











Stormwater Solutions Handbook



Sam Adams, Commissioner Dean Marriott, Director

#### Acknowledgements

This document was prepared for the City of Portland Environmental Services.

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More information on City of Portland stormwater projects is available online www.cleanriverspdx.org

#### For a CD of

stormwater materials or for information or to register for the Clean River Rewards program visit www.CleanRiverRewards.com or call 503-823-1371

Graphic Design Leslie Winter-Gorsline WS 0603 Printed on 100% recycled paper.

# Stormwater Solutions Handbook

ortland receives about 37 inches of rain a year. When it rains, stormwater runoff that isn't managed properly washes over streets, roofs, parking lots and other hard surfaces and carries dirt, oil, metals and chemicals into our rivers and streams. How we manage runoff impacts our streams, our built environment and our pocketbooks. Up to 95% of Portland's rain falls in small, frequent storms. Runoff from small storms can easily be managed at most sites by integrating stormwater with site and building design. Managing stormwater at its source with natural systems reduces the need to build storm sewers.

As Portland grows, the City works to accommodate growth and commerce while maintaining clean rivers and streams, air quality and livability. Urban practices and the growing amount of paved areas, roof tops and other impervious surfaces pollute rivers and streams, increase flooding, and degrade fish and wildlife habitat. Loss of vegetation increases air and water temperatures. The solution is to develop in a way that restores the function and value of trees, soil and open space in our communities. If we develop today with long-term sustainability in mind, future generations can enjoy a vibrant city and clean and healthy rivers, instead of bearing the burden of our actions.

The following stormwater solutions are for anyone interested in managing stormwater onsite, planning or designing new construction projects or making changes to existing development. Whether you are repaving a driveway or adding a garage to your home, planning an apartment complex or town center, redeveloping a warehouse, or building a public road, these stormwater management techniques will help meet the City's objectives for stormwater management, clean water, and healthy habitat for people, fish and wildlife.

This handbook is divided into three sections:

- 1. When It Falls On The Roof
- 2. When It Gets To The Ground
- 3. Taking It Underground

Depending on your location, the site conditions, type of buildings on your site, and the complexity and expense of the stormwater management system, examples from one or all sections of this guide may be useful. This handbook is not intended as a comprehensive or technical guide to the design of stormwater management systems, but it is a starting point to give a context for consideration of different stormwater solutions. New innovations and improvements occur all the time. For more technical and detailed information, refer to the Stormwater Management Manual or consult with a professional. The Stormwater Management Manual is available at portlandonline.com/bes.

# Table of contents



When it gets to the ground	1
Trees	2
Contained planters2	4
Vegetated swales	6
Vegetated infiltration basins2	8
Flow-through planters	0
Infiltration planters	2
Pervious pavers	4
Pervious pavement	6
Turf blocks	8

Taking it underground	 1
Drywells	 2
Soakage Trenches	 4

<b>Planting Choices</b> .		÷			÷	• •	÷			 ÷	• •	.47
Landscaping Examples				•								.48

For more information		1
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# Introduction

### Why Sustainable Stormwater Management Matters

B efore Portland was developed, forests and open spaces absorbed rainwater. Today, rain falls on buildings, streets, sidewalks, and other hard surfaces and runs off into rivers and streams. Stormwater runoff causes erosion, carries pollution and sediment to the river, decreases groundwater recharge, and increases river temperatures. Sustainable stormwater management is a strategy that helps the City of Portland comply with pollution prevention and resource protection regulations by managing water at its source.

Sustainable stormwater management is rapidly gaining acceptance in the United States, particularly here in Portland. The increased interest is a response to mounting infrastructure costs of new development and redevelopment projects, more rigorous environmental regulations, and concerns about the impact of growth on natural resources.

The strategy recognizes the relationship between the natural environment and the built environment, and manages them as integrated components of a watershed. Sustainable stormwater management is an alternative to the traditional piped approach. It promotes onsite collection and conveyance of stormwater from roofs, parking lots, streets, and other surfaces to infiltrate into the ground or collect for reuse, often reducing the need for costly underground structures.

The approach relies on vegetated natural systems to slow and filter the water. Vegetation enhances both interception and evaporation of rainfall through its leaves. Vegetation reduces stormwater runoff volume as well as pollutants in urban runoff.

Studies show that natural landscaping at a residential development can reduce annual stormwater runoff volume by as much as 65%. Natural drainage and native landscaping areas in residential developments can remove up to 80% of the suspended solids and heavy metals, and up to 70% of nutrients like phosphorous and nitrogen from stormwater runoff.

Sustainable stormwater management uses both structural devices such as rain barrels, cisterns, and planters, and non-structural devices like landscaped swales and infiltration basins. The sustainable approach is cost effective and attractive. It also addresses erosion, water pollution, combined sewer overflows and other stormwater runoff problems all at once.

The information presented shows how to use one or a combination of technologies to effectively manage stormwater onsite and reduce the impacts of development on water quality.

This information is not intended as a substitute for professional advice applicable to specific project circumstances. Design approaches are offered to facilitate understanding of the concepts and must be considered in terms of the project, site conditions, local building codes, water availability, and regional climate. Readers are urged to seek professional assistance before applying any of these techniques. The techniques and other information presented may not represent the latest, approved approaches of the City of Portland.

### residential and neighborhood facilities





Disconnected downspout

rainbarrels





ecoroof on garage

garden swale





driveway of pervious pavers

flagstone driveway





large trees

naturescaping

### **Commercial and industrial** facilities





Disconnected downspout

Disconnected downspout



roof garden



ecoroof





pervious paver parking lot

parking lot swales



sidewalk planter with trees



naturescaping

#### General factors that influence the selection of stormwater management facilities

This chart is a guide to typical site conditions, the benefits of specific approaches and how they may influence your selection of stormwater management facilities. It is a general guide, not a definitive analysis.



**Constraints** When selecting an appropriate facility, it is important to assess your site for soil type, slope, amount of space, and proximity to your foundation and your neighbor's property. For example, infiltration facilities do not perform well in soils that do not drain well (such as clay) or on sites that have steep slopes due to erosion concerns.

Space limitations	•	•	-	•	•		•	0	•	•		•	•	•	•	•	
Poorly-draining soils	0	•	•	•	•	•		0	•	•	0	0	0	0	0	0	
Steep slopes	0	•	0	•	•	•	0	0	0	•	0	0	0	0	0	0	

**Benefits** Some facilities are best for flow control (reducing total volume and/or velocity), other facilities are better for cleansing and filtering pollutants, some facilities do both, and some facilities achieve cooler air and water temperatures.

Air and water temperature reduction	•	0	0	•	•	•	•	•	•	•	•	0	0	0	•	•	
Water quality		0	0	•	•	0	•	•	0	•	•				0	0	
Flow control	•	•	•	•	•	0	•	•	0	•	•	0			•	•	
<ul> <li>Most appropriate</li> <li>Moderately appropriate</li> <li>O Least appropriate</li> </ul>																	



# when it falls on the roof

R ooftops account for about 20% of the surface area in the City of Portland. Rain on the roof drains through a pipe or downspout. Downspouts connected directly to the City's combined sewer system contribute to combined sewer overflows (CSOs). CSOs occur when stormwater runoff fills combined sewers to capacity and they overflow to the Willamette River. Stormwater that doesn't overflow goes to the City's sewage treatment plant. Sending relatively clean roof runoff into the sewer system also adds unnecessary treatment expense.

