



# Best Management Practices Factsheets

Incentivizing low-impact development  
Beyond permit requirements  
Guidance for Local Jurisdictions



Washington State  
Department of  
**Commerce**



Puget Sound Regional Council

# Bioretention and rain gardens

Bioretention is a shallow landscaped depression with a designed soil mix (the bioretention soil mix or “BSM”) and plants adapted to local climate and soil moisture conditions.

Bioretention can be designed as a cell, a swale (conveying stormwater in addition to treating it), a planter (with impervious sides and an open bottom), or a planter box (with impervious sides and a bottom). Bioretention facility designs are required to be stamped by a professional engineer.

## Benefits

- Can be designed to create an attractive landscape feature.
- Provides habitat for beneficial insects and birds.
- Can help meet requirements for on-site stormwater management, water quality treatment, and flow control.
- Increases property values through social, economic, and environmental benefits that help offset design costs.
- Can be used as a traffic-calming feature.

## Design tips

- Provide a 4- to 6-inch drop from the curb to prevent sediment and debris clogging the inlet and stormwater from entering the facility.
- Include a concrete pad or rock at the bottom of the inlet to prevent erosion.
- Facilitate easier long-term maintenance by adjusting curb cut openings and the curb bulb radius to accommodate available sweeping and vacuum equipment.
- Incorporate maintenance or pedestrian pathways through bioretention areas to reduce future soil compaction.
- Test soil permeability to ensure bioretention is feasible for your site.



## CASE STUDY

In 2003, the Seattle Housing Authority worked with developers to redevelop the High Point neighborhood in West Seattle to increase housing density. A primary feature of the project is over 11,000 linear feet of bioretention swales constructed to manage and treat stormwater runoff.

## What's new in design and installation



A variety of curb cut inlet configurations have been used for bioretention facilities, addressing concerns over car tires rolling through the openings, trash buildup at the inlet, and inefficient flow capture from the curb line to the cell. Solutions include curb covers at the inlet to deter car tires, expanded curb cut widths and a 4- to 6-inch drop into the facility to reduce buildup of debris, and a depression in the gutter line to help direct flows into the facility.



A mortar bed can be used in pre-settling zones to hold cobbles in place that filter sediment before it spreads across the facility, thereby reducing maintenance demands. Dry filter boxes can also be installed at curb cut inlets to collect sediment and other debris and to facilitate easy long-term maintenance.



Elevated underdrains can be integrated into a bioretention facility design to reduce nitrogen in stormwater (nitrogen is a contaminant of concern for marine and groundwater) and provide more moisture for plants during our dry summers.



The current bioretention soil mix specification (40% compost and 60% sand) should not be used within ¼ mile of phosphorus-sensitive waterbodies per the 2019 Stormwater Management Manual for Western Washington (Volume V, Chapter 5). A new bioretention soil mix specification is being developed that can be used near phosphorus-sensitive waterbodies and should be available for use in 2020.



Select native perennial plants that are already adapted to the region, have lower irrigation demands, and require less maintenance once established.

## What's new in maintenance



Traditional landscaping crews may need additional training for bioretention maintenance versus traditional landscaping maintenance. Often, bioretention facilities are designed for a lower level of pruning and vegetation removal than a typical landscaped feature.



Bring boards to stand on or use maintenance pathways (see design tips) during maintenance to reduce soil compaction.



Use a vacuum truck to quickly and easily clean out a mortar bed or dry filter box (see What's new in Design and Installation).

## More Information and Resources

[Stormwater Management Manual for Western Washington](#)

[Low Impact Development Technical Guidance Manual for Puget Sound](#)

[Rain Garden Handbook for Western Washington](#)

[Western Washington LID OandM Guidance Document](#)

[Statewide LID Training Program Module 3.2 \(Intermediate LID Design: Bioretention\), Module 5.0 \(Advanced Longterm LID Operations: Bioretention\), and Module 6.2 \(Advanced LID Design: Bioretention Media and Compost Amended Soils\)](#)

[Washington State University Extension and Washington Stormwater Center LID Training](#)

[Washington State University Assessing and Monitoring Rain Gardens](#)

[12,000 Rain Gardens Resources for Rain Gardens](#)



# Pervious Concrete

Pervious concrete is a rigid pavement similar to conventional concrete that uses a cementitious material to bind aggregate together. The fine aggregate (sand) component is reduced or eliminated in the gradation compared to conventional concrete; as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

Pervious concrete is typically used for low-volume residential streets, parking lots, public walkways and sidewalks, bike lanes, plazas, and patios. Pervious concrete is a durable pavement with a similar life span to conventional concrete.

