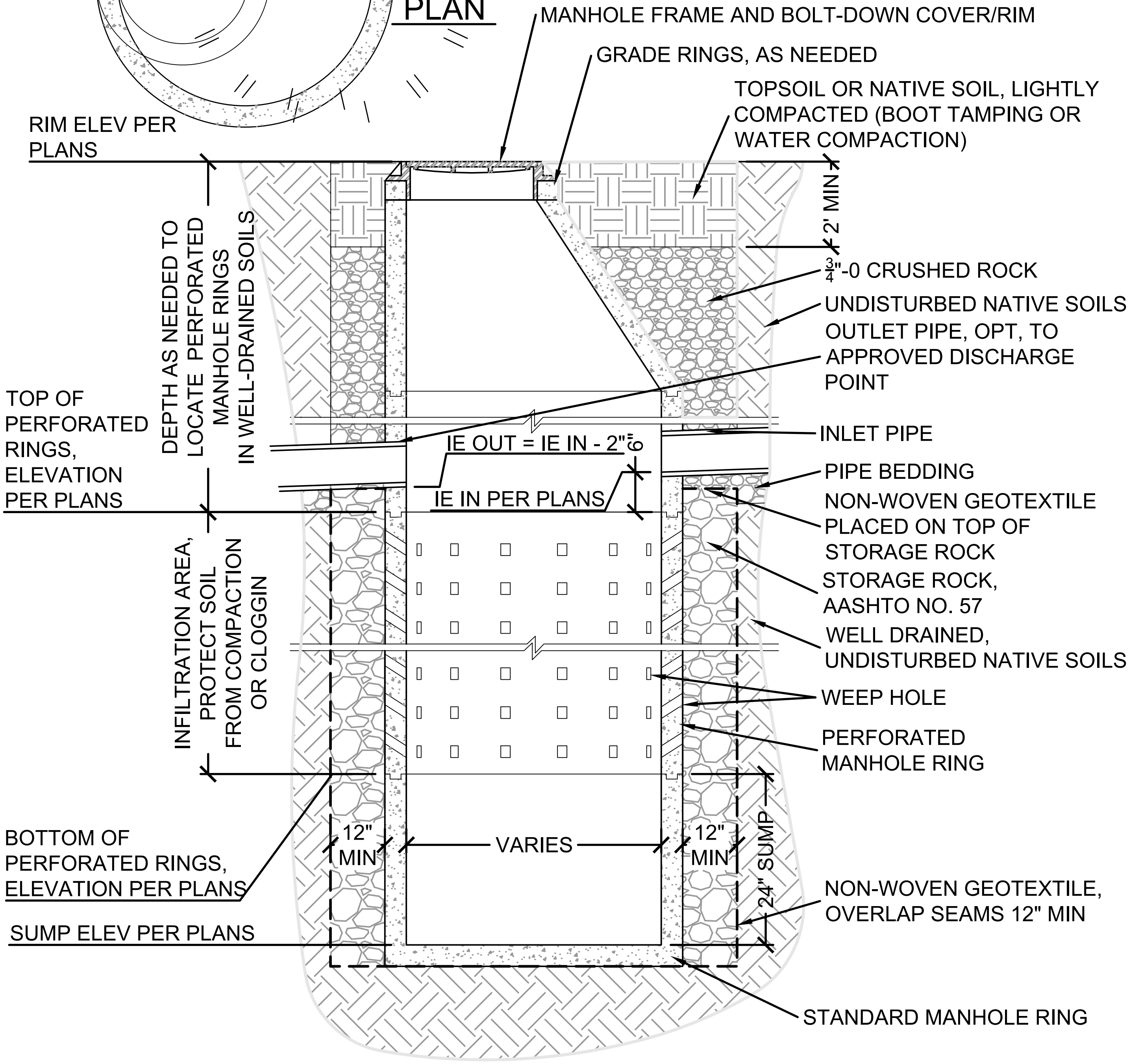
1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.

THIS STANDARD DETAIL DOES NOT CONFORM TO THE 2014 OREGON SPECIALTY PLUMBING CODE; HOWEVER, PER THIS SECTION 301.4 ALTERNATIVE ENGINEERED DESIGN THE BUILDING OFFICIAL HAS THE AUTHORITY TO APPROVE THIS DETAIL. SEE PLUMBING CODE FOR MORE INFO.



PLAN



SECTION A-A'

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Drywell in Landscape Area	BMP 7.01 1 of 2 Scale: NTS Date: 2-09-18

ROCK AGGREGATE SPECIFICATIONS

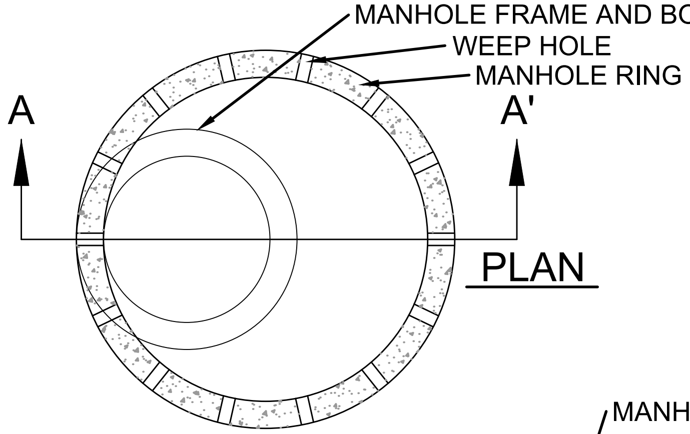
1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL MEET THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

GEOTEXTILE FABRIC SPECIFICATIONS

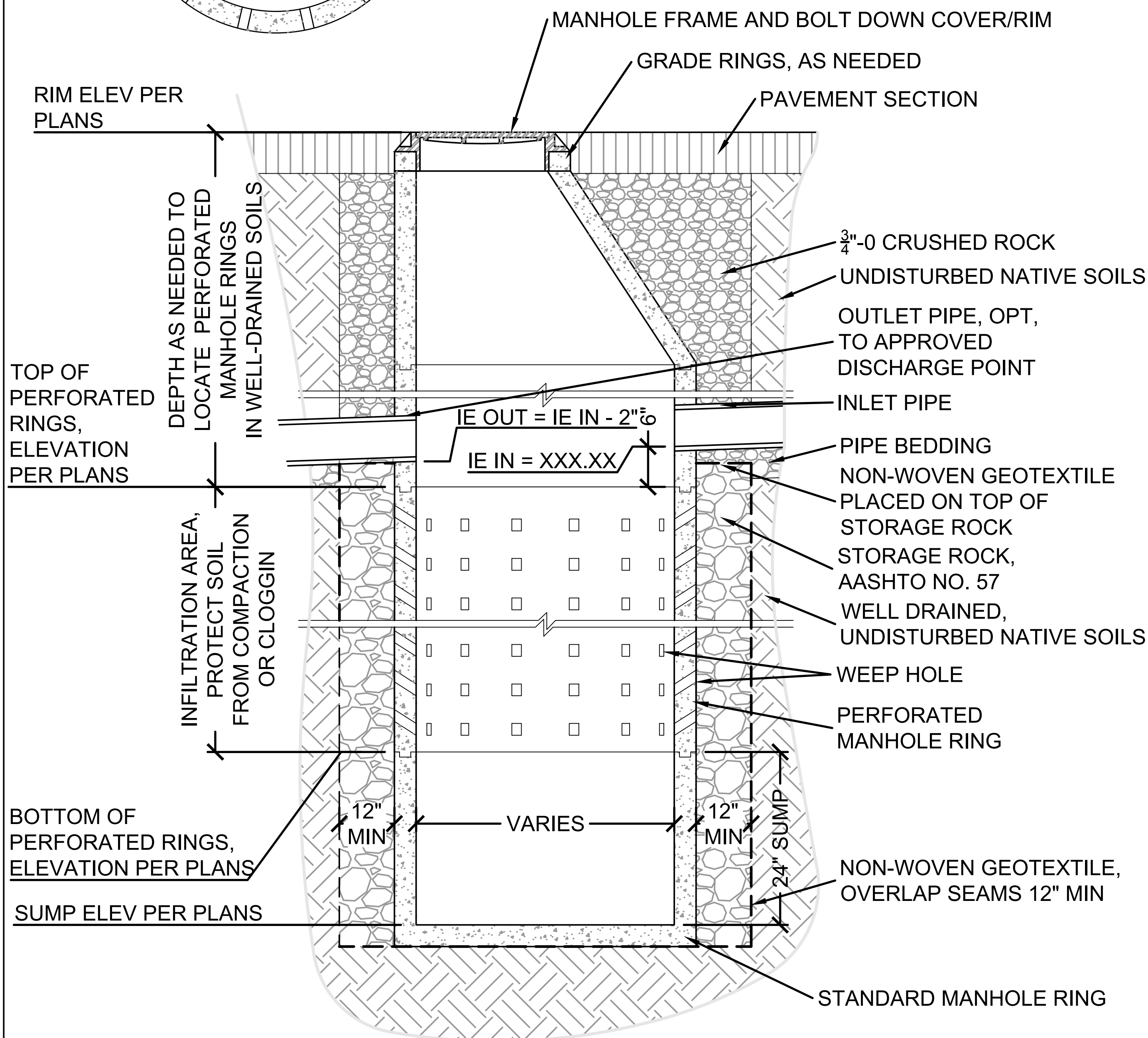
1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.



PLAN

THIS STANDARD DETAIL DOES NOT CONFORM TO THE 2014 OREGON SPECIALTY PLUMBING CODE; HOWEVER, PER THIS SECTION 301.4 ALTERNATIVE ENGINEERED DESIGN THE BUILDING OFFICIAL HAS THE AUTHORITY TO APPROVE THIS DETAIL. SEE PLUMBING CODE FOR MORE INFO.



SECTION A-A'

City of Grants Pass, Oregon Stormwater Management Typical Details	Drywell in Paved Area	BMP 7.02 1 of 2 Scale: NTS Date: 2-09-18

ROCK AGGREGATE SPECIFICATIONS

1. ALL ROCK AGGREGATE SHALL:
   a. BE WASHED ROCK WITH A MAXIMUM 0.5% WASH LOSS.
   b. HAVE A MINIMUM DURABILITY INDEX OF 35
   c. HAVE A MINIMUM ABRASION OF 10% FOR 100 REVOLUTIONS AND MAXIMUM OF 50% FOR 500 REVOLUTIONS.
2. UNLESS OTHERWISE APPROVED BY ENGINEER, UNIFORMLY GRADED STORAGE ROCK SHALL MEET THE FOLLOWING GRADATION (AASHTO #57):