Solutions can be as simple as:

- Disconnecting the roof downspout from the sewer pipe and letting runoff flow to a lawn or garden.
- Directing runoff to a rain barrel or cistern to save for reuse.
- Adding an ecoroof or roof garden to absorb rain.

Stormwater treatments described in this section include:

Downspout Disconnection Rain Barrels Cisterns Ecoroofs Roof Gardens

- For systems that free-fall to the air away from the building, the collection area below the concentrated discharge must have a minimum of 2 inches of gravel per story of free-fall or other protective material rated to withstand flows and be spaced away from the building foundation according to the standards above.
- Refer to Portland's Stormwater Management Manual for detailed information on sizing, placement, and design.

You can also replace downspouts with other structures that convey roof runoff to the discharge point, such as:

- Drip chains, usually made of steel, with a minimum three-inch diameter;
- Scuppers, which collect and concentrate the runoff and allow it to free-fall; and
- Decorative gargoyles that concentrate the runoff and allow it to free-fall.





#### **Permits**

The City requires a permit to disconnect a residential downspout, unless working with the Environmental Services Downspout Disconnection Program. The City requires a plumbing permit if the downspout is directed to an onsite stormwater management facility such as a cistern.

#### Examples

Bureau of Environmental Services Water Pollution Control Laboratory, 6543 N Burlington Avenue, under the St. Johns Bridge.

Oregon Convention Center, NE 1st Avenue and Lloyd Blvd.

Friends of Trees, 3117 NE ML King Jr. Blvd.

Liberty Centre Parking Garage, NE Oregon between 6th and 7th

George Middle School, 10000 N Burr





The system you choose can be simple or complex

# DOWNSPOUT DISCONNECTION

### (splashblock disconnection)

n conventional construction, roof runoff flows through gutters and downspouts to a drywell, storm sewer or combined sewer. Disconnecting downspouts helps keep clean roof runoff from overloading the sewer system when it rains. Roof runoff can be redirected to a yard, garden, swale, or stormwater planter, or to a rain barrel or cistern for storage.



Downspouts can be disconnected on residential, commercial and industrial properties. The system you choose can be as simple or complex as your goals and site requirements allow.

#### **Benefits**

Downspout disconnection reduces stormwater in the sewer system. Storing roof runoff for irrigation or gray water systems conserves potable water and can reduce water bills. Disconnection is simple, inexpensive, effective, and easily integrated into the landscape design. In Portland, over 47,000 residential properties have disconnected downspouts, removing more than one billion gallons of roof water every year from the combined sewer system.

#### Maintenance

Maintenance is minimal. Check periodically to ensure the discharge location has proper erosion control and drainage. Check materials for leaks or defects, and remove accumulated leaves or debris, especially from gutters. Most materials can last for about ten years, and can easily be replaced.

#### Cost

Downspout disconnection is inexpensive. In targeted neighborhoods, the City pays homeowners \$53 for each downspout they

disconnect themselves, or will do the work for free. Materials such as elbows and extensions are readily available at hardware, building supply, and home improvement stores.

#### **Safety and Siting Requirements**

- A common method of residential disconnection is to cut the downspout above the sewer standpipe, plug the standpipe and attach an elbow and extension piece that directs runoff to the discharge point. In many cases, a splash block at the end of the extension conveys water away from foundations and prevents erosion.
- Roof runoff must be discharged at least five feet away from any property lines.
- Make sure the discharge from the pipe does not flow toward the building or neighboring property.
- In east Portland, the discharge point should be at least six feet away from basements and two feet away from crawl spaces and porches.



rain barrels are containers that capture the roof runoff flowing out of a downspout

# RAIN BARRELS

R ain barrels placed at the end of roof downspouts capture and store roof runoff for non-potable water use, like irrigation. Rain barrels come in a wide variety of materials, designs, and colors. Common sizes for residential use are 55 gallons and 90 gallons. They are usually installed on the ground next to buildings.

Commercial or industrial properties are more likely to use cisterns because of their larger capacity and durability.



#### **Benefits**

Using rain barrels to temporarily store and reuse rainwater slows and reduces stormwater runoff from the site. They conserve non-potable water and may reduce water use charges. Rain barrels are inexpensive, easy to install and maintain, and readily available.

#### Maintenance

Inspect periodically for leaks, especially spigots and other connection points. Make sure debris does not clog the system. Screen all vents to prevent mosquito breeding. For maximum stormwater benefits, empty the barrel between rain events in the wet season. Clean the rain barrel interior annually by brushing or disinfecting with vinegar or other non-toxic cleaners. The washout can be disposed of onsite to vegetated areas if disinfecting agents are adequately diluted so they do not harm plants. A rain barrel and its system components have a lifespan of about 20 years.

#### Cost

Do-it-yourself rain barrels can be constructed for under \$30. Ready-made 55 gallon to 90 gallon rain barrels generally cost from \$50 to \$300 uninstalled. All rain barrels must be mosquito proof, have approved overflow points and meet city standards.



#### **Safety and Siting Requirements**

- A typical residential rain barrel design includes an opening in the sealed lid to accept downspout flow, an overflow pipe for when the barrel is full, and a spigot at or near the bottom to attach a hose or faucet. A screen at the opening controls mosquitoes and other insects. Several rain barrels can be connected to store more rainwater.
- Locate rain barrels on a flat surface next to or near roof downspouts.
- In areas with soils that drain well, you can direct overflow from the rain barrels onto the yard or landscape areas. The area must meet the safety requirements listed under downspout disconnect.
- Only collect roof water for reuse. Do not reuse water from parking or pedestrian areas, surface water runoff, or bodies of standing water.
- Refer to Portland's Stormwater Management Manual for detailed sizing, placement, and design information.



#### Permits

 Rain barrels attached to a downspout that do not connect back into the building's water system do not require permits.

#### Examples

Friends of Trees, 3117 NE ML King Jr. Blvd.

### CISTERNS

cistern is a structure that captures and stores roof runoff. The collected water can be used for landscape irrigation and some interior uses, such as toilets and washing machines. It is possible to use a cistern system for household drinking water if it has proper filtration, inspection and permitting. Cisterns are constructed of durable material, such as concrete, plastic, polyethylene, or metal. They are larger and usually more permanent than rain barrels, ranging in size from 100 gallons to 10,000 gallons. They can be placed above-ground, underground or on a rooftop.



A roof washer or filter removes contaminants and debris before the runoff enters the cistern. A pipe from the cistern conveys the stored water, either by gravity or pump, to the designated interior or exterior use. In some instances, an overflow system conveys excess runoff to a destination location. At sites with soils that drain well, the overflow can be conveyed to onsite landscaped areas or into perforated underground pipes if permitting requirements are met.

#### **Benefits**

Using a cistern to store and reuse rainwater reduces or eliminates stormwater runoff from the site. It conserves potable water and reduces water charges with an installed meter. Cisterns are available from many sources, and are relatively easy and inexpensive to install and maintain, especially if they are above ground. Rainwater can be used for potable applications if the water is treated and meets state and federal safe drinking water standards, and the system meets permitting requirements.

#### Maintenance

Inspect the cistern periodically to ensure debris does not clog the system. Check for leaks at connection points. Clean the cistern interior annually with a brush and vinegar or other non-toxic cleaner that will not degrade water quality or harm the cistern. The washout from cleaning can be disposed of onsite to vegetated areas if disinfecting agents are adequately diluted so they do not harm plants. Schedule cleaning during dry weather. A cistern and its components have a lifespan of 20 to 50 years, depending on location and material.

#### Cost

Costs for a cistern, not including installation, range from about \$250 for a 200-gallon cistern to \$5,000 for a 10,000-gallon cistern.