## Benefits

- Allows for direct infiltration into the subgrade soils, maximizing site functionality while reducing surface runoff
- Can reduce or eliminate the need for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which saves on overall project cost and space
- Can be mixed in smaller batches for repair and replacement
- Reduces noise caused by tire-pavement interaction
- Long-lasting, high-strength choice for permeable pavement

## Design Tips

- Different colors can be added to pervious concrete to integrate artistic elements and designate different use areas in plazas, patios, walkways, or parking lots (e.g., parking stalls, walkways, play areas, etc.).
- Can be used on slopes up to 6% with check dams in the reservoir course.
- Plan project staging and erosion control measures to avoid contaminating or compacting the subgrade.
- Can be striped like conventional solid pavement.



### CASE STUDY

The City of Lacey Regional Athletic Complex includes 36,000 square feet of pervious concrete that directly infiltrates rainfall through the ballfield plaza. A majority of the site's two miles of trails were constructed with porous asphalt. Stormwater runoff from the remainder of the 70-acre site is routed to infiltration trenches beneath the ballfields.

## What's new in design and installation



Pervious concrete specifications developed by the APWA-WA Construction Materials Committee are now part of WSDOT's General Special Provisions (GSPs) and have addressed design issues and inconsistent specifications encountered in past installations: [www.wsdot.wa.gov/partners/apwa](http://www.wsdot.wa.gov/partners/apwa)



Researchers are currently testing pervious concrete mixes with additives such as carbon fiber composites to increase durability and strength. The composites—a waste product of the aviation industry—are dispersed throughout the pavement mix to provide uniform strength.



Setting time and shrinkage are accelerated in pervious concrete construction. Joint installation should quickly follow compaction. Rolling joint tools are recommended for their efficiency and are recommended over sawcutting to reduce raveling and clogging from cutting operations.



The National Ready Mixed Concrete Association (NRMCA) offers a pervious concrete contractor certification program. Three levels of certification are available: pervious concrete technician, pervious concrete installer, and pervious concrete craftsman. The Washington Aggregates and Concrete Association (WACA) offers courses on an as-needed basis. A database of the certifications can be found on NRMCA's website: [www.nrmca.org/certifications/pervious/SearchNew](http://www.nrmca.org/certifications/pervious/SearchNew)



Pervious concrete is designed using traditional rigid pavement methods using a factored flexural strength; however, traditional ASTM test methods for concrete do not apply, and alternate construction verification methods are used.



Observation wells (6-inch PVC pipe) that extend to the bottom of the aggregate layer should be integrated into the design to help facilitate routine inspections and maintenance.

## What's New in Maintenance



Routine vacuuming with a regenerative air vacuum sweeper is recommended to remove accumulated sediments. The frequency of the vacuuming directly depends on the amount of sediment buildup over time, but it should be done at least once annually.



Small ride-on cleaning equipment is now available for routine and restorative maintenance of pervious concrete surfaces.



Restorative maintenance is more expensive and time-consuming than routine maintenance, but can be used to restore sections of pavement that have not been adequately maintained.

## More Information and Resources

[Stormwater Management Manual for Western Washington](#)

[Western Washington LID OandM Guidance Document](#)

[Pervious Concrete Contractor Certification Program](#)

[Statewide LID Training Program Module 3.3 \(Intermediate LID Design: Permeable Pavement\) and Module 5.1 \(Advanced Long-term LID Operations: Permeable Pavement\)](#)

# Porous Asphalt

Porous asphalt is a flexible pavement similar to conventional asphalt that uses a bituminous binder to bind aggregate together. The fine aggregate (sand) component is reduced or eliminated in the gradation compared to conventional asphalt; as a result, voids form between the aggregate in the pavement surface and allow water to infiltrate.

Porous asphalt is typically used for low-volume residential streets, parking lots, public walkways and sidewalks, bike lanes, plazas, and trails.