US. STANDARD SIEVE SIZE	PERCENT PASSING
$1\frac{1}{2}$"	100
1"	95-100
$\frac{1}{2}$"	25-60
#4	0-10
#8	0-5

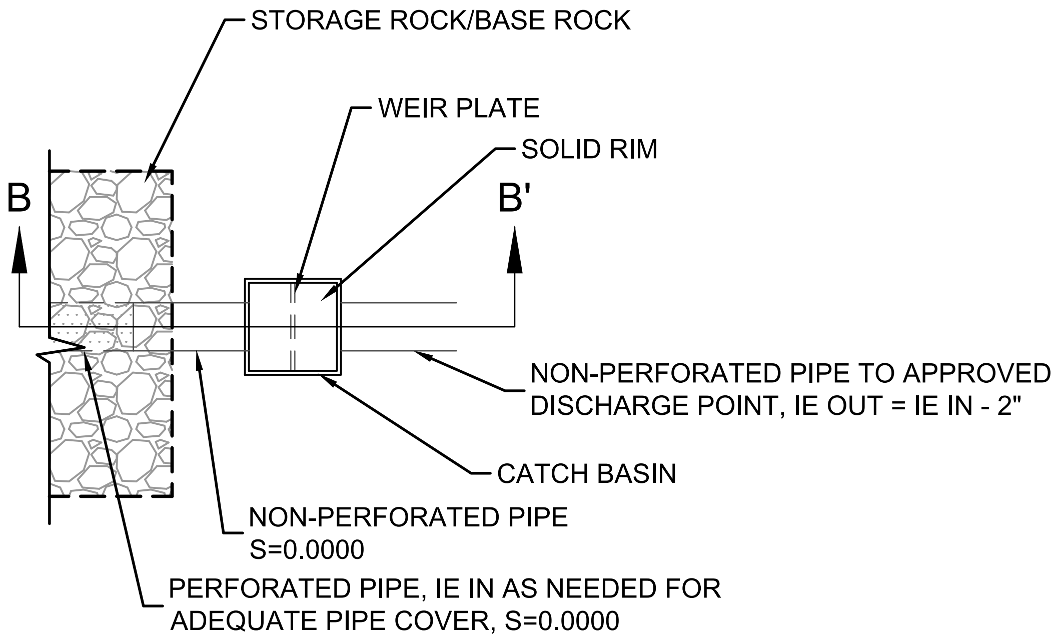
GEOTEXTILE FABRIC SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. NON-WOVEN GEOTEXTILE (DRAINAGE FILTER FABRIC) SHOULD CONFORM TO THE FOLLOWING CRITERIA:
   a. MINIMUM FLOW RATE OF 95 GAL/MIN/FT2 ASTM D-4491-85
   b. GRAB TENSILE STRENGTH MIN 115 LB. ASTM D-4632-86
   c. BURST STRENGTH MIN 150 PSI ASTM D-3786-80A
   d. PUNCTURE RESISTANCE MIN 45 LB. ASTM D-4833-88
   e. APPARENT OPENING SIZE 60-90 U.S. STANDARD SIEVE

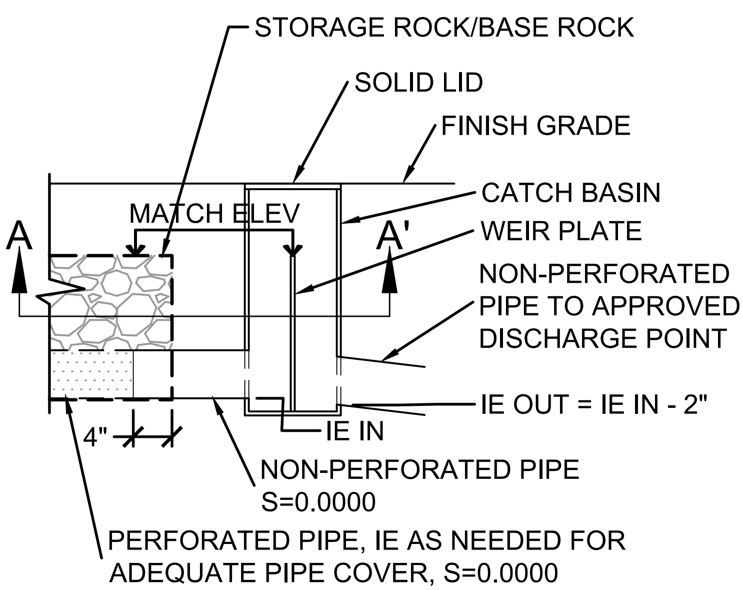
2. INSTALLATION. GEOTEXTILE FABRIC SHOULD BE INSTALLED PER THE FOLLOWING GUIDANCE:
   a. PLACE GEOTEXTILE IN ACCORDANCE WITH MANUFACTURER'S STANDARDS AND RECOMMENDATIONS.
   b. ADJACENT STRIPS OF GEOTEXTILE SHOULD OVERLAP A MINIMUM OF SIXTEEN (16) INCHES.
   c. SECURE GEOTEXTILE AT LEAST FOUR (4) FEET OUTSIDE OF EXCAVATED AREA OVER EXPOSED SOIL AND TAKE ANY STEPS NECESSARY TO PREVENT ANY RUNOFF OR SEDIMENT FROM ENTERING THE PAVEMENT ROCK BASE.
   d. AFTER POROUS PAVEMENT SURFACE IS INSTALLED, CUT EXCESS GEOTEXTILE FABRIC AT THE INTERFACE BETWEEN THE GROUND AND THE PAVEMENT, SO THAT IT CANNOT BE SEEN ANY LONGER.

FROM BMP TO APPROVED DISCHARGE POINT

===> FLOW OF WATER WHEN OVERFLOWING ===>



PLAN (SECTION A-A')

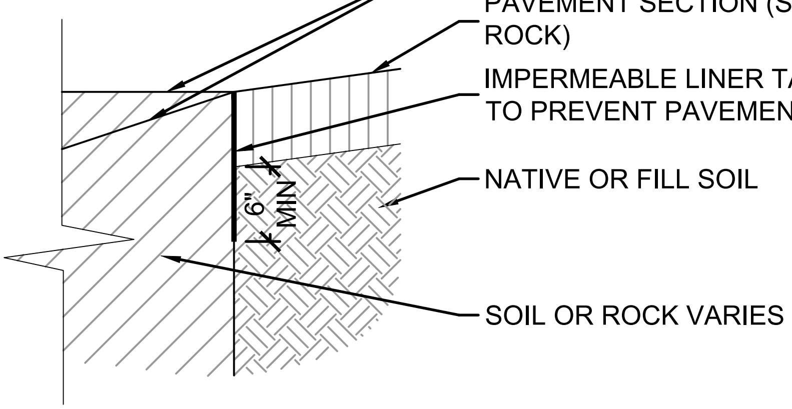


ELEVATION (SECTION B-B')

NOTES

1. APPLICABILITY. THE CATCH BASIN CONTROL STRUCTURE ALLOWS WATER TO BACK UP IN THE VOIDS OF THE STORAGE ROCK/BASE ROCK TO INFILTRATE THEN OVERFLOW WHEN THE VOIDS ARE FULL. INCLUDE THIS DETAIL ON PLANS WHEN A PERFORATED PIPE IS PLACED AT THE BOTTOM OF THE FOLLOWING BMPS:
   - SOAKAGE TRENCH BMP
   - POROUS PAVEMENT BMP
2. TO REDUCE THE LIKELIHOOD OF FUTURE MODIFICATION BY OPERATIONS & MAINTENANCE STAFF, THE WEIR SHALL NOT BE FIELD CONSTRUCTED, BUT INSTEAD SHALL BE PREFABRICATED BY THE CATCH BASIN MANUFACTURER. CONSULT MAINTENANCE STAFF TO ENSURE THAT EQUIPMENT IS AVAILABLE TO MAINTAIN THIS CATCH BASIN, OTHERWISE, USE A DIFFERENT STRATEGY TO BACK WATER INTO THE STORAGE ROCK.

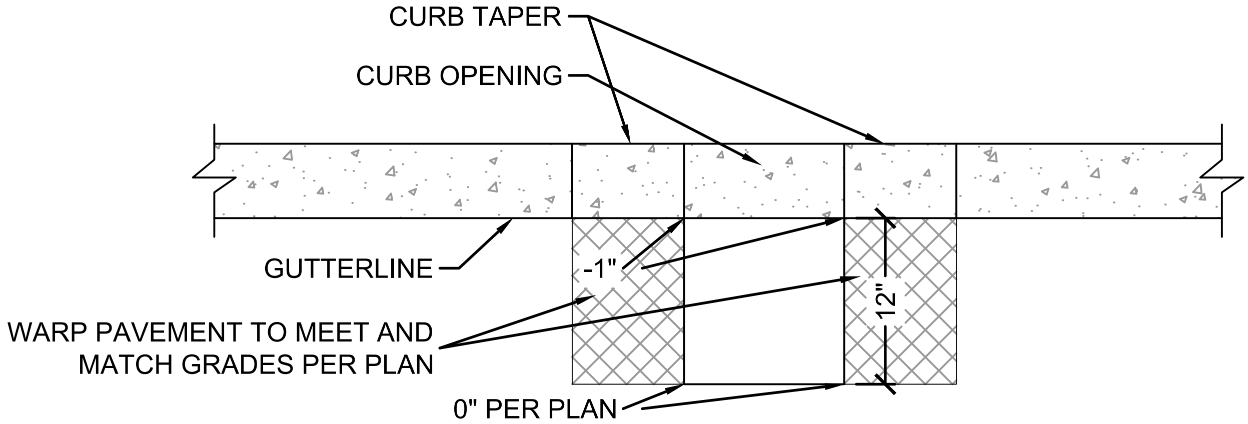
City of Grants Pass, Oregon Stormwater Management Typical Details	Catch Basin Outlet Control Structure for Infiltration Facilities	BMP 8.01 1 of 1 Scale: NTS Date: 2-09-18



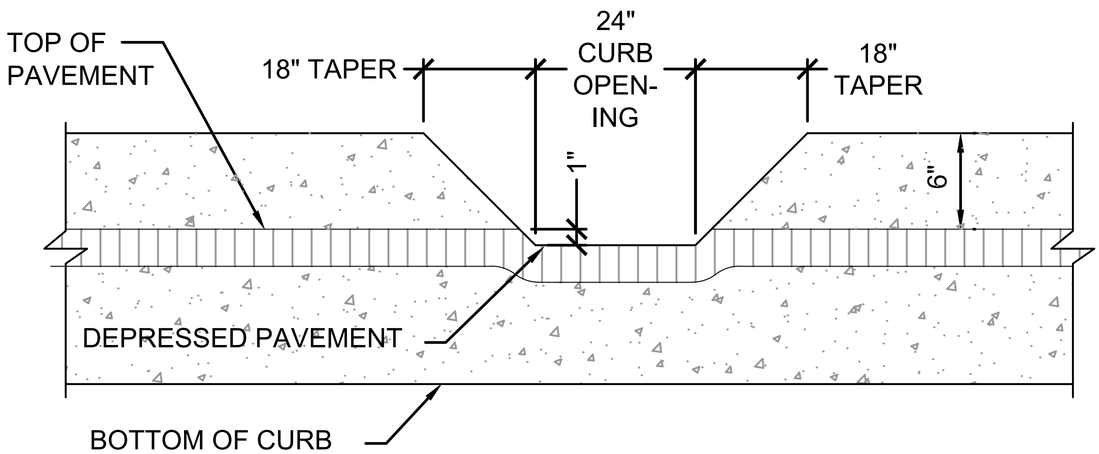
NOTES

1. APPLICABILITY: THIS DETAIL IS APPLICABLE TO INFILTRATION BMPS (RAIN GARDEN, LID SWALE, VEGETATED FILTER STRIP, AND SOAKAGE TRENCH) WHERE WATER MAY POND UP DIRECTLY ADJACENT TO PAVEMENT AND CAUSE UNDERCUTTING.