#### **Safety and Siting Requirements**

- Only collect roof water for reuse. Do not reuse water from parking or pedestrian areas, surface water runoff, or bodies of standing water.
- With the proper permitting, underground cisterns in areas with soils that drain well may be approved to overflow into underground perforated pipes.

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- In areas where soils do not drain well, overflow to a city system is required.
- Refer to Portland's Stormwater Management Manual for detailed sizing, placement, and design information.

- Installing a cistern requires a plumbing permit from the City's Bureau of Development Services (BDS) because installation usually involves altering or adding plumbing components.
- Any pumps or other electrical controls require an electrical permit from BDS.
- Any cistern footings, foundations, enclosures, and roof structures require a building permit from BDS.

#### aboveground



- Rooftop cisterns require a building permit for structural review and approval by BDS.
- Underground tanks require a grading and erosion control permit.

#### Examples

DaVinci Middle School (aboveground) 2508 NE Everett Street

Portland State University-Stephen Epler Hall (underground) SW 12th and Montgomery

Oregon Natural Resources Council (ONRC) (underground) 5825 N Greeley Avenue







Ecoroofs can out last conventional roofs by twenty years or more

# ECOROOFS

#### (extensive roof or green roof)

n ecoroof is a lightweight vegetated roof system used in place of a conventional roof. Ecoroofs are typically made of a waterproof membrane, drainage material, a lightweight layer of soil, and a cover of plants. Choose species appropriate for a rooftop environment - dry and hot in summer, wet in winter. Ecoroofs are not intended to be accessed except for maintenance, unless walkways or plazas are incorporated into the design.



#### **Benefits**

An ecoroof can capture and retain 60% of the annual precipitation that falls on it. Nearly all of the rainfall is absorbed during warm weather storm events and stormwater detention and peak attenuation is also notable during saturated winter months. This reduces the runoff flow rate, volume and temperature of roof runoff. Ecoroofs can outlast conventional roofs by twenty years or more. An ecoroof also filters air pollutants: reduces outdoor air temperatures and the resulting urban heat island effect; increases wildlife habitat and urban green space; insulates the building and lowers heating and cooling costs; and is visually attractive. Buildings in the Central City that have Citycertified ecoroofs can receive from one to three square feet of additional floor area ratio (FAR) for each square foot of ecoroof.

#### Vegetation

There are many options for ecoroof plantings. Choose drought tolerant species such as sedums, succulents, or hardy perennials. Plants should be low maintenance, able to tolerate shallow soil, and be self-sustaining without fertilizers or pesticides and minimum summer irrigation.

#### Maintenance

Like a conventional roof, an ecoroof requires some care to maintain optimum function. This may include occasional summer watering, weeding, and mulching, particularly during the plant establishment period. If the roof includes grasses or other annual plants, occasionally cut and remove dry vegetation to ensure that combustible material does not accumulate. Inspect the roof regularly to check drainage and vegetation. Some additional plantings may be needed to fill in bare soil areas.

#### Cost

An ecoroof initially costs more than a conventional roof, but typically lasts twice as long (about 40 years). Costs range from \$10 to \$15 per square foot for new construction and \$15 to \$25 per square foot for re-roofing. Long-term savings from deferred repair and replacement, lower heating and cooling costs, and reduced maintenance help offset the short-term capital costs. As the ecoroof industry develops, costs may decrease.



#### **Safety and Siting Requirements**

- Consult a design professional
- Locate ecoroofs on flat or pitched structures up to a slope of 25%.
- Roof strength must be adequate to hold 10-25 pounds per square foot above the requirements for a basic roof.
- Choose the area and depth of the ecoroof based on your water-retention goals, structure, and planting requirements.
   Thicker ecoroofs provide more flow control and allow for more vegetation options, but require additional structural support.
- Include overflow structures such as drains or downspouts.
- Refer to Portland's Stormwater Management Manual for detailed sizing, placement, and design information.



ROOT BARRIER (as needed)

#### Permits

- Ecoroofs usually require certification from a structural engineer to receive City approval.
- Ecoroofs may require alteration of downspouts or other piping, requiring a plumbing permit from the Bureau of Development Services.
- If applying for the Floor Area Ratio (FAR) bonus program, an ecoroof design is subject to Environmental Services review and the City Design Review.

#### **Examples**

Jean Vollum Natural Capital Center, 721 NW 9th Avenue

Hawthorne Hostel, 3031 SE Hawthorne Blvd.

Multnomah County building, 501 SE Hawthorne Blvd.

Metro Regional Headquarters 600 NE Grand Avenue



roof gardens can support pedestrian traffic

# ROOF GARDENS

#### (intensive roof)

roof garden is a heavyweight vegetated roof system used in place of a conventional roof. Roof gardens typically consist of a waterproof membrane, drainage layer, and a thick layer of soil (typically 12 inches or more), vegetation, and hardscaping to allow access to the garden (e.g., planters, stepping stones, benches).

Because a roof garden can support pedestrian traffic, it can be designed as a building amenity, with walkways, terraces, plazas or seating areas. It differs from an ecoroof by its greater soil depth and weight, accessibility, and the greater range of plants it can accommodate.



#### **Benefits**

A roof garden reduces runoff flow rate, volume, and temperature. Roof gardens can outlast conventional roofs by twenty years. They also filter air pollutants, reduce outdoor air temperatures and the resulting urban heat island effect, increase wildlife habitat; insulate the building and lower energy costs. Long-term savings from deferred repair and replacement, lower heating and cooling costs, and reduced structural maintenance help offset the shortterm capital costs. In addition, turning previously wasted rooftop space into an accessible and appealing area adds value to the building.

#### Vegetation

Roof gardens can be planted with a wide variety of vegetation including trees, shrubs, herbs, succulents, and grasses. Plants should be drought tolerant and self-sustaining, without the need for fertilizers or pesticides. They should be appropriate for the limited soil depths, moisture, and nutrient level.

#### Maintenance

Like a conventional roof, a roof garden requires care to maintain optimum function. This includes irrigation, and manual weeding and mulching, especially during the plant establishment period. Maintenance and irrigationneeds will depend on design and vegetation used. If the roof includes grasses or other annual plants, cut and remove dry vegetation to prevent combustible material from accumulating. Check drainage and vegetation regularly. Some plant replacement may be necessary.

#### Cost

The initial cost of a roof garden is more than a conventional roof, but will last longer. Costs also depend on the type and amount of waterproofing and drainage material, depth of soil, amount of hardscaping and size and type of plant material.

#### **Safety and Siting Requirements**

- Consult a design professional
- Locate roof gardens on flat or shallowpitched roof structures.
- Building structures must be adequate to hold the additional weight on the roof.
- Roof gardens can contain picnic, park or other multiple use areas. They can include walkways for recreation or maintenance.
- Include overflow structures such as drains or downspouts.
- Refer to Portland's Stormwater Management Manual for detailed sizing, placement, and design information.

#### **Permits**

- Roof gardens require substantially upgraded structural support. Bureau of Development Services (BDS) approval requires a signed document from a structural engineer.
- Roof garden retrofits usually need alteration of downspouts or other piping, requiring a plumbing permit from BDS.
- The stormwater management portion of the facility must be reviewed by Environmental Services.



#### **Examples**

Market Building, 200 SW Market Street

The PacWest Building, 1211 SW 5th Avenue

Terry Shrunk Plaza, SW 3rd and 4th Avenues and Madison and Jefferson Streets, is a street-level roof garden over an underground parking garage.