## Benefits

- Allows for direct infiltration into the subgrade soils, maximizing site functionality while reducing surface runoff.
- Can reduce or eliminate the need for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which saves on overall project cost and space.
- Reduces noise caused by tire-pavement interaction.
- Does not have to cure and can be opened to traffic sooner.
- Lower cost choice for permeable pavement.

## Design tips

- Seasonal availability of the required asphalt binder should be considered in project planning.
- Can be used on slopes up to 6% with check dams in the reservoir course.
- Plan project staging and erosion control measures to avoid contaminating or compacting the subgrade.
- Can be striped like conventional solid pavement.
- Use for projects that will have light loads and minimal turning movements, such as driveways and minor roads. Porous asphalt is easily damaged with larger vehicles and under turning movements.



### CASE STUDY

In 2007, the City of Olympia, Wash. conducted a study of varying stormwater mitigation strategies on two blocks of Decatur Street between 9th and 11th. A total of 200 feet of porous asphalt roadway was compared to conventional asphalt and traditional stormwater management facilities and was found to have similar cost/benefit ratios for treatment efficiency.

## What's new in design and installation



Porous asphalt specifications developed by the APWA-WA Construction Materials Committee are now part of WSDOT's General Special Provisions (GSPs) and have addressed design issues and inconsistent specifications encountered in past installations: [www.wsdot.wa.gov/partners/apwa](http://www.wsdot.wa.gov/partners/apwa)



Porous asphalt does not require proprietary ingredients or special paving equipment. With proper mix design, general contractors can install porous asphalt with minimal additional training or certification.



Insulated covers over loads during hauling can reduce heat loss during transport and increase working time. Temperatures at delivery that are too low can result in shorter working times, increased labor for hand work, and increased cleanup from asphalt adhering to machinery.



Air temperatures should be no lower than 45 degrees Fahrenheit during installation of porous asphalt.



Observation wells (6-inch PVC pipe) that extend to the bottom of the aggregate layer should be integrated into the design to help facilitate routine inspections and maintenance.

## What's New in Maintenance



Routine vacuuming with a regenerative air vacuum sweeper, or pressure washing, is recommended to remove accumulated sediments. The frequency of the vacuuming directly depends on the amount of sediment buildup over time, but it should be done at least once annually.



If pavement patching is necessary, conventional asphalt can be used for small areas (typically less than 10% of the pavement area).



Small ride-on cleaning equipment is now available for routine and restorative maintenance of porous asphalt pavement.



Restorative maintenance is more expensive and time-consuming than routine maintenance, but can be used to restore sections of pavement that have not been adequately maintained in the past.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Western Washington LID O and M Guidance Document](#)

[National Asphalt Pavement Association](#)

[Statewide LID Training Program Module 3.3 \(Intermediate LID Design: Permeable Pavement\) and Module 5.1 \(Advanced Long-term LID Operations: Permeable Pavement\)](#)

[Washington Stormwater Center Permeable Pavement Training Videos](#)



# Permeable pavers / open-cell grids

Permeable interlocking concrete pavers (PICPs) are solid, precast, manufactured modular units. The pavers are solid (impermeable), and the joints are filled with aggregate (permeable). Permeable pavers are typically installed in plazas, patios, sidewalks, driveways, and parking lots.

Open-celled grid systems are made of concrete or plastic. The grid openings can be filled with topsoil and grass, or aggregate (permeable). Grid systems are typically installed in overflow parking areas, emergency vehicle access roads that are not frequently used, and driveways.

## Benefits

- Permeable pavers and open-celled grid systems allow for direct infiltration into the subgrade soils, maximizing site functionality while reducing surface runoff.
- Can reduce or eliminate the need for traditional curbs, gutters, drainage structures, piping, water quality treatment, and detention, which saves on overall project costs and space requirements.
- Ability to remove a few pavers or grid segments at a time to access underlying aggregate, then replace by hand rather than sawcut and repave.

## Design tips

- Permeable pavers can be used to integrate artistic elements into plazas, patios, or walkways.
- Different colors or patterns of permeable pavers can be used to designate different areas (e.g., parking stalls, walkways, play areas, etc.)
- Permeable pavers and open-celled grid systems can be installed just in parking stalls or in entire parking lots.
- Open-celled grid systems can be a helpful solution for overflow parking areas as they typically have low maintenance needs and costs.