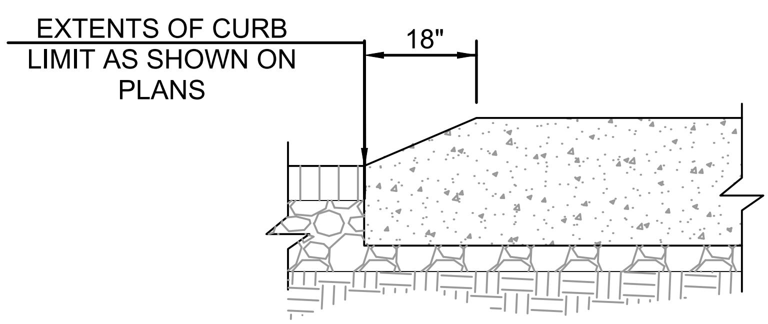
	City of Grants Pass, Oregon Stormwater Management Typical Details	Pavement Undercut Protection for Infiltration Facilities	BMP 8.02 1 of 1 Scale: NTS Date: 2-09-18



PLAN



GUTTERLINE SECTION

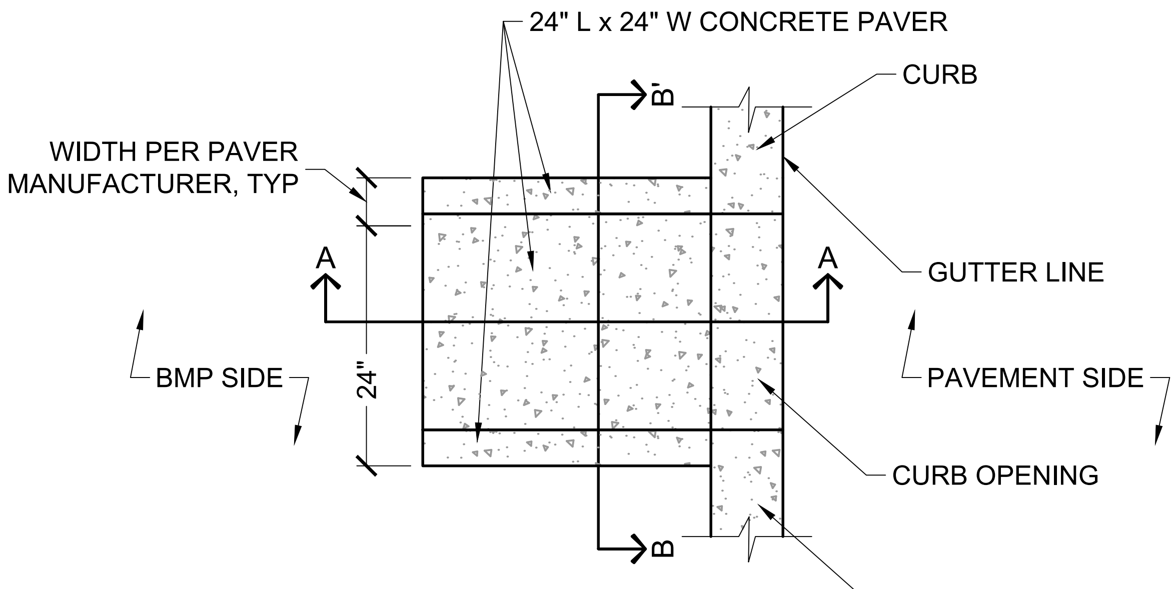


CURB TAPER ELEVATION

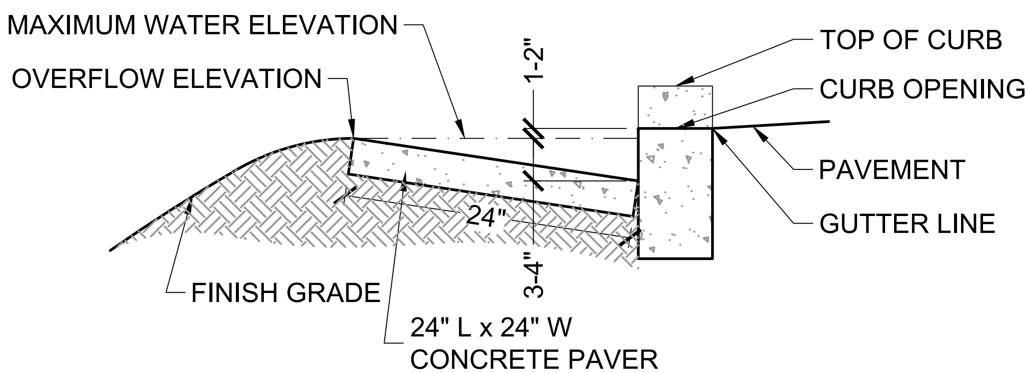
NOTES

1. THE DEPRESSED PAVEMENT SHOWN IN PLAN AND GUTTERLINE SECTION ABOVE IS INTENDED FOR CURB CUTS WHERE WATER MUST MAKE A 90-DEGREE TURN TO ENTER A FACILITY, WHICH ARE PRONE TO GETTING BLOCKED WITH SEDIMENT. CURB CUTS PERPENDICULAR TO WATER FLOW (BUMPOUT CONFIGURATION) OR AT THE CENTER OF A VALLEY DO NOT REQUIRE THE DEPRESSED PAVEMENT STRATEGY.

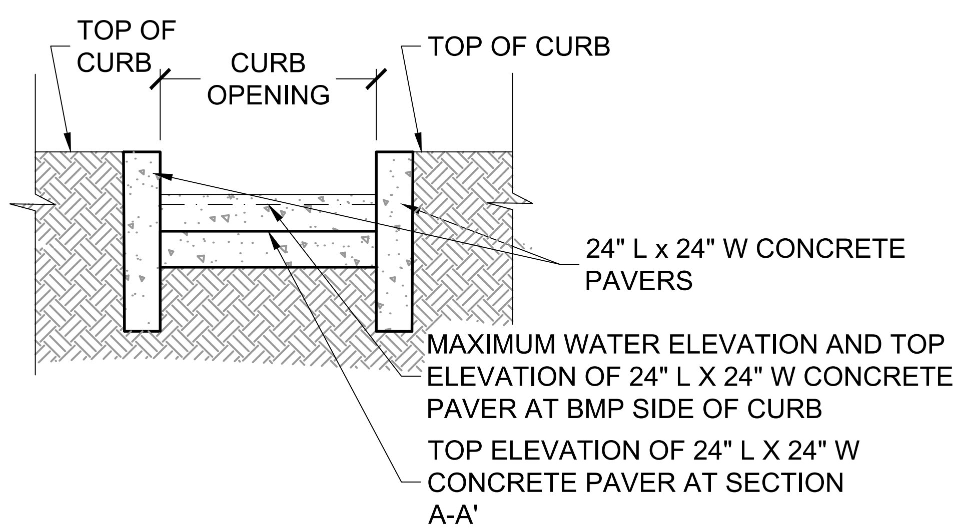
Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Curb Cut / Curb Opening	BMP 8.03 1 of 1 Scale: NTS Date: 2-09-18



PLAN

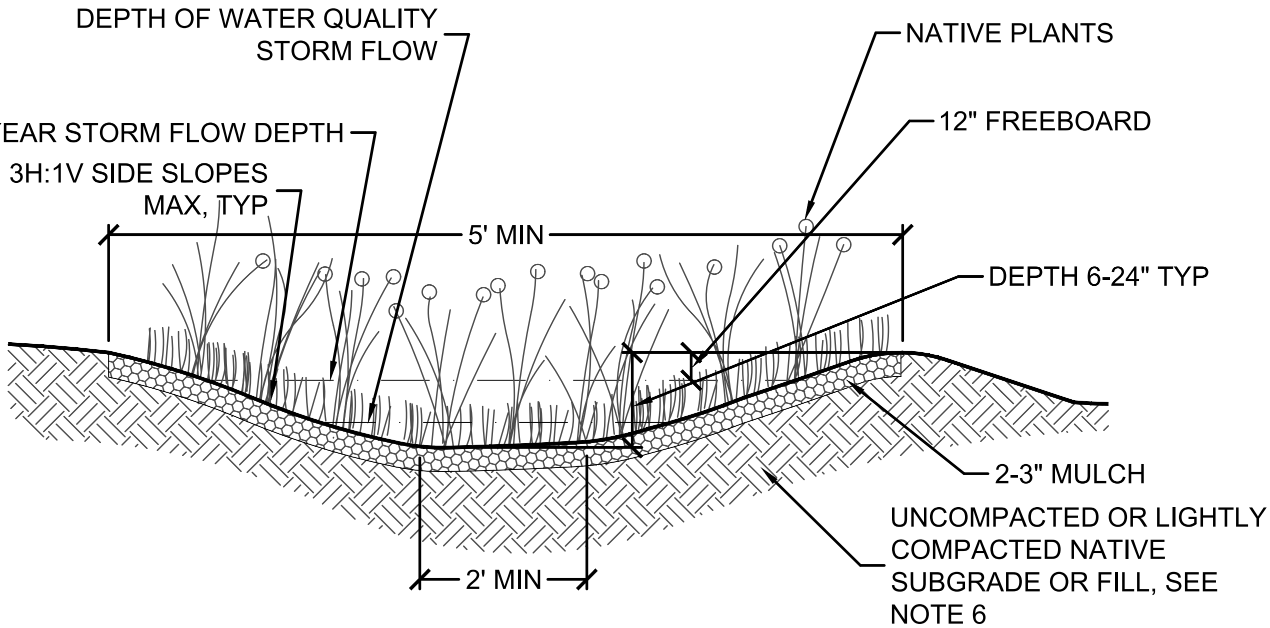


SECTION A-A'



SECTION B-B'

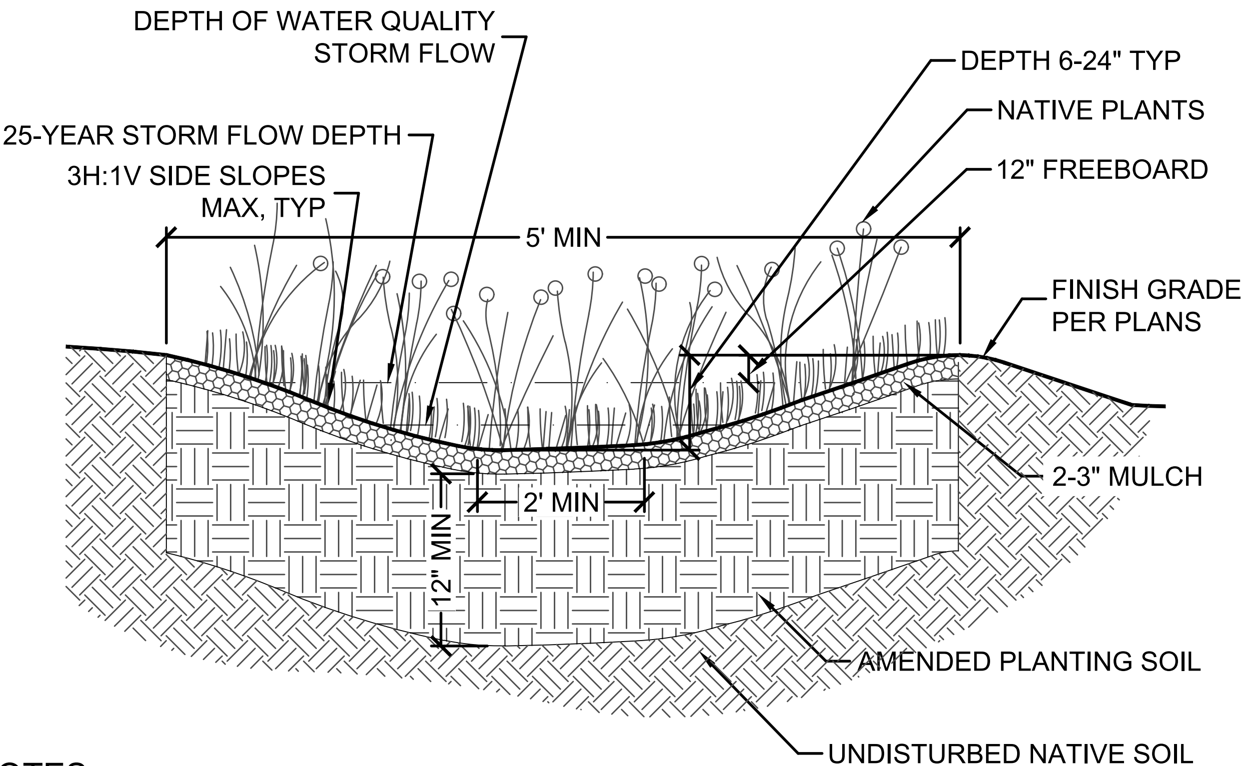
City of Grants Pass, Oregon Stormwater Management Typical Details	Inlet Pretreatment & Energy Dissipater	BMP 8.04 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. PLANT PER RECOMMENDED PLANTING PLAN IN DETAIL BMP 9.05. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY AND HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. TO ENSURE IDEAL CONDITIONS FOR PLANT ESTABLISHMENT, PLANTING AREAS (THE AREA OF THE SWALE AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF PRIOR TO BEGINNING EARTH MOVING THROUGH PROJECT COMPLETION TO PREVENT COMPACTION OF THE SURFACE OR SUBGRADE. LIGHT COMPACTION WITH BOOT OR WATER COMPACTION OR LIGHT TAMPING IS ACCEPTABLE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. SEE DETAIL BMP 3.07 FOR DESIGN AND CONSTRUCTION OF SWALE END.
6. REFER TO APPENDIX C FOR MORE INFORMATION ON MATERIALS SPECIFICATIONS AND CONSIDERATIONS DURING CONSTRUCTION.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Water Quality Conveyance Swale	BMP 9.01 1 of 1 Scale: NTS Date: 2-09-18