Portland State University-Native American Student Center, 710 SW Jackson Street







when it gets to the ground

### Landscape Solutions

Plants and trees add visual appeal and can increase property values. Careful landscaping can also help manage stormwater, save energy, reduce pollution and improve air quality. Even sites with space constraints or poor drainage can benefit from landscaping for stormwater management. It doesn't have to be complex or expensive, and it can often reduce the development costs by eliminating the need for inlets, drains, and stormwater piping.

Stormwater treatments include: Trees Contained Planters Vegetated Swales Vegetated Infiltration Basins Flow-Through Planters Infiltration Planters

### **Paving Solutions**

Even when an area requires paving, there are still options to infiltrate stormwater into the ground.

Stormwater treatments include: Pervious Pavers Pervious Pavement Turf Block



adding trees

is easy,

and has

many

benefits

Adding trees to landscaping is easy, attractive, and has many stormwater benefits. A single mature tree with a 30 foot crown can intercept over 700 gallons of rainfall annually. Evergreen trees will capture more rainwater in winter months than deciduous trees.



#### **Benefits**

Trees capture and hold rainfall in leaves and branches. They slow runoff flow and can decrease stormwater volume by 35% or more for small storms. Trees improve water quality by filtering rainwater and holding soils in place, which is especially important along stream banks. Their shade reduces pavement heat, which in turn lowers runoff temperature. Tree wells can provide additional benefits by accepting runoff from sidewalks or other paved areas.

#### Maintenance

Selecting appropriate trees reduces maintenance needs. Trees usually require watering in the summer and wind protection in the first one to three years. Stake loosely for the first year. Routine maintenance includes raking and disposing of leaves and debris, removing weeds, pruning dead branches, and controlling pests.

#### Cost

Costs vary with the type and size of the tree, but the general range is \$20 to \$100 each, not including planting. Local non-profit groups often supply free or low-cost trees that are appropriate for our climate.

#### **Safety and Siting Requirements**

- Trees provide the greatest stormwater and environmental benefit when their canopy covers impervious areas and intercepts water before it falls to the ground.
- Choose trees suitable for the soil type, amount and intensity of sunlight and space requirements.
- Street trees are regulated by Portland Parks & Recreation. Call 503-823-PLAY for more information.
- Locate utilities before digging. Call 503-246-6699. (Portland)
- Refer to Portland's Stormwater Management Manual for information on sizing, placement, and design.

#### Permits

- No permits are required for planting trees on private property.
- Planting or removing trees from the public right-of-way requires a tree permit from the City Forester.
- Natural area trees are regulated by E-Zone requirements.

- To receive stormwater management credit per the Stormwater Management Manual, new deciduous trees must be at least 2" caliper and new conifers must be at least 6 feet tall. In the right-of-way, new trees must be at least 2" caliper for residential areas and 3.5" caliper in commercial and industrial zones.
- For Clean River Rewards credit trees must be at least 15 feet tall and on private property. This does not include trees in the public right-of-way such as street trees.

#### **Examples**

SW Park Blocks

Friends of Trees, 3117 ML King Jr. Blvd.

NE Ainsworth Linear Arboretum, NE Ainsworth from ML King Jr. Blvd. to NE 42nd

SE Ladd's Addition

Hoyt Arboretum





contained planters can be placed on many types of flat impervious surfaces

### CONTAINED PLANTERS

#### (contained planter boxes)

Contained planter is filled with soil and plants that accept precipitation only, not stormwater runoff from another source. It is placed above ground on an impervious surface. Rainwater is temporarily stored above the soil, and then filters down through the planter. In some cases, weep holes provide drainage through the bottom of the planter onto the impervious surface. Contained planter boxes can be prefabricated pots or constructed in place. They come in all shapes and sizes, are made of stone, concrete, brick, plastic lumber or wood, and can hold a variety of plants.



#### **Benefits**

A contained planter reduces impervious area and stormwater runoff. Contained planters are simple, cost-effective, and visually appealing. They can be placed on many types of flat impervious surfaces, such as sidewalks, plazas, and rooftops.

#### Vegetation

Planters can contain small trees, shrubs, flowers, bulbs, and groundcovers. Trees are especially recommended because they provide canopy cover for impervious surfaces not covered by the planter. Self-sustaining plants that do not require additional fertilizers or pesticides are recommended.

#### Maintenance

Contained planters require minimal maintenance. Check them periodically to maintain adequate drainage. They are likely to need summer watering and weeding. Potted plants require more water than the same plants growing in the ground.

#### Cost

The cost of contained planter boxes varies, depending on the size and materials.

#### **Safety and Siting Requirements**

- Locate planters on virtually any impervious surface. They can be any shape or size, as site requirements, budget and maintenance dictates.
- Refer to Portland's Stormwater Management Manual for detailed information on sizing, placement, and design.

#### **Permits**

• Planters located on ground level within the public right-of-way may require approval from the City Forester and Portland Department of Transportation.





### **VEGETATED SWALES**

#### (bioswales, grassy swales)

Swales are gently sloping depressions planted with dense vegetation or grass that treat stormwater runoff from rooftops, streets, and parking lots. As the runoff flows along the length of the swale, the vegetation slows and filters it and allows it to infiltrate into the ground. Where soils do not drain well, swales are typically lined and convey runoff to a drywell or soakage trench. Swales can include check dams to help slow and detain the flow. A swale can look like a typical landscaped area.



#### **Benefits**

The plants in a swale filter and slow stormwater runoff while sediments and other pollutants settle out. Swales are costeffective, attractive and can provide wildlife habitat and visual enhancements. Single or multiple swale systems can treat and dispose of stormwater runoff from an entire site. Swales can reduce the number and cost of storm drains and piping required when developing a site.

#### Vegetation

Swales can be planted with a variety of trees, shrubs, grasses, and ground covers. Plants that can tolerate both wet and dry soil conditions are best. Plant grassy swales with native broadleaf, dense-rooted grass varieties. Avoid trees in areas that require enhanced structural stability, such as bermed side slopes. Summer irrigation and weed pulling may be required in the first one to three years.

#### Maintenance

Inspect swales periodically, especially after major storm events. Remove sediment and trash, clean and repair inlets, curb cuts, check dams, and outlets as needed. Maintain side slopes to prevent erosion and ensure proper drainage. With proper construction and maintenance, swales can last indefinitely.

#### Cost

Costs vary but swales typically cost less than a standard piped, drainage system.

#### **Safety and Siting Requirements**

- Swales located closer than 10 feet from building foundations need a variance from Bureau of Development Services (BDS)
- Locate swales at least 5 feet from any property line
- Grade the site so that water drains to the swale, or provide some form of conveyance such as a trench or berm to direct the runoff into the swale if site grading is impractical.
- Many parking lot planting islands can be excavated and retrofitted into swale systems with curb cuts.
- Refer to Portland's Stormwater Management Manual for detailed information on sizing, placement, and design.

- Swales that accept roof runoff may require altering downspouts or other piping and a plumbing permit from the Bureau of Development Services (BDS).
- Depending on the area of ground disturbance, a clearing and grading permit may be required from BDS.
- The stormwater management portion of the facility may need review from the Bureau of Environmental Services (BES).
- Stormwater systems on non-residential sites need a commercial building permit.



#### **Examples**

OMSI and PCC annex parking lots, 1945 S.E. Water Ave.

Water Pollution Control Lab, 6543 North Burlington Ave.

Parkrose Middle School, 11800 NE Shaver

Glencoe Elementary School, 825 SE 51st Ave.