### CASE STUDY

Chuck's Produce in Vancouver, Wash. integrated permeable pavers into its parking lot design when it opened a second location. A total of 29,000 square feet of permeable pavers were installed in the parking stalls and sidewalks. Colored pavers designate sidewalks and areas where shopping carts should be returned.



## What's new in design and installation



Permeable pavers and open-celled grid systems can be used for low-speed, heavier vehicle traveling surfaces. With an appropriate aggregate course depth below, permeable pavers can support up to 8,000 pounds per square inch, and open-celled grid systems can support up to 15,000 pounds per square inch.



Some of the original permeable pavers on the market did not meet ADA standards due to the width of the aggregate-filled joints; however, there are now numerous options available from several different vendors with narrower joints that meet ADA standards. Several open-celled grid systems can also be designed to meet ADA standards.



Mechanical paver installations can save time and money on larger paver installations compared to manual paver installations, but only work with full pavers (no partial bricks) and specific patterns.

- Mechanical paver installation: ~3,000 to 10,000 square feet per machine per day
- Manual paver installation: ~1,000 square feet per person per day



In addition to PICP and open-celled grid systems, there is also a pervious paver available made of natural stone. Water can flow through the pervious paver itself (approximately one gallon per second per square foot), so the aggregate-filled joints included in a traditional PICP system are not necessary to include in the design, and a smaller area of pervious pavers may be needed to manage stormwater runoff from the site.



The Interlocking Concrete Pavement Institute (ICPI) offers a one-day PICIP course for contractors on installing permeable pavers. A PICIP specialist designation can also be earned by meeting additional requirements: [www.icpi.org/node/2727](http://www.icpi.org/node/2727).

## What's new in maintenance



Moss grows on permeable and impermeable pavement in the Pacific Northwest, but there are options for removing moss and weeds in paver joints. If moss is inhibiting infiltration or posing a slip safety hazard, it can be removed from sidewalks using a stiff broom in the summer when it is dry. Vacuum sweeping or a combination of a stiff broom/power brush can remove moss from parking lots and roadways. Weed burners can be useful tools for removing weeds growing in paver joints.



The ICPI and multiple vendors have developed materials to support design and maintenance to ensure permeable pavers are properly installed and meet long-term performance goals.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Western Washington LID OandM Guidance Document](#)

[Interlocking Concrete Pavement Institute \(ICPI\)](#)

[Statewide LID Training Program Module 3.3 \(Intermediate LID Design: Permeable Pavement\), and Module 5.1 \(Advanced Long-term LID Operations: Permeable Pavement\).](#)



# Vegetated roofs

**Vegetated roofs (also known as green roofs and ecoroofs) are thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs. All vegetated roofs consist of four basic components:**

- Waterproof membrane
- Drainage layer
- Lightweight growth medium (typically 2 to 6 inches)
- Vegetation (ranging from low groundcover to trees)

**Additional (optional) components may include:**

- Protection layer
- Root barrier
- Insulation
- Moisture-retention mat
- Leak-detection system
- Filter fabric

## Benefits

- Increases property values through social, economic, and environmental benefits that help to offset design costs. These roofs often double as social space in buildings where people gather.
- Reduces energy usage (average of 10%) and doubles the lifespan of a typical roof (to 50 years).
- Reduces cooling load and tenant energy costs.
- Provides an aesthetically pleasing amenity that has been shown to relieve mental fatigue and lower stress.
- Reduces peak flows (by approximately 50%) and total runoff volume (up to 70%).
- Reduces heat island effects and improves air quality within dense urban settings.

## Design tips

- A variety of planting palettes can accommodate varying light availability, roof slope, irrigation, and desired maintenance frequency. Plants can range from low groundcover to tall trees.
- Roof slopes between 5 to 20 degrees are most suitable, but vegetated roofs can be installed on roofs with slopes up to 40 degrees with specific design.
- Vegetated roofs should be combined with a rainwater harvesting system with caution. The water filtered through the vegetated roof contains tannins and fine sediment.