NOTES

1. PLANT PER PLANTING PLAN AND STANDARD DETAIL BMP 9.05. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY AND HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT DAMAGE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. TO ENSURE IDEAL CONDITIONS FOR PLANT ESTABLISHMENT, PLANTING AREAS (THE AREA OF THE SWALE AS DEFINED BY THE TOP ELEVATION OF THE FACILITY) SHALL BE FENCED OFF FROM THE FIRST DAY OF EARTH MOVING UNTIL PROJECT COMPLETION TO PREVENT COMPACTION OF THE SURFACE OR SUBGRADE. LIGHT COMPACTION WITH BOOT OR WATER COMPACTION OR LIGHT TAMPING IS ACCEPTABLE.
4. IF THE NATIVE SOIL HAS BEEN EXPOSED TO RAINFALL, HAND RAKE THE SURFACE TO A DEPTH OF 3" TO RESTORE INFILTRATION CAPACITY.
5. SEE DETAIL BMP 3.07 FOR DESIGN AND CONSTRUCTION OF SWALE END.
6. SEE APPENDIX C FOR SPECIFICATIONS ON COMPOST AND MULCH.

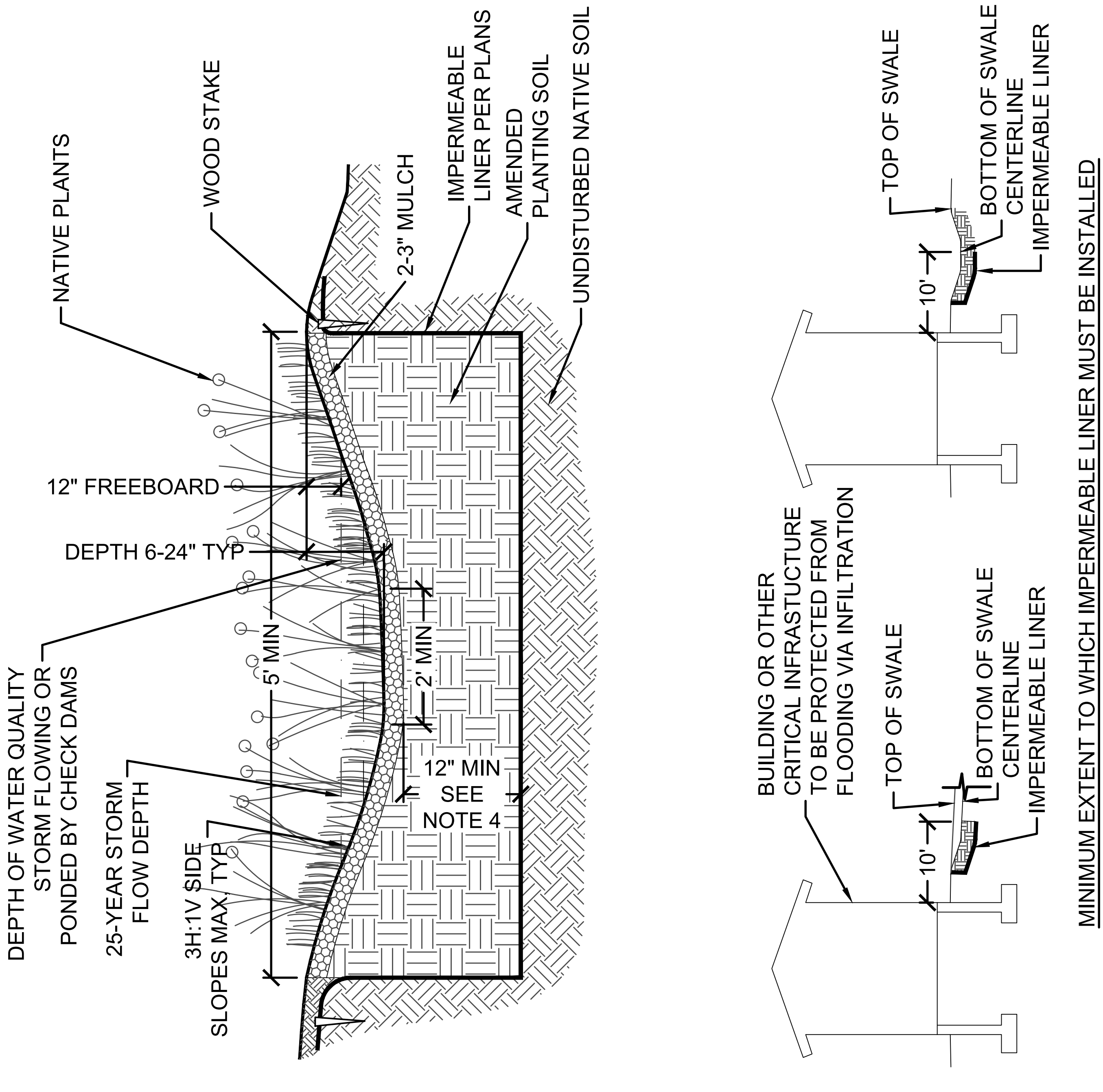
Grants Pass LIVE ROGUE	City of Grants Pass, Oregon Stormwater Management Typical Details	Water Quality Conveyance Swale with Amended Planting Soil	BMP 9.02 1 of 2 Scale: NTS Date: 2-09-18

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.



THIS DETAIL MAY BE USED FOR PARTIALLY LINED FACILITIES THAT MAY INFILTRATE OUT THE END OR SIDE. INDICATE EXTENT OF LINER CLEARLY ON PLANS. REFER TO DETAIL BMP 3.07 FOR CONSTRUCTION OF SWALE END.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Partially Lined Water Quality Conveyance Swale	BMP 9.03 1 of 3 Scale: NTS Date: 2-09-18

NOTES

1. PLANT PER RECOMMENDED PLANTING PLAN IN DETAIL BMP 9.05. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY & HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT IMPACT THE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. DEPTH OF SOIL VARIES WITH PROPOSED VEGETATION TYPE:
    - GRASSES 12"
    - SMALL SHRUBS 18"
    - LARGE SHRUBS 24"
    - TREES 36"

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
    a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
    b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
    c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
    d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
    e. 2-5% CLAYEY FINES CONTENT
    f. pH BETWEEN 5.5 AND 7.5
    g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

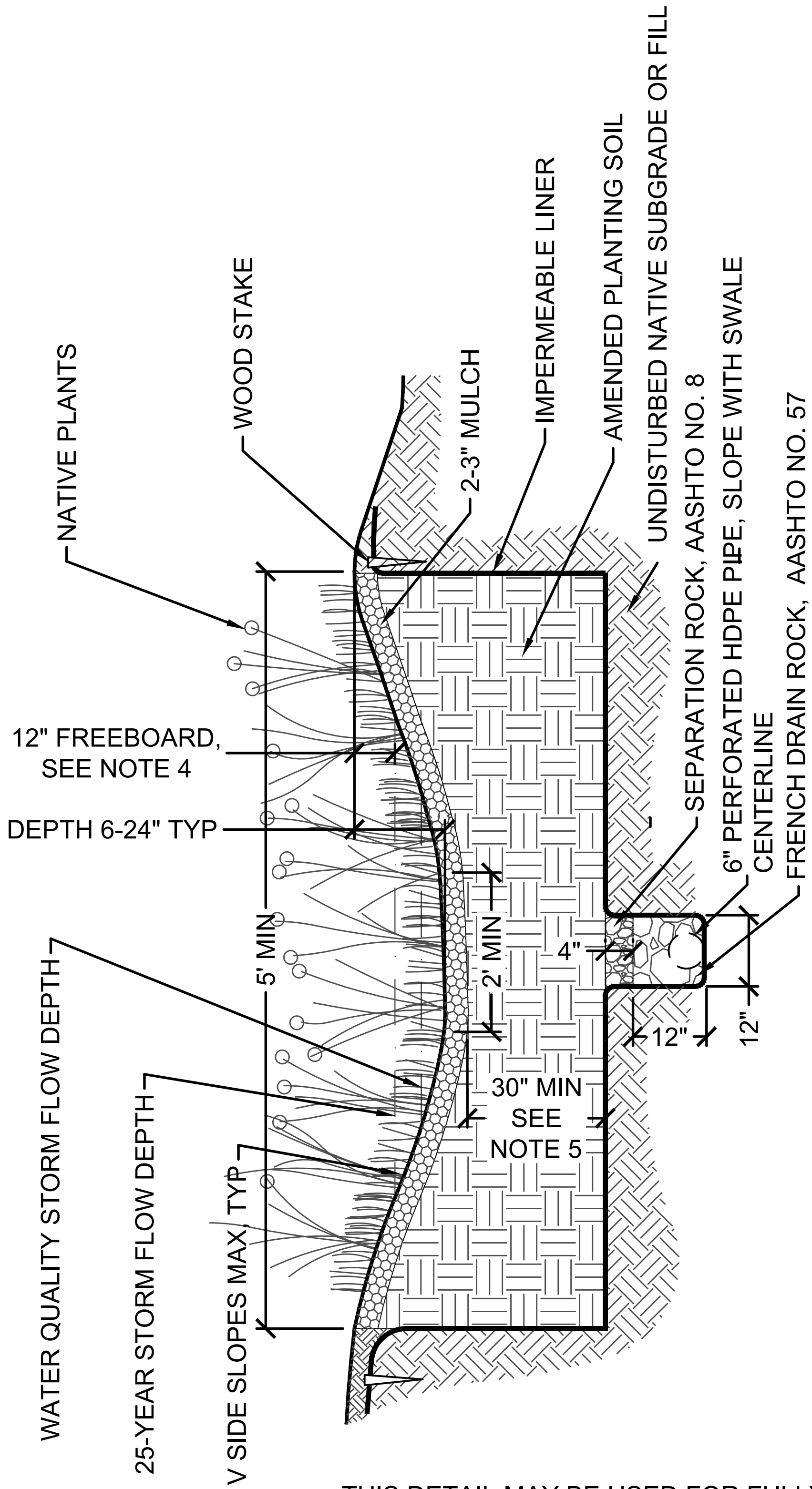
US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
    a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
    b. DO NOT PLACE SOILS IF SATURATED.
    c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

IMPERMEABLE LINER SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. IMPERMEABLE LINERS MAY BE A 45-MILLIMETER (MINIMUM) LOW DENSITY POLYETHYLENE (LDPE), 45-MILLIMETER (MINIMUM) ETHYLENE PROPYLENE DIENE MONOMER (EPDM) OR BENTONITE CLAY MAT PER MANUFACTURER GUIDANCE.
2. PLACEMENT. INSTALL THE LINER SECURELY AT A HEIGHT EQUAL TO THE DEPTH OF WATER THAT MAY BE PONDED OR FLOWING DURING ANY STORM, NOT JUST THE DESIGN STORM. IF AN OUTLET STRUCTURE IS PRESENT, ATTACH THE LINER TO THE OUTLET STRUCTURE WITH ADHESIVE OR MECHANICAL METHOD PER MANUFACTURER'S GUIDELINES.