Siskiyou Green Street, NE Siskiyou between 35th Place and 36th Ave.





rain gardens can be sized to handle small or large storm events

### VEGETATED INFILTRATION BASINS

#### (rain gardens)

Vegetated infiltration basins are landscaped depressions that are either excavated or created with bermed side slopes. An inlet pipe from or sheet flow over impervious surfaces conveys stormwater runoff into the basin, where it is temporarily stored until it infiltrates into the ground. Basins often provide complete onsite infiltration for small storm events. Check dams or weirs can be used to detain the flow. They can be sized to infiltrate large storms in areas where soils drain well, or they may require a safety overflow or disposal method.



#### **Benefits**

Basins or rain gardens eliminate or dramatically reduce stormwater flow rates and volumes. They improve water quality by settling and filtering out pollutants, they recharge groundwater, and they can provide stormwater storage capacity in a large drainage area. Trees planted in infiltration basins can shade buildings and parking lots or other paved areas, reducing runoff temperatures. The vegetation also helps prevent soil erosion, provides wildlife habitat, and is visually attractive. Vegetated infiltration basins can have an informal or formal design and are easily integrated into the overall landscape or site design.

#### Vegetation

Vegetated infiltration basins can be planted with a variety of trees, shrubs, grasses, and ground covers. Trees are highly recommended for their shading and temperature reduction benefits. Avoid permanent irrigation where possible. Basins are likely to need watering and weed pulling during the first one to three years.

#### Maintenance

Inspect the vegetation and structure periodically and after major storm events. Vegetation maintenance is similar to that used for other types of managed landscapes. Maintenance needs include removing sediment and debris; cleaning and repairing inlets, embankments, berms, dams, and outlets as needed; controlling erosion; and ensuring proper drainage. Some plant replacement may be necessary. With proper construction and maintenance, a vegetated infiltration basin can last indefinitely.

#### Cost

The cost of vegetated infiltration basins varies depending on size, site conditions, and the type and size of the vegetation used. Costs compare favorably with conventional stormwater management facilities.

#### **Safety and Siting Requirements**

 Vegetated infiltration basins work best in areas that drain relatively shallow slopes of usually less than 5%. Runoff from steeper slopes can be piped into the basin with proper erosion control measures in place.

- Infiltration basins located closer than ten feet from building foundations need a variance from Bureau of Development Services (BDS).
- Locate basins at least five feet away from property lines.
- Underlying soils should have a minimum infiltration rate of two inches per hour and should not be compacted.
- Where needed include an emergency overflow disposal system to a drywell or to the City's storm system.
- Infiltration basins may not be appropriate in areas with high water tables. They should not be designed as a pond, and should drain a storm event within 30 hours.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- Depending on the size of ground disturbance, a clearing and grading permit may be required from the Bureau of Development Services.
- The stormwater management portion of the facility will need review from the Bureau of Environmental Services (BES).
- Stormwater systems on non-residential sites need a commercial building permits.



#### Examples

Buckman Heights Apartments, 430 NE 16th Ave.

Glencoe Elementary School, 825 SE 51st Ave.

Oregon Convention Center, NE 1st Ave. and Lloyd Blvd.

Wattles Boys and Girls Club 9330 SE Harold Street





flow-through planters temporarily store runoffcleaning it before it drains to a conveyance system

# FLOW-THROUGH PLANTERS

For placed on impervious surfaces. They do not infiltrate into the ground. They can be placed in or above the ground level. Flow-through planters are filled with gravel, soil, and vegetation and are typically waterproofed. They temporarily store stormwater runoff on top of the soil and filter sediment and pollutants as water slowly infiltrates down through the planter. Excess water collects in a perforated pipe at the bottom of the planter and drains to a destination point or conveyance system. Flow-through planters come in many sizes and shapes, and are made of stone, concrete, brick, plastic lumber or wood.



#### **Benefits**

Because flow-through planters can be built immediately next to buildings, they are ideal for constrained sites with setback limitations, poorly draining soils, steep slopes, or contaminated areas. Flow-through planters reduce stormwater flow rates, volume, and temperature, and improve water quality. They can also provide shading and energy benefits when sited against building walls. They can be an attractive landscape feature and provide wildlife habitat.

#### Vegetation

Flow-through planters can contain a variety of shrubs, small trees, and other plants appropriate for seasonally moist and dry soil conditions. Summer irrigation and weed pulling may be required. Minimize the need for permanent irrigation as much as possible by using native and well-adapted plants.

#### Maintenance

Inspect plants and structural components periodically. Maintenance is similar for all container plantings. Other maintenance needs may include removing sediment, cleaning and repairing pipes, and maintaining proper drainage. Downspouts, curb cuts, and other features where debris may obstruct flow must be inspected and cleaned periodically.



Environmental Services - City of Portland Oregon

#### Cost

The cost of flow-through planter boxes varies depending on size and materials. For new development and redevelopment, they are often less expensive than conventional stormwater management facilities.

#### **Safety and Siting Requirements**

- Flow-through planters are recommended for compact sites because their size can vary.
- An approved overflow to a proper destination disposal point is required.
- Flow-through planters can be located next to building foundations or in other situations where infiltration is a concern.
- They are ideal for sites with soil that does not drain well, and are suitable to all soil types.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

#### Permits

- Flow-through planters that alter existing plumbing such as downspouts, or add new pipes for disposal require a plumbing permit from the Bureau of Development Services (BDS).
- Depending on the area of ground disturbance, in-ground systems may need a clearing and grading permit from BDS.
- The stormwater management portion of the facility will need review from the Bureau of Environmental Services (BES).
- Stormwater systems on non-residential sites need a commercial building permit.

#### **Examples**

Pearl Court Apartments, 920 NW Kearney St.

Rebuilding Center of Our United Villages, 3625 N. Mississippi Ave.

George Middle School, 10000 N. Burr

Portland State University-Helen Gordon Child Development Center, SW 12th and Mill and SW 13th and Market

PSU Stephen Epler Hall



31



infiltration planters allow runoff to slowly soak into the ground

### **INFILTRATION PLANTERS**

nfiltration planters are structures or containers with open bottoms to allow stormwater to slowly infiltrate into the ground. They contain a layer of gravel, soil, and vegetation. Stormwater runoff temporarily pools on top of the soil, and then slowly infiltrates through the planter into the ground. Infiltration planters come in many sizes and shapes, and are made of stone, concrete, brick, plastic lumber, or wood. Infiltration planters are not recommended for soils that don't drain well. Use flow-through planters instead.



#### **Benefits**

Infiltration planters are ideal for space-limited sites with good drainage. They reduce stormwater runoff flow rate, volume, temperature and pollutants, and recharge groundwater. Infiltration planters can be attractive, and are easily integrated into the overall landscape design. They can also provide energy benefits when sited near building walls.

#### Vegetation

Infiltration planters can contain a variety of shrubs, small trees, and other plants appropriate for seasonally moist and dry soil conditions. Avoid permanent irrigation if possible. Planters are likely to need watering and weeding in the first one to three years.

#### Maintenance

Inspect plants and structural components periodically. Remove sediment and clear debris from inlet pipes and curb cuts to maintain proper drainage.

#### Cost

Costs vary depending on size and materials. For new development and redevelopment, infiltration planters are often less expensive than more conventional stormwater management facilities.