## CASE STUDY

Mukilteo City Hall (completed in 2008) was the first facility in Snohomish County to be certified as LEED Gold. It includes a 2,900-square-foot vegetated roof in addition to permeable pavement (pervious concrete and open-celled grass grids) and a biofiltration swale.

## What's new in design and installation



Modular vegetated roof systems are available in trays or mats that can speed up the installation process and reduce costs. Trays or mats can be delivered to the site either partially or fully planted.



There is a green roof professional (GRP) training and accreditation program available that addresses design and installation, waterproofing and drainage, and plants and growing media: <https://greenroofs.org/green-roof-professional-training>



Vegetated roof retrofits can occur on existing conventional roofs with the assistance of a licensed structural engineer. Considerations should be made for the additional dry and wet soil weight, as well as wind loading.



The City of Portland's Ecoroof Program has developed numerous helpful vegetated roof resources, including an Ecoroof Handbook, an Ecoroof Guide, information on a 2008-2012 incentive program, and videos addressing a range of topics including permitting, vegetation, installation, operations and maintenance, irrigation, and case studies: [www.portlandoregon.gov/bes/44422](http://www.portlandoregon.gov/bes/44422)

## What's new in maintenance



Weeding and irrigation are the primary maintenance requirements for vegetated roofs. Roof drains must be kept clear of blockage and debris to prevent clogging.



Vegetated roofs require a specialized growth medium engineered for the specific system installed. Adding compost per manufacturer's recommendations will help to maximize functionality and plant growth.



Sedums can be mulch mowed to create cuttings and encourage establishment during the first two years or as needed to increase establishment in future years.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Low Impact Development Technical Guidance Manual for Puget Sound](#)

[Western Washington LID OandM Guidance Document](#)

[Statewide LID Training Program Module 3.5 \(Rainwater Collection Systems and Vegetated Roofs\) and Module 2.1 \(Introduction to LID for Inspection and Maintenance Staff\)](#)

# Rainwater harvesting

Rainwater harvesting is the capture and storage of rainwater for beneficial use. In 2009, the Washington Department of Ecology issued a rainwater interpretive policy, which clarifies that a water rights permit is not required to use water collected from a rooftop in Washington. Roof runoff may be routed to cisterns for storage and nonpotable uses such as:

- Irrigation
- Toilet flushing
- Cold water laundry

Rainwater harvesting occurs on larger-scale commercial and institutional projects and on smaller-scale residential projects with pumped systems and simple gravity-fed rain barrel systems.

## Benefits

- Reduces energy consumption within a community by decreasing demand for treated water distributed by local municipalities.
- Conserves water and mitigates stormwater flows.
- Marketed as a green feature alongside other low-impact development features such as bioretention or rain gardens.

## Design tips

- Can be designed for potable or non-potable uses. Potable uses are limited to single-family residential applications.
- Cisterns are available in a variety of sizes, shapes, materials, and colors to fit site constraints, cost, and aesthetics, either blending in or contrasting with the building and site design.
- Cisterns may be placed above, below, or partially buried below the ground surface.
- For potable systems, prefinished metal roofing is preferred.
- Install pre-filters and screen all inflows to the cistern with 1/16" stainless steel mesh to prevent leaves and other debris from entering the cistern.



### CASE STUDY

The Center for Urban Waters in Tacoma, Wash. (completed in 2010) follows the concept of a living laboratory, incorporating sustainable features to minimize the building's environmental footprint. Rainwater is collected into a 10,000-gallon cistern and reused for irrigation and low-flow flush fixtures within the building.



## What's new in design and installation



Material lifespan is an important design consideration when installing a rainwater harvesting system. Typical warranties for cisterns range from 15 to 30 years, while pumps have warranty periods ranging from 2 to 10 years.



The American Rainwater Catchment Systems Association (ARCSA) and the American Society of Plumbing Engineers (ASPE) have developed design and installation standards for rainwater catchment systems for engineers, designers, plumbers, builders/developers, local government officials, and end users:

[www.aspe.org/content/arcasaaspeansi-63-2013-rainwater-catchment-systems-electronic-download](http://www.aspe.org/content/arcasaaspeansi-63-2013-rainwater-catchment-systems-electronic-download)



The ASPE offers an on-demand rainwater harvesting webinar and a green plumbing design certificate program:

- Rainwater harvesting webinar: <https://education.aspe.org/products/rainwater-harvesting>
- Green plumbing design program: <https://aspe.org/GPD>



The RainWise program in King County and Seattle offers training and certification courses for contractors and rebates for eligible property owners: [www.700milliongallons.org/rainwise](http://www.700milliongallons.org/rainwise)



The Washington Stormwater Center developed a video that documents a simple potable rainwater system: <https://vimeo.com/133942623>

## What's new in maintenance



Cisterns generally have low maintenance demands but can accumulate sediment over time. An annual cistern inspection is recommended to identify and remove any debris.