   IF AN LDPE OR EPDM LINER WILL BE USED, USE A SINGLE, SOLID PIECE BIG ENOUGH TO BE INSTALLED AS SHOWN ON PLANS AND DIRECTED ABOVE SO THAT PIECES ARE GLUED OR OTHERWISE WATERPROOFED TOGETHER PER MANUFACTURER GUIDELINES. OVERLAPPING SHEETS WILL NOT ADEQUATELY PREVENT INFILTRATION, IF THIS IS THE INTENT OF THE DESIGN. IF THE DESIGN CALLS FOR A BENTONITE CLAY MAT, FOLLOW THE MANUFACTURER'S GUIDANCE FOR INSTALLATION.



THIS DETAIL MAY BE USED FOR FULLY LINED FACILITIES ONLY IN WATERSHEDS NOT LIMITED FOR NUTRIENTS. SEE DETAIL BMP 3.02 FOR DESIGN AND CONSTRUCTION GUIDANCE FOR SWALE END.

Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Fully Lined Water Quality Conveyance Swale	BMP 9.04 1 of 3 Scale: NTS Date: 2-09-18

NOTES

1. PLANT PER RECOMMENDED PLANTING PLAN IN DETAIL BMP 9.05. NATIVE PLANTS ARE PREFERRED, BECAUSE NON-NATIVE AND INVASIVE SPECIES CAN REPRODUCE DOWNSTREAM AND DAMAGE HYDROLOGY & HABITAT. IF NON-NATIVES ARE CHOSEN, BE SURE THAT THEY WILL NOT IMPACT THE DOWNSTREAM WATERWAYS.
2. BUILD AND VEGETATE SWALE AS EARLY AS POSSIBLE TO ESTABLISH PLANTINGS BEFORE DIRECTING STORMWATER RUNOFF TO IT OR DIVERT STORMWATER AROUND FACILITY. PREFERABLY, THIS PERIOD WOULD LAST A MINIMUM OF 3 MONTHS OR PER LANDSCAPE ARCHITECT/DESIGNER GUIDELINES.
3. FREEBOARD IS REQUIRED UNLESS A HIGH FLOW BYPASS IS INCORPORATED THAT WILL ROUTE STORMS GREATER THAN THE WATER QUALITY DESIGN STORM AROUND THE FACILITY.
4. DEPTH OF SOIL IS 30 INCHES MINIMUM TO REDUCE PHOSPHORUS EXPORT FROM UNDERDRAIN. INCREASE DEPTH OF SOIL TO 36" IF INCORPORATING TREES OVER LINER.
5. PROVIDE CLEANOUT AT TOP OF PIPE IN FRENCH DRAIN.

AMENDED PLANTING SOIL MIX SPECIFICATIONS

1. AMENDED PLANTING SOIL MAY BE EITHER AMENDED NATIVE OR IMPORTED SOIL MIX WITH THE FOLLOWING CHARACTERISTICS:
   a. INFILTRATE BETWEEN 0.5 AND 12 INCHES/HOUR.
   b. BE FREE OF WEED SEEDS, CONTAMINANTS, AND HAZARDOUS MATERIALS.
   c. ORGANIC CONTENT MATTER FROM 8-10% BY WEIGHT
   d. CATION EXCHANGE CAPACITY (CEC) GREATER THAN OR EQUAL TO 5 MILLIEQUIVALENTS/100 GRAMS OF DRY SOIL
   e. 2-5% CLAYEY FINES CONTENT
   f. pH BETWEEN 5.5 AND 7.5
   g. CONFORM TO THE FOLLOWING GRADATION FOR THE MIX:

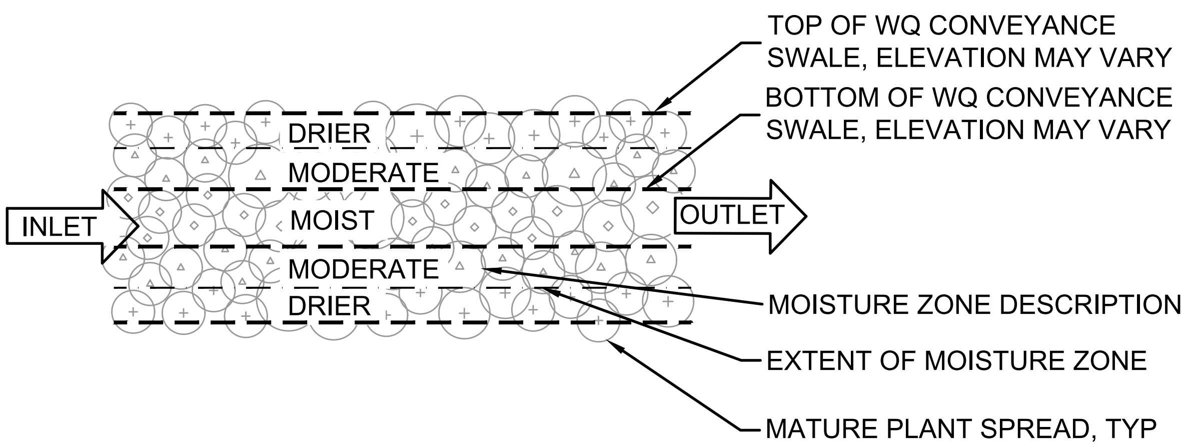
US STANDARD SIEVE SIZE	PERCENT PASSING
$\frac{3}{8}$"	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

2. IMPORTED SOIL MIX SHALL BE COMPOSED OF 60% LOAMY SAND & 40% ORGANIC MATTER COMPOST.
3. AMENDED NATIVE PLANTING SOIL MIX MAY BE CREATED BY BLENDING COMPOST INTO THE NATIVE SOIL AT A RATE OF 1 (COMPOST):2 (SOIL). SOIL MIX MUST STILL MEET THE SPECIFICATIONS IN NOTE 1, a AND b ABOVE.
4. AMENDED NATIVE OR IMPORTED SOIL MIX SHOULD BE UNIFORMLY MIXED.
5. PLACEMENT OF AMENDED NATIVE OR IMPORTED SOIL MIX SHALL OCCUR AS FOLLOWS:
   a. PLACE SOIL IN 8" MAXIMUM LIFTS (I.E. DEPTHS).
   b. DO NOT PLACE SOILS IF SATURATED.
   c. COMPACT EACH LIFT WITH LIGHT TAMPING OR BOOT PACKING TO ACHIEVE 85% COMPACTION. DO NOT COMPACT WITH HEAVY MACHINERY OR VIBRATORY COMPACTION.

IMPERMEABLE LINER SPECIFICATIONS

1. MATERIAL SPECIFICATIONS. IMPERMEABLE LINERS MAY BE A 45-MILLIMETER (MINIMUM) LOW DENSITY POLYETHYLENE (LDPE), 45-MILLIMETER (MINIMUM) ETHYLENE PROPYLENE DIENE MONOMER (EPDM) OR BENTONITE CLAY MAT PER MANUFACTURER GUIDANCE.
2. PLACEMENT. INSTALL THE LINER SECURELY AT A HEIGHT EQUAL TO THE DEPTH OF WATER THAT MAY BE PONDED OR FLOWING DURING ANY STORM, NOT JUST THE DESIGN STORM. IF AN OUTLET STRUCTURE IS PRESENT, ATTACH THE LINER TO THE OUTLET STRUCTURE WITH ADHESIVE OR MECHANICAL METHOD PER MANUFACTURER'S GUIDELINES.

   IF AN LDPE OR EPDM LINER WILL BE USED, USE A SINGLE, SOLID PIECE BIG ENOUGH TO BE INSTALLED AS SHOWN ON PLANS AND DIRECTED ABOVE SO THAT PIECES ARE GLUED OR OTHERWISE WATERPROOFED TOGETHER PER MANUFACTURER GUIDELINES. OVERLAPPING SHEETS WILL NOT ADEQUATELY PREVENT INFILTRATION, IF THIS IS THE INTENT OF THE DESIGN. IF THE DESIGN CALLS FOR A BENTONITE CLAY MAT, FOLLOW THE MANUFACTURER'S GUIDANCE FOR INSTALLATION.



LEGEND:

CONTOUR LINE

MOISTURE ZONE

PLANT SPECIES APPROPRIATE FOR MOISTURE ZONE:

DRIER

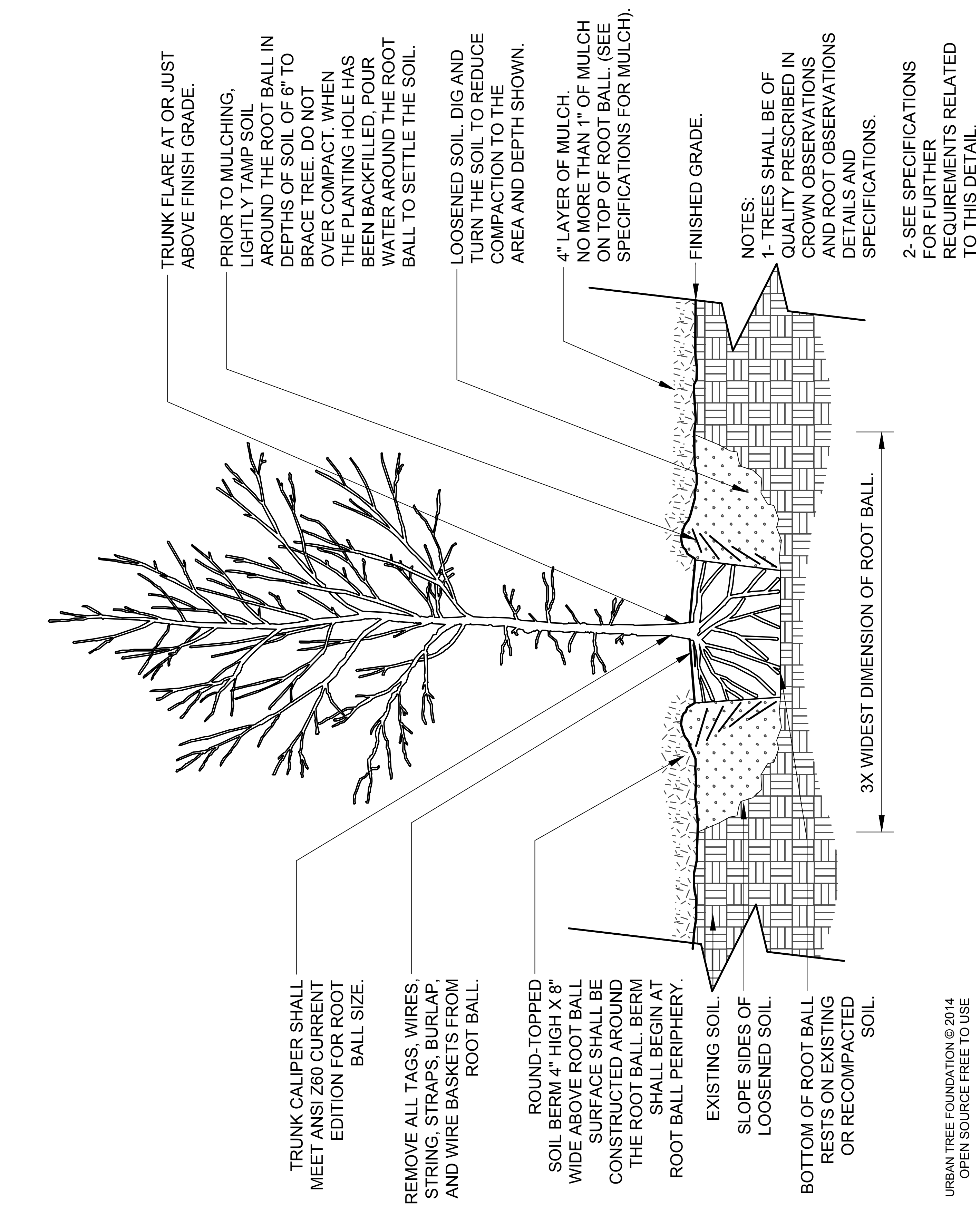
MODERATE

MOIST

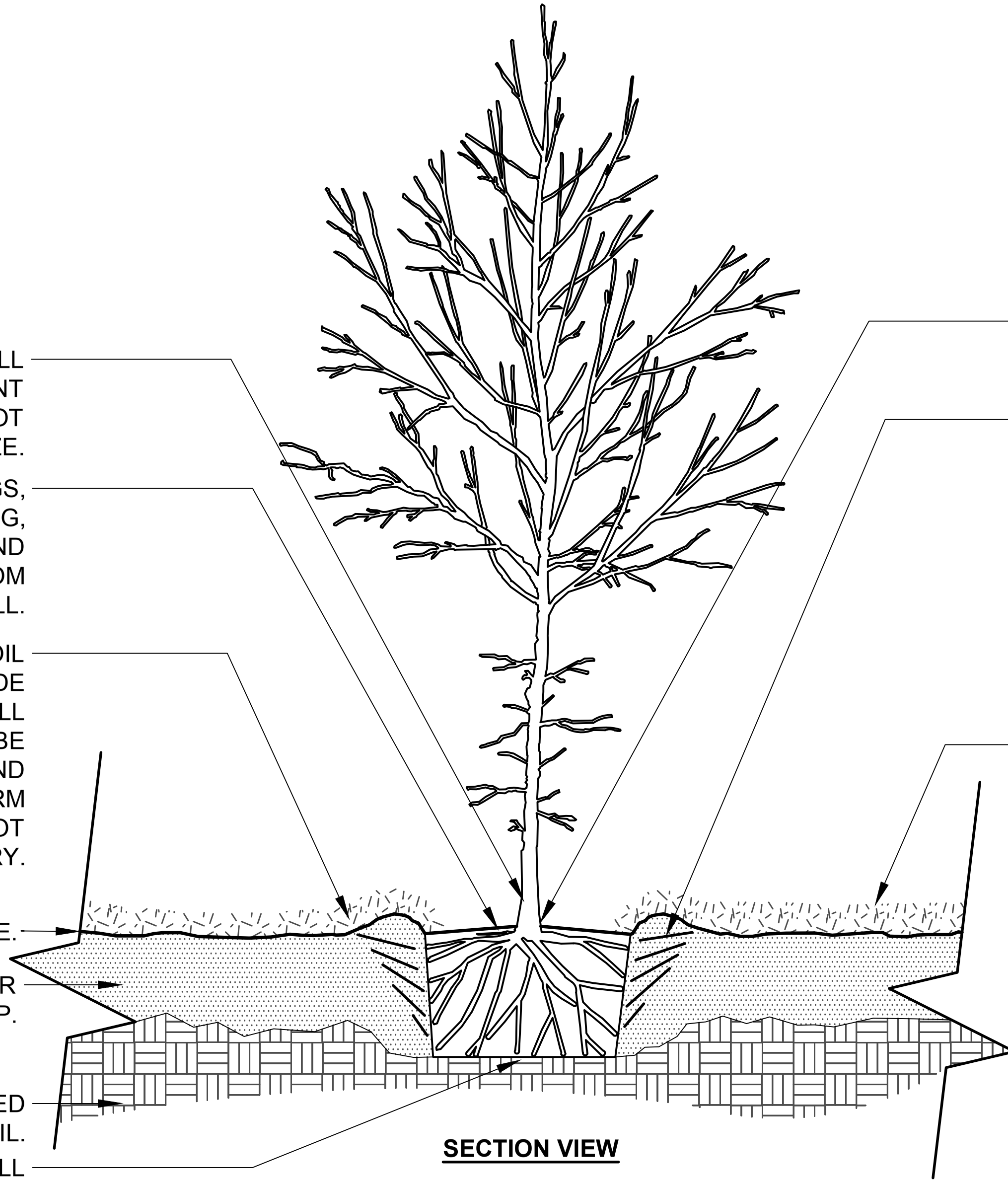
NOTES:

1. THIS DETAIL IS PROVIDED AS A SCHEMATIC EXAMPLE OF THE RANDOM PLANT PLACEMENT AND 95% COVERAGE AFTER ESTABLISHMENT PERIOD DESIRED TO REDUCE EROSION AND WEEDS.
2. INSTALL PLANTS PER PLANS, ACCORDING TO LANDSCAPE DESIGN PLANT TABLE , WHICH SHOULD INCLUDE PLANT SPECIES, SPACING, AND QUANTITIES IN EACH MOISTURE ZONE.
3. MOISTURE ZONES VARY FROM THOSE SHOWN DEPENDING ON GRADING PLAN, LOCATION OF INLET (S) AND OUTLET(S) AND FACILITY SHAPE.

Grants Pass LIVE ROGUE Oregon	City of Grants Pass, Oregon Stormwater Management Typical Details	Water Quality Conveyance Swale Planting Schematic	BMP 9.05 1 of 1 Scale: NTS Date: 2-09-18



City of Grants Pass, Oregon Stormwater Management Typical Details	Tree with Berm	BMP 10.01 1 of 1 Scale: NTS Date: 2-09-18



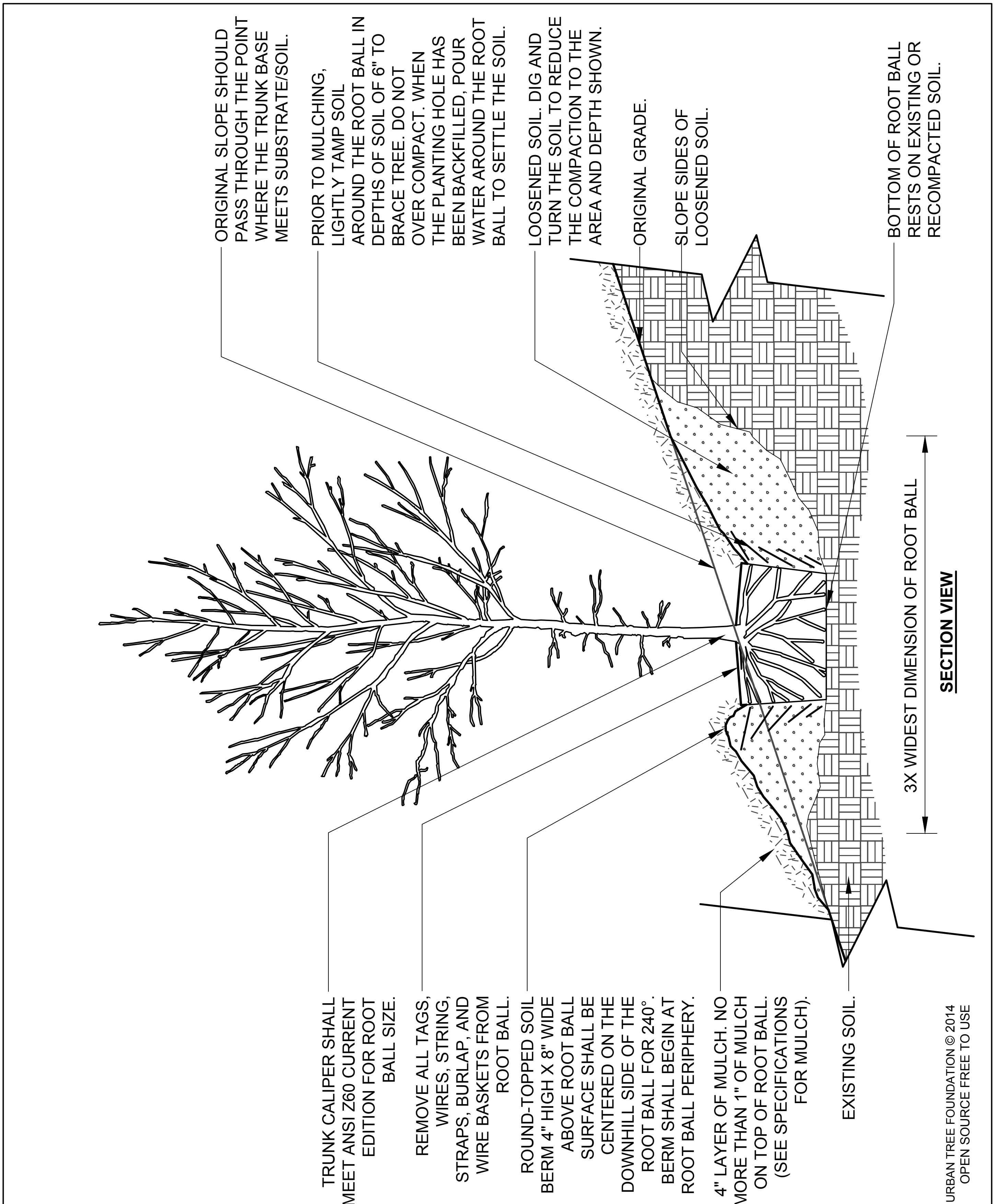
NOTES:
1- TREES SHALL BE OF QUALITY PRESCRIBED IN CROWN OBSERVATIONS AND ROOT OBSERVATIONS DETAILS AND SPECIFICATIONS.

2- SEE SPECIFICATIONS FOR FURTHER REQUIREMENTS RELATED TO THIS DETAIL.