#### **Safety and Siting Requirements**

- Infiltration planters located closer than ten feet from foundations need a variance from Bureau of Development Services (BDS).
- Locate planters at least five feet from any property line.
- Infiltration planters are only suitable for soil types that drain well.
- Place them flush to the ground or above it.
- An approved overflow to a proper destination point is required.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- Infiltration planters that require alteration of downspouts or other piping require a plumbing permit from BDS.
- Depending on the size of ground disturbance, in-ground systems may need a clearing and grading permit from BDS.
- The stormwater management portion of the facility must be reviewed by the Bureau of Environmental Services (BES).
- Stormwater systems on non-residential sites need commercial building permits.

#### **Examples**

Liberty Centre Parking Garage, 600 NE Holladay

Buckman Terrace Apartments, 303 NE 16th Ave.

The ReBuilding Center of Our United Villages, 3625 N. Mississippi Ave. (on Missouri Street)

PSU Green Street, SW 12th between Montgomery and Mill

Mississippi Commons 3701 N Mississippi Avenue







pervious pavers can support heavy weights while allowing water to soak into the ground

# PERVIOUS PAVERS

#### (unit pavers)

Pervious pavers are typically made of pre-cast concrete, brick, stone, or cobbles. Pavers usually form interlocking patterns, and are placed within a rigid frame on top of a sand bed or an under drain system. Sand or gravel fills the gaps between pavers, allowing water to pass to the underlying subgrade then infiltrate into the ground. Some pavers also have small voids in the pavement surface to increase permeability. Pervious pavers are available in many colors, shapes, sizes, and textures, and can support heavy traffic loads and weights. They can replace conventional asphalt or concrete paving in parking lots, roads, and sidewalks.



#### **Benefits**

By infiltrating precipitation, pervious pavers reduce stormwater runoff flow rate, volume, and temperature, and filter pollutants. They help recharge groundwater and maintain stream base flows. Pervious pavers may reduce or eliminate the need for an underground storm drain system or a curb and gutter system. They are durable and attractive, and allow great flexibility of design. Pervious paver areas can serve as an overflow for other stormwater management techniques.

#### Maintenance

It is important to control site erosion and sedimentation to prevent clogging. Annual vacuum sweeping helps maintain permeability. The gaps between pavers may require occasional weeding or scorching and sand or gravel replenishment. Because pervious pavers are easily lifted and reset, they are easy to repair or replace.

#### Cost

Pervious paver systems range in cost depending on the size of the installation and the installation technique. Data gathered from Bureau of Environmental Services Westmoreland Pilot Project (2004) indicate an estimated cost of \$5 per square foot installed, including base rock.

#### **Safety and Siting Requirements**

- Follow the manufacturer's installation specifications.
- Use over soils that drain well such as gravelly or loamy sand.
- Do not use pervious pavers in areas with high sediment loads that can clog pores in the pavement.
- Pervious pavers are not allowed in areas where hazardous material is stored or transported.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- Pavers used in public areas and City rightsof-way require City review for drainage and Americans with Disabilities Act (ADA) compliance. Contact the Portland Office of Transportation (PDOT) or the City's Bureau of Development Services (BDS) with questions about use in these areas.
- Stormwater systems on non-residential sites need commercial building permits.

#### **Examples**

Oregon Natural Resources Council building parking lot, 5825 N. Greeley Ave.

Multnomah Arts Center, SW 31st and Capital Hwy

SE Westmoreland, SE 21st and Rex and SE Knapp

East Holladay Park NE 128th and Holladay





Pervious pavement allows precipitation to percolate through to the ground

# PERVIOUS PAVEMENT

#### (porous pavement, porous concrete/asphalt)

Pervious pavement is made of either pervious asphalt or pervious concrete. Both materials resemble conventional asphalt and concrete, but have more air spaces that allow water to pass through the pavement into a reservoir base of crushed aggregate, then infiltrate into the ground. Pervious pavement is designed to accept precipitation only and is typically thicker than traditional concrete to support the same loads.



**Pervious asphalt** consists of coarse stone aggregate and asphalt binder, with very little fine aggregate. Water percolates through the small voids left in the finished asphalt. A thick layer of gravel underneath allows water to drain through quickly. Pervious asphalt looks similar to conventional asphalt, although with a rougher surface, which accounts for its common name "popcorn mix."

**Pervious concrete** consists of specially formulated mixtures of Portland cement, open-graded coarse aggregate, and water. It has enough void space to allow rapid percolation of water and resembles exposed aggregate concrete.

#### **Benefits**

Pervious pavement reduces stormwater runoff flow rate and volume, recharges groundwater and maintains stream base flows. The subgrade also filters pollutants. Pervious pavement is less prone to cracking or buckling from freezing and thawing. Studies indicate it requires less frequent repair and patching than conventional paving. In some cases, pervious pavement may reduce or eliminate the need for an underground storm drain system or a curb and gutter system. Pervious pavement is an effective method of managing stormwater runoff without limiting use of the space.

#### Maintenance

It is important to control site erosion and sedimentation of the pavement surface to prevent clogging and maintain permeability. Cleaning or vacuuming the surface once or twice a year maintains porosity. Properly installed pervious paving systems last more than 20 years.

#### Cost

Pervious concrete pavements range in cost depending on the size of the installation. In the Bureau of Environmental Services North Gay Avenue Project (Summer 2005), a pervious concrete street cost about \$100 per square yard installed, including base rock.

#### **Safety and Siting Requirements**

- Follow manufacturer's installation instructions.
- Weather conditions during installation can affect the performance and longevity of pervious pavement. Check with manufacturers for guidelines.

- Slope must be less than 10% over the paved area.
- Use pervious pavement over soils that drain well, like gravelly or loamy sand.
- Do not use pervious pavements in areas with high sediment loads.
- Pervious pavement is not allowed in areas where hazardous material is stored or transported.
- Most systems include an under layer of at least 12 inches of clean gravel over a layer of geotextile fabric. The under layer serves as an underground detention basin and should include an overflow outlet to prevent water from rising through the pavement.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- Pervious pavement systems used to replace public parking or walkway areas require a building permit from the City's Bureau of Development Services.
- Stormwater systems on non-residential sites need commercial building permits.

#### Examples

The Rebuilding Center of our United Villages, parking lot, 3625 N. Mississippi Ave.

N. Gay Avenue between N. Wygant and N. Sumner (pervious concrete and asphalt)

Pervious Concrete at Broadway Pump Station, NE 91st and Broadway

Ecotrust Building Parking Lot (Drive aisles), 721 NW 9th Ave.







turf block accepts precipitation that falls on it and can withstand traffic

# TURF BLOCK

#### (grass grid, open-cell unit paver, geoblock)

Turf block consists of interlocking concrete or plastic cells filled with soil and planted with turf grass or a low-maintenance groundcover. Water passes through the turf block into a reservoir base of crushed aggregate, then infiltrates into the subgrade. Turf block accepts precipitation only, not stormwater runoff. It is available in a variety of colors, shapes, sizes, and textures. Turf block is best suited for areas of low traffic and infrequent parking, such as patios, walkways, and terraces, residential driveways, overflow parking areas, emergency access roads, and street shoulders.



#### **Benefits**

Turf block reduces stormwater runoff flow rate, volume, and temperature, filters pollutants, helps recharge groundwater and maintain stream base flows, and controls erosion. In some cases, turf block may reduce or eliminate the need for an underground storm drain system or a curb and gutter system. It has a green appearance and structural strength.

#### Vegetation

Turf block systems can be planted with a variety of grasses and low growing groundcovers that can withstand foot and vehicular traffic and occasional heavy loads. Self-sustaining native species are recommended.

#### Maintenance

Maintenance is similar to a regular lawn, requiring mowing, irrigation, raking, and occasional reseeding. Native grass species suitable for the specific area can minimize maintenance needs. It is important to control site erosion, sedimentation, and soil compaction to prevent clogging and maintain permeability.

#### Cost

Installation costs \$4 to \$6 per square foot, higher than for conventional concrete or asphalt paving. This cost may be offset if it is not necessary to install an underground drainage system or curb and gutter drainage system.

#### **Safety and Siting Requirements**

- Follow manufacturer's installation and siting instructions.
- Use only in gravelly sand, loamy sand or other pervious native soils.
- Like other pervious pavement, turf blocks are not allowed for areas where hazardous material is stored or transported.
- Use in low to moderate traffic areas without high weight-bearing loads.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- Using turf blocks in public parking areas, walkways or rights-of-way requires a building permit from the City's Bureau of Development Services, with review from the Portland Office of Transportation.
- Stormwater systems on non-residential sites need commercial building permits.

#### **Examples**

Dosha Building, 2281 NW Glisan

SE Water Avenue - across from OMSI

Washington School for the Blind 2310 E 13th street Vancouver, Washington







# taking it underground

nderground stormwater management systems are more complex than many of the techniques in this guide. The U.S. Environmental Protection Agency regulates drywells and soakage trenches to prevent surface contaminants from polluting drinking water in wells. Underground systems, except for those taking only residential roof runoff, must be registered with the state Department of Environmental Quality. These systems can be valuable stormwater management tools when properly sized, sited and maintained. They keep stormwater out of combined sewers, eliminate the need for curb drains and piping, and recharge groundwater to provide year-round stream flow. They can be cost-effective and do not require space on the ground surface or roof.

Underground systems used in conjunction with above ground treatment systems are known as a treatment train. For example, stormwater is directed first to a swale or infiltration basin and any overflow goes to the underground disposal facility. The technique protects water quality while disposing of stormwater runoff on site.

In areas of Portland with high water tables, this type of disposal is not permitted. Underground facilities must also be a sufficient distance from private drinking water wells. Before installing an underground stormwater disposal system, check the zoning in your neighborhood.

Stormwater Treatments include: Drywells Soakage Trenches drywells collect runoff and allow it to percolate into the soil

## DRYWELLS

drywell is an underground perforated pipe surrounded with gravel that collects stormwater runoff and infiltrates it into the ground. Stormwater from roofs, parking lots, and other impervious surfaces flows through an inlet pipe that empties into the drywell. Drywells are made from concrete or plastic in a variety of widths and depths. A catch basin may be required for drainage areas other than residential roofs.

Drywells can be installed under any surface with adequate drainage. They are not allowed for wastewater drainage or in wellhead protection areas. Plants can be established on top of the facility, however there is a need for occasional access for maintenance and inspection.



#### **Benefits**

Drywells reduce runoff flow rate, volume, and temperature, and help recharge groundwater. They are disposal only systems and are usually paired with a water quality or pretreatment facility.

#### Maintenance

Periodically inspect drywell systems to ensure proper operation and structural stability. Maintenance needs include controlling erosion, removing excessive debris, and cleaning and repairing inlet and outlet pipes. Clogged drywells must be refurbished or replaced. A drywell can last up to 30 years with proper construction and maintenance.

#### Cost

Drywells are commonly available from construction supply companies, and are relatively inexpensive to install and maintain. Depending on their size, drywell systems cost from \$1,200 to \$1,500 including installation.

#### **Safety and Siting Requirements**

- Drywells are prohibited where there is permanent or seasonal groundwater within 10 feet of the bottom of the drywell.
- Use drywells in soils that drain well and in areas with low water tables. Drywells are prohibited in some parts of northeast Portland near the Columbia River.
- Place drywells at least 10 feet from the building foundation or basement, 20 feet from any cesspool, and five feet from any property lines.
- Pits for drywells must be at least four feet in diameter and five feet deep. Minimum drywell diameter is 28 inches.
- Drywells must be at least 500 feet from private drinking water wells.
- Refer to Portland's Stormwater Management Manual for details on sizing, placement, and design.

- All drywells, except those that drain only residential rooftops, must be registered with the Oregon Department of Environmental Quality before receiving City permits.
- The City's Bureau of Development Services (BDS) must approve drywell siting and sizing.
- New or altered plumbing connections require a plumbing permit from BDS.

#### **Examples**

Drywells are located on private property throughout Portland, and in many public streets on the east side of the Willamette River. Because they are subsurface facilities, there are no examples to view.



#### note:

Silt basin/collection box or an equivalent washer is optional but recommended for roof runoff.

Silt basins are highly recommended for all other surfaces.



soakage trenches are regulated to prevent pollution

### SOAKAGE TRENCHES

#### (infiltration trenches)

Solve or below ground - may be used). The runoff then enters the trench through a perforated pipe that allows it to drain through the backfill material and soak slowly into the underlying soil. It is usually not necessary to have an overflow mechanism to a secondary disposal or conveyance system.



Soakage trenches can pollute groundwater if not properly sited, designed, and operated. They are regulated under the federal Underground Injection Control (UIC) program. Contact the Oregon Department of Environmental Quality for requirements.

#### **Benefits**

Soakage trenches reduce runoff flow rate, volume, and temperature and recharge groundwater. With a sufficient amount of sand or soil for filtration, they may be used to meet pollution reduction requirements.

#### Vegetation

Grasses, small plants, or shrubs can be used over the soakage trench. Trees or other deeprooted plants may damage the piped conveyance system.

#### Maintenance

Inspect soakage trenches periodically and after major storm events to ensure proper operation and structural stability. Maintenance needs include controlling erosion and debris accumulation; cleaning, repairing, or replacing the piping and fabric filter as needed; removing sediment from the silt basin or collection box, and replacing clogged aggregate. With proper construction and maintenance, a soakage trench can last up to 30 years.

#### Cost

Soakage trenches usually cost between \$20 and \$30 per cubic foot.

#### **Safety and Siting Requirements**

- Soils must have a tested infiltration rate of at least two inches per hour. The bottom of the trench must be at least four feet from the water table or any rock layer, hardpan, or other impervious underground layer.
- A soakage trench, sized to City of Portland standards, can serve a maximum of 15,000 square feet of impervious area.

- Install soakage trenches on slopes of less than 20%.
- Place the soakage trench at least 10 feet from the building foundation or basement and five feet from any property lines.
- Install the trench in native soil level with and parallel to the site contour.
- Portland's Stormwater Management Manual provides details on sizing, placement and design of soakage trenches.

- All soakage trenches, with the exception of those that drain residential rooftops only, must be registered with the Oregon Department of Environmental Quality before receiving any City permits.
- The City's Bureau of Development Services (BDS) must approve soakage trench siting and sizing.
- New or altered plumbing connections require a plumbing permit from BDS.
- For soakage trenches sited on slopes of greater than 20%, City approval requires a stamped and signed geotechnical report addressing slope stability.

#### **Examples**

Because they are subsurface facilities, there are no installed examples to view.



#### note:

Silt basin/collection box or an equivalent washer is optional but recommended for roof runoff.

Silt basins are highly recommended for all other surfaces.



# plant choices

### Landscaping Examples

Many types of plants are well suited for onsite stormwater management. You can design your site to fit in with any number of aesthetics and still provide stormwater management and other landscaping benefits.

Here are a few examples from around Portland, with photographs of each facility followed by a list of the plants included in each. Note the placement of plants listed here such as in the bottom, on the slopes of, and upland of a facility. Different plants will have a different tolerance to wet and dry conditions. Consider the constraints of each site; all plants pictured here will not be suitable for every situation. See the Portland Stormwater Management Manual for a more comprehensive list of appropriate plants.