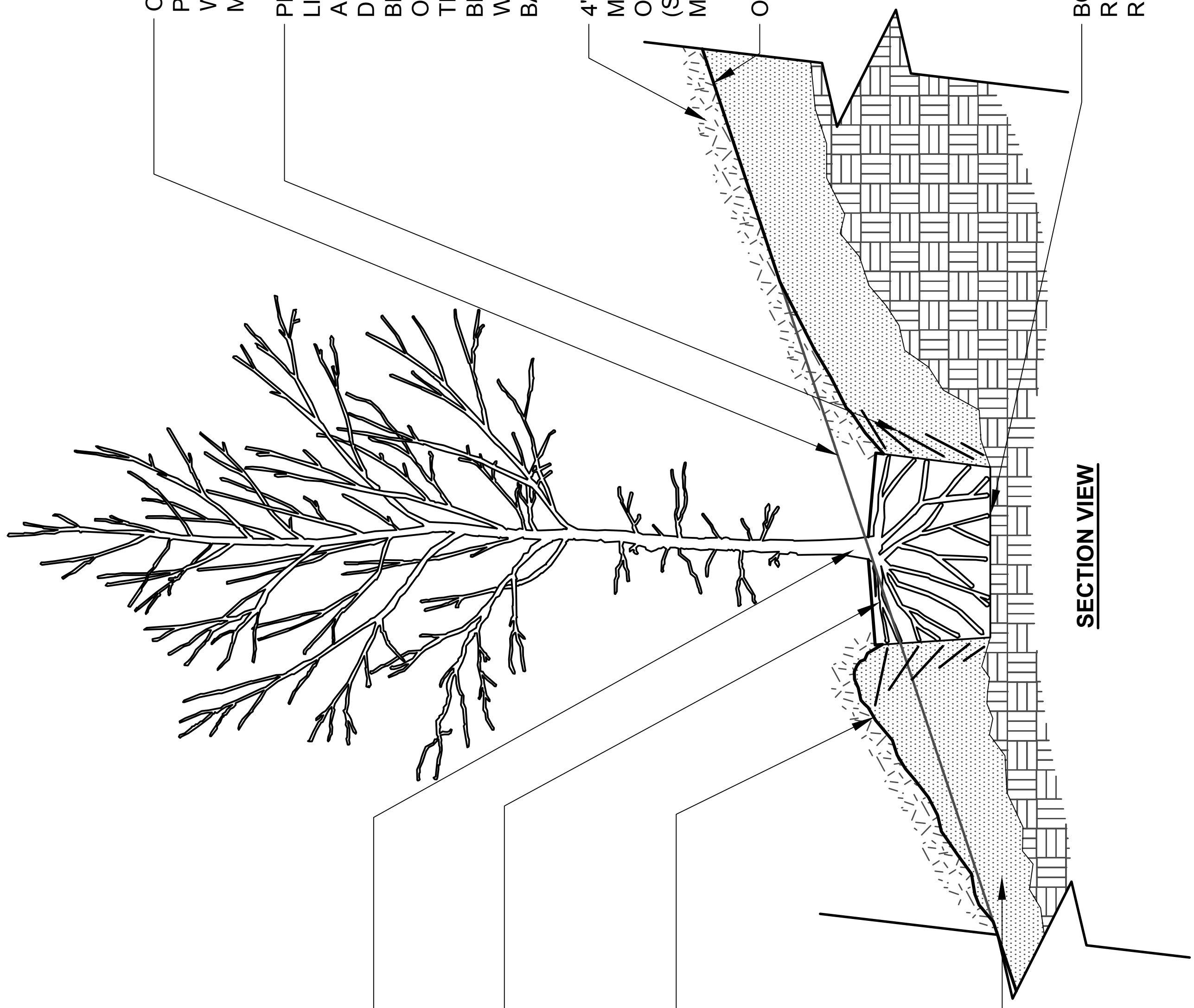
City of Grants Pass, Oregon
Stormwater Management
Typical Details

Tree with Berm (Existing Soil Restored)

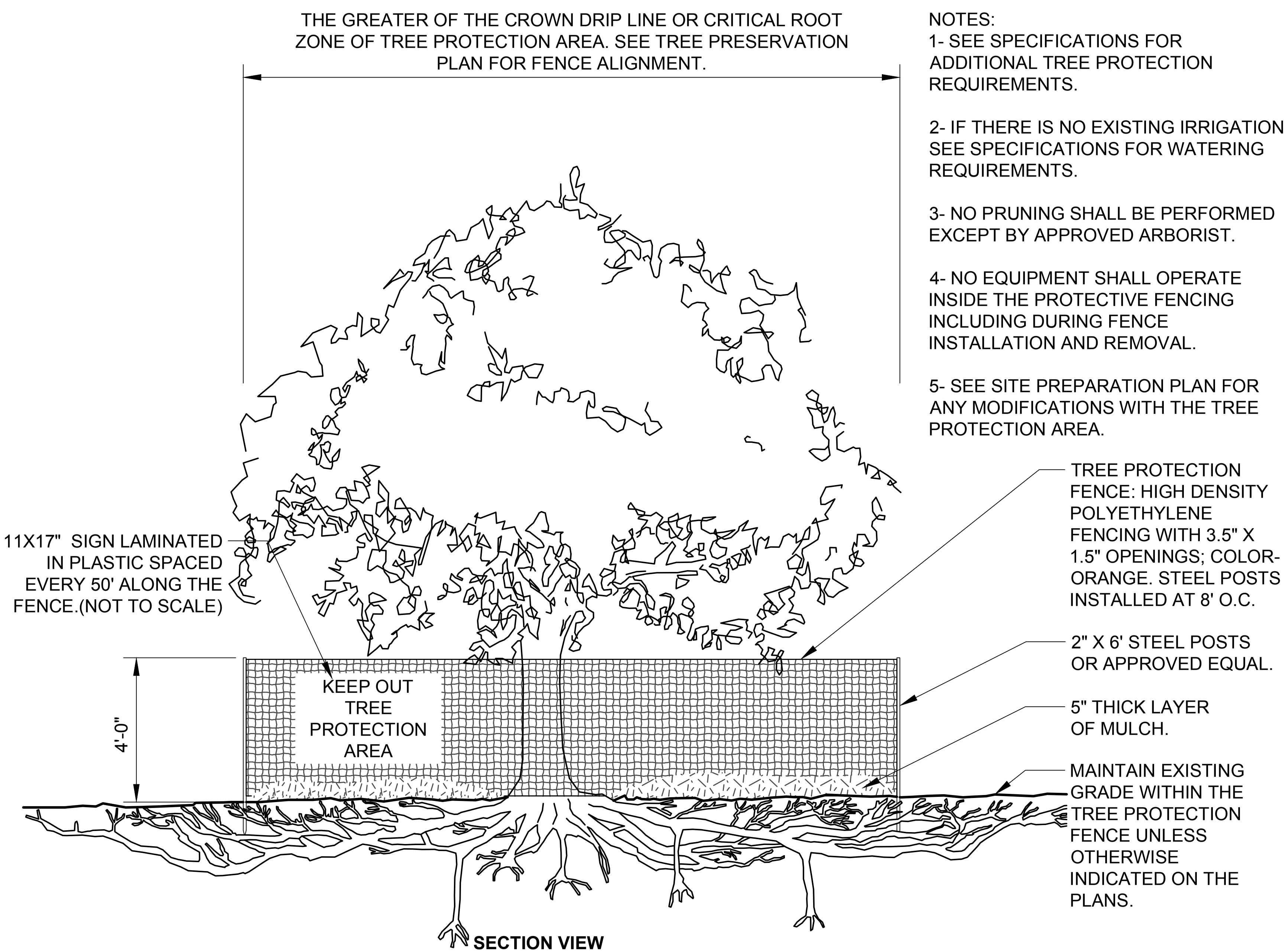
BMP 10.02
1 of 1
Scale: NTS
Date: 2-09-18



City of Grants Pass, Oregon Stormwater Management Typical Details	Tree on Slope 5% (20:1) to 50% (2:1)	BMP 10.03 1 of 1 Scale: NTS Date: 2-09-18



Grants Pass	City of Grants Pass, Oregon Stormwater Management Typical Details	Tree on Slope 5% (20:1) to 50% (2:1) (Existing Soils Restored)	BMP 10.04 1 of 1 Scale: NTS Date: 2-09-18



NOTES:

1- SEE SPECIFICATIONS FOR ADDITIONAL TREE PROTECTION REQUIREMENTS.

2- IF THERE IS NO EXISTING IRRIGATION, SEE SPECIFICATIONS FOR WATERING REQUIREMENTS.

3- NO PRUNING SHALL BE PERFORMED EXCEPT BY APPROVED ARBORIST.

4- NO EQUIPMENT SHALL OPERATE INSIDE THE PROTECTIVE FENCING INCLUDING DURING FENCE INSTALLATION AND REMOVAL.

5- SEE SITE PREPARATION PLAN FOR ANY MODIFICATIONS WITH THE TREE PROTECTION AREA.

City of Grants Pass, Oregon
Stormwater Management
Typical Details

Tree Protection

BMP 11.01
1 of 1
Scale: NTS
Date: 2-09-18

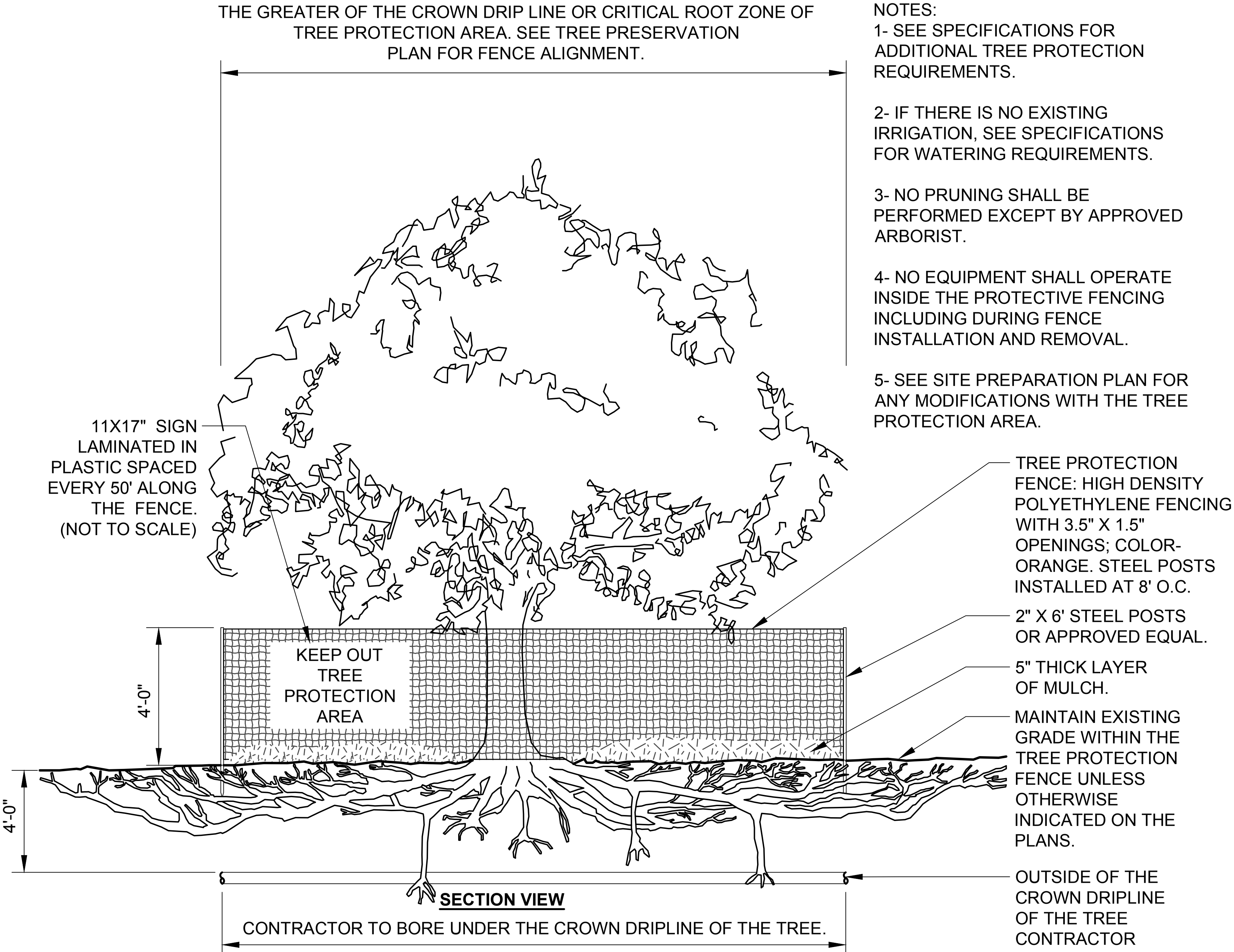
NOTES:
1- SEE SPECIFICATIONS FOR ADDITIONAL TREE PROTECTION REQUIREMENTS.

2- IF THERE IS NO EXISTING IRRIGATION, SEE SPECIFICATIONS FOR WATERING REQUIREMENTS.

3- NO PRUNING SHALL BE PERFORMED EXCEPT BY APPROVED ARBORIST.

4- NO EQUIPMENT SHALL OPERATE INSIDE THE PROTECTIVE FENCING INCLUDING DURING FENCE INSTALLATION AND REMOVAL.

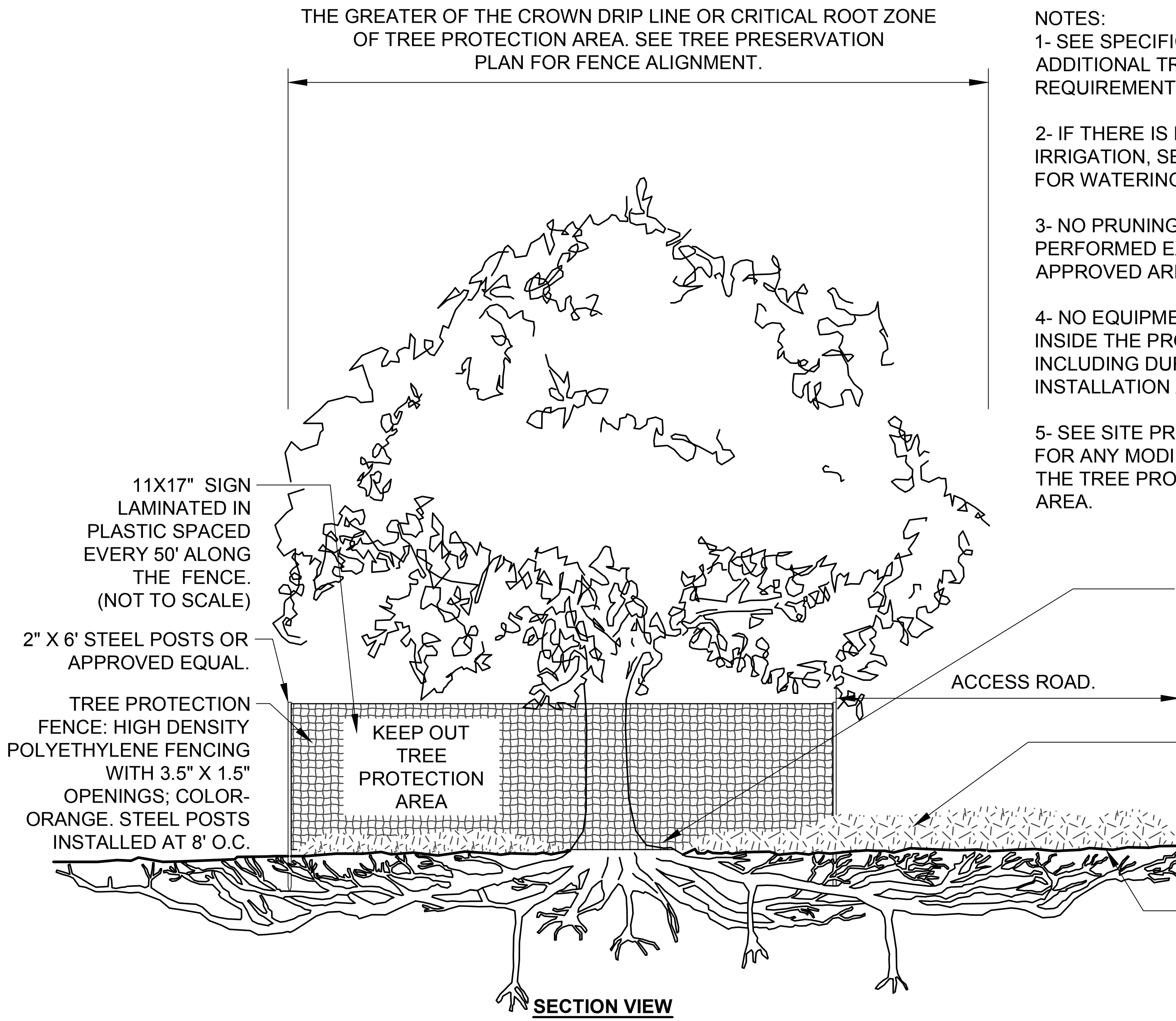
5- SEE SITE PREPARATION PLAN FOR ANY MODIFICATIONS WITH THE TREE PROTECTION AREA.



City of Grants Pass, Oregon
Stormwater Management
Typical Details

Tree Protection - Boring Under Dripline

BMP 11.02
1 of 1
Scale: NTS
Date: 2-09-18



NOTES:

1- SEE SPECIFICATIONS FOR ADDITIONAL TREE PROTECTION REQUIREMENTS.

2- IF THERE IS NO EXISTING IRRIGATION, SEE SPECIFICATIONS FOR WATERING REQUIREMENTS.

3- NO PRUNING SHALL BE PERFORMED EXCEPT BY APPROVED ARBORIST.

4- NO EQUIPMENT SHALL OPERATE INSIDE THE PROTECTIVE FENCING INCLUDING DURING FENCE INSTALLATION AND REMOVAL.

5- SEE SITE PREPARATION PLAN FOR ANY MODIFICATIONS WITH THE TREE PROTECTION AREA.

City of Grants Pass, Oregon
Stormwater Management
Typical Details

Tree Protection - Temporary Access Road

BMP 11.03
1 of 1
Scale: NTS
Date: 2-09-18

APPENDIX G: BMP SUITABILITY MATRIX

BMP SUITABILITY MATRIX

Effectiveness level ***

- H Very Effective
- M Moderately Effective
- L Supports Function
- Not Applicable

Suitability level****

- 3 Well Suited to Condition
- 2 Moderately Suited to Condition
- 1 Less Suited to Condition
- Not Applicable

	Water Quality		Water Quantity			Site Conditions						Drainage Area				Land Use						Land Ownership		Development Type		
	On-site	Downstream	Flow Control	Evaporation	Aquifer Recharge	Steep Slopes	High Groundwater	Shallow Bedrock	Slow Draining Soils	Expansive Clay Soils	Contaminated Soils	Rooftops	Roadways	Sidewalks	Landscapes	Single-family Residential Lot	Subdivisions & Campuses of any land use	Commercial	Institutional	Roads and Public Right-of-Way	Industrial	Private	Public	Retrofit	Redevelopment	New Development
Prevent Runoff: Minimize Impervious Area BMPs																										
Share Parking Spaces BMP	M	H	L	M	L	3	3	3	3	3	3		3				2	3	2		1	2	2	2	2	3
Minimize Front Setbacks BMP	M	H	L	M	L	3	3	3	3	3	3		3	3		3	2		2			3	2		1	3
Prevent Runoff: Limit Disturbance BMPs																										
Construction Sequencing BMP	H	H	L	L	L	3	3	3	3	3	3					3	3	3	3	3	3	3	3	3	3	3
Conserve Fast(er) Draining Soils	M	H	L	M	L	3	3	3	3	3	3				3	3	3	3	3	1	3	3	3	3	3	3
Cluster Development BMP	H	H	L	H	L	3	3	3	3	3	3	3	3	3	3		3	2	2		2	3	3		1	2
Tree Protection BMP	H	H	L	M	L	3	3	3	3	3	3	2	3	3	3		3	2	2	3	2	3	3	3	2	2
Minimal Foundation BMP	L	M	H		L	3	3	3	3	3	3	3				3	2	3	3		3	3	3		1	3
Prevent Runoff from Landscape and Hardscape Areas																										
Restored Soils BMP	H	H	L	M	M	3	3	3	3	3					3	3	3	3	3	3	2	3	3	3	3	3
Tree Planting BMP	M	H	M	M	M	3	3	3	3	3	3	1	2	2	3	2	3	1	2	2	2	3	3	3	3	3
Depave Existing Pavement BMP	M	H	M	M	M	3	3	3	3	3	3		2	2		2	3	2	3	2	2	3	3	3	3	2
Contained Planter(s) BMP	M	M	L	H		3	3	3	3	3	3	2	3	3		3	3	3	3	2	2	3	3	3	3	2
Vegetated Roofs (Green Roofs) BMP	M	M	M	H		3	3	3	3	3	3	3				2	2	3	2		3	2	3	1	2	3
Porous Pavement (Rainfall) BMP	H	H	H		H		1	1	3				3	3		2	2	3	3	2	2	2	3	1	1	3
Reduce Runoff from Landscape and Hardscape Areas																										
Porous Pavement (Runoff) BMP	H	H	H		H		1	1	3			3	2	2		2	3	3	3	3	3	2	3	1	1	3
Infiltration Rain Garden, LID Swale, or Stormwater Planter BMP	H	H	H	M	H				2	3		3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
Soakage Trench BMP*	H	H	H		H		1	1	2			3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Drywell BMP**	H	H	H		H		1	3		2		3	2	2	1	3	3	3	3	3	3	3	3	3	3	3
WQ Conveyance Swale BMP	M	L	L	L	L	3	3	3	3	3		3	3	3	3	1	3	3	3	3	3	3	3	3	3	3
Dispersion: Vegetated Filter Strips BMP	M	L	L	L	L		1	1	3	3		1	3	3	3	3	3	2	3	3	2	3	3	3	3	3
Dispersion: Downspout Disconnection BMP	M	L	L	L	L		1	1	3	3		3				3	3	2	3		2	3	3	3	3	3
Provide Minimal Water Quality Treatment of Runoff from Landscape & Hardscape Areas:																										
Lined Rain Garden, LID Swale, or Stormwater Planter BMP	H	L	L	M		3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3
Wet, Extended Wet, and Dry Detention Ponds																										
Wet Pond	L	L	H	M	L	1	3	3	3	3		2	3	3	3		3	3	3	2	3	3	3	3	3	3
Extended Wet Pond	M	M	H	M	L	1	3	3	3	3		2	3	3	3		3	3	3	2	3	3	3	3	3	3
Dry Detention Pond*****	L	L	H	L	L	3	3	3	3	3		2	3	3	3		3	3	3	2	3	3	3	3	3	3

Use the LID Implementation Form to apply BMPs in the preferred order (i.e. stormwater hierarchy). Brief descriptions of column headings are as follows (see Chapter 4 for additional information):

Water Quality. Indicates which BMPs address water quality on-site and which substantially reduce runoff volume to protect against erosion and subsequent re-pollution of downstream waterways.
Drainage Area. Indicates which BMPs can be applied to which surfaces.
Challenging Sites. Indicates which BMPs are feasible at sites where infiltration of runoff is not recommended.
Flow Control. Indicates which BMPs serve as a substitute for a detention basin (i.e. are effective for flood control).
Land Use. Indicates the land uses/zoning classifications where LID can and has been implemented in Oregon.
Ownership. Indicates which BMPs may be used in private development or public development.
Development Type. Indicates which BMPs may be used in a retrofit, redevelopment or new development.

*Soakage trenches under pavement are not suitable for expansive soils, but are well suited under landscape areas with expansive soils.
** With adaptations, drywells may sometimes be used below contaminated soils. See Chapter 4 "*Drywells BMP*".
*** Effectiveness level assumes the BMP is acting as a stand alone BMP under average conditions. When BMPs are used in a conjunction with others (e.g. any "*Minimize Impervious Area BMPs*" are combined with "*Restored Soils BMP*") their effectiveness tends to increase.
****Suitability level accounts for general difficulty in implementing or use by stakeholders under average conditions.
*****Water quality can be addressed when modified to have a vegetated swale.

Table G-1. Use the BMP Suitability Matrix to identify potential BMPs in early planning. Consider printing this table out for easy reference when planning projects, and revisit it as the site plan changes.