### Stormwater Facility Science

The surface area of a typical stormwater facility allows runoff to pond and evaporate while sediments settle into a layer of mulch. The organic mulch layer prevents soil bed erosion and retains moisture for plant roots. It also provides a medium for biological growth and the decomposition or decay of organic matter.

The soil stores water and nutrients to support plant life. Worms and other soil organisms are very good at degrading organic pollutants, like petroleum-based compounds. They also help mix organic material, increase aeration, and improve water infiltration and water holding capacity. Bacteria and other beneficial soil microbes process the majority of pollutants, including most of the nitrogen.

The stiff structure of plants such as rushes and sedges slows water passage and traps sediments within the surface area of the facility.



#### **Stormwater Planters**

#### Mississippi Commons

Grooved rush Juncus patens
 Red twig dogwood Cornus sericea
 American cranberry bush Viburnum trilobum var.
 Camas lily Camassia leichtlinii
 Yellow-eyed grass Sisyrinchium californicum
 Sword fern Polystichum munitum
 Hardstem bulrush Scirpus acutus

Creeping Oregon grape Curly sedge

Mahonia repens Carex rupestris



NOOTKA ROSE

817 4 8

RUSH

#### **Stormwater Planters**

- The ReBuilding Center
  Red twig dogwood
  Baltic rush
  Highbush cranberry
  Pacific ninebark
  Tufted hairgrass
  Slender rush
  Nootka rose
  Pacific crabapple
  Douglas spiraea
- Cornus stolonifera Juncus balticus Viburnum edule Physocarpus capitatus Deschampsia caespitosa Juncus tenuis Rosa nutkana Malus fusca Spiraea douglasii

#### Not Pictured:

or Hardhack

- Common camas Yellow monkey flower Douglas iris Slough sedge
- Camassia quamash Mimulus guttatus Iris douglasiana Carex obnupta



STORMWATER SOLUTIONS HANDBOOK - Environmental Services - City of Portland Oregon



#### **Infiltration Basins / Raingardens**

#### Buckman Heights Apartments

- 1 Tall Oregon grape **2** Douglas spiraea or Hardhack
- **6** Siberian iris var.
- 4 David viburnum
- **6** Daylily var.
- **6** Littleleaf boxwood

Mahonia aquifoliu	JM
Spiraea douglasii	

- Iris sibirica Viburnum davidii
- Hemerocallis sp. var.
- Buxus microphylla var.



OREGON GRAPE

HARDHACK



### **Parking lot Swales**

- Glencoe Elementary School • Creeping Oregon grape **2** Grooved rush **8** Slough sedge 4 Salal **6** Spanish lavender 6 Blue arctic willow
- **7** Native wetland grass mix
- 8 Sugar Maple
- **9** Vine Maple

Not pictured: Dense sedge Kinnikinnick Tall blue oat grass Mahonia repens Juncus patens Carex obnupta Gaultheria shallon Lavandula stoechas var. Salix purpurea nana

Acer Sacharrum Acer Circinatum

Carex densa Arctostaphylos uva-ursi Helictotrichon sempervirens



### Ecoroof

Hamilton West Apartments Plants include the following mix:

Cascade stonecrop Spanish stonecrop White stonecrop Biting stonecrop Reflexed stonecrop Tasteless stonecrop Iceplant Autumn joy sedum Blue fescue Two-row stonecrop Pink

Sedum divergens Sedum hispanicum var. Sedum album Sedum acre Sedum reflexum Sedum sexangular Delosperma var. Sedum telephium var. Festuca glauca Sedum spurium var. Dianthus sp. var.





ICE PLANT



#### Ecoroof

Multnomah County Building (deeper soil base) Plants include the following mix:

- Corn poppy English wallflower Sweet William Maiden pink Spurred snapdragon Plains coreopsis Missouri evening primrose Telephium sedum
- Papaver rhoeas Cherianthus Cheiri Dianthus barbatus Dianthus deltoides Linaria maroccana Coreopsis tinctoria Oenothera missouriensis Sedum telephium var.

## For More Information

#### **General Stormwater**

#### City of Portland Stormwater Management Manual

Outlines regulations, specifications and requirements for stormwater facilities www.portlandonline.com/bes/index.cfm?c=35117

#### Center for Watershed Protection

www.stormwatercenter.net

International Stormwater Best Management Practices (BMP) Database www.bmpdatabase.org

City of Portland Clean River Rewards Program www.CleanRiverRewards.com 503-823-1371

#### **City Agencies**

City of Portland, Environmental Services 503-823-7740 www.portlandonline.com/bes/index.cfm?c=34598

City of Portland, Office of Sustainable Development 503-823-7222 www.portlandonline.com/osd

City of Portland, Bureau of Development Services 503-823-7300 www.portlandonline.com/bds

Portland Parks Urban Forestry 503-823-4489 www.portlandonline.com/parks/index.cfm?c=38294

#### **Downspout Disconnection**

City of Portland, Environmental Services, Downspout Disconnection Program 503-823-5858 www.portlandonline.com/bes/index.cfm?c=31246

#### Utility Locate - Call before you dig

503-246-6699

#### **Drywells**

Oregon DEQ Underground Injection Control Program 503-229-5886 www.deg.state.or.us/wg/groundwa/uichome.htm

#### Ecoroofs

City of Portland, Environmental Services, Ecoroof Program 503-823-7740 www.portlandonline.com/bes/index.cfm?c=34663

#### **Ecoroofs Everywhere**

This local non-profit provides free or low-cost information, technical design assistance and construction assistance. 503-823-7616 www.ecoroofseverywhere.org

#### **Infiltration Basins**

Infiltration Basin (Rain Garden) in Bellingham, WA www.psat.wa.gov/Publications/Rain\_Garden\_book.pdf

#### A Rain Garden in Every Community

http://basineducation.uwex.edu/rockriver/rgcommunity.cfm

#### Landscape Solutions

American Society of Landscape Architects Oregon Chapter www.aslaoregon.org

#### **Paving Solutions**

U.S. Environmental Protection Agency (EPA) Fact sheet and list of vendors www.epa.gov/owm/mtb/porouspa.pdf

#### Interlocking Concrete Pavement Institute

Trade organization has information on many styles and vendors www.icpi.org

Asphalt Pavement Association of Oregon 503-363-3858 www.apao.org

Oregon Department of Environmental Quality (DEQ) 503-229-5189 www.deq.state.or.us/wq/wqpermit/wqpermit.htm

#### Portland Bureau of Development Services: 503-823-7300

503-823-7300 www.portlandonline.com/bds

#### Portland Office of Transportation

503-823-5185 www.portlandonline.com/transportation

#### Plants

#### City of Portland, Environmental Services, Plant List

Lists beneficial, nuisance and prohibited plants, along with useful information, including sources of native plants. www.portlandonline.com/bes/index.cfm?&a=40732&c=32142

#### Stormwater Management Manual, plant list

www.portlandonline.com/shared/cfm/image.cfm?id=55831

#### Native Plant Society of Oregon

www.npsoregon.org

#### U. S. Natural Resource Conservation Service

U. S. native plants guide: http://plant-materials.nrcs.usda.gov/technical/websites/nat.html

#### **Rain barrels and cisterns**

King County, WA guide to rain barrels and list of PNW vendors. http://dnr.metrokc.gov/wlr/Pl/rainbarrels.htm





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