Keeping roof gutters clear is an important step to reducing sediment accumulation and maintenance issues. One of the most common maintenance requirements is annual filter replacement. Pump replacement can be minimized with proper care of system components.



Water quality testing is required for rainwater harvesting for potable use.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Rainwater Interpretive Policy and Rainwater Harvesting Calculator](#)

[Statewide LID Training Program Module 3.5 \(Rainwater Collection Systems and Vegetated Roofs\) and Module 2.1 \(Introduction to LID for Inspection and Maintenance Staff\)](#)

# Amended soil

Amended soil refers to the practice of restoring soils that are disturbed during construction activities. Soil is biologically active and is composed of weathered rock fragments and organic matter, which is full of living microorganisms. All soils can benefit from additions of organic matter, which serves to build and stabilize the structure of soil, improving both aeration and permeability.

**Options to restore disturbed soils include:**

- Till compost into existing soil
- Stockpile and reuse existing topsoil (amend if needed to meet organic matter content requirements)
- Import compost-amended topsoil and till into existing soil

## Benefits

- Reduces need for fertilizers and pesticides.
- Reduces irrigation demand by up to 50 percent (three- to seven-year payback on irrigation savings alone).
- Creates marketable buildings and landscapes.
- Decreases erosion.
- Improves plant health and survival.

## Design tips

- Leaving undisturbed vegetation and soil is always the preferred method for retaining soil health, but not always feasible in construction projects.
- Redistribute existing topsoil whenever feasible to maintain soil health.
- Where existing soils cannot be reused, establish new topsoil to a minimum of eight inches to promote healthy plantings.
- Development of a soil management plan is often required with this BMP to determine the amounts of compost, amended soil, and mulch to be used on site.



### CASE STUDY

Redmond Ridge, a large, master planned development, had soft soils with excessive water retention and low nitrogen content. Developers graded the site 12 inches below finished grade and applied 14 inches of amended soil mix. Native duff and compost were blended offsite. Organic matter, pH, and C:N ratios were controlled to meet amended soil requirements and to achieve optimal plant growth.

## What's new in design and installation



In some jurisdictions, compost used for erosion control during the construction phase (compost blankets, berms, and compost filter socks) can be incorporated into the soil after the construction phase to meet amendment requirements, which eliminates disposal costs and promotes faster plant establishment and growth for significant cost savings.



“Topsoil” is not a defined, regulated product. Topsoil products can often include subsoil, uncomposted organic material, and/or land clearing and construction debris. Use mixes containing only clean compost and mined sand or “sandy loam,” as defined by the USDA.



Make sure to fence soil protection zones and inform all contractors and subs that stockpiles and vehicle and equipment traffic are not allowed in fenced areas. If temporary vehicle access is required, place steel plates over six inches of coarse wood chips.

## What's new in maintenance?



The most important maintenance activity is replenishing the soil organic matter content by leaving leaf litter and grass clippings on site and maintaining two to three inches of mulch over bare areas in the spring or fall. Arborist wood chips are preferred.



In order to maintain infiltration, compacted turf areas should be aerated and top-dressed with ¼ to ½ inch of compost.



Weeds should be removed manually using pincer-type weeding tools, flame weeders, or hot water weeders. Unhealthy vegetation should be removed and replaced.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Western Washington LID OandM Guidance Document](#)

[Statewide LID Training Program Module 2.1 \(Introduction to LID for Inspection and Maintenance Staff\) and Module 6.2 \(Bioretention Media and Compost Amended Soils\)](#)

[Building Soil Manual](#)

[Erosion Control with Compost](#)

# Minimal excavation foundations

A minimal excavation foundation minimizes a building's required mass grading and site disturbance by distributing its structural load onto piles or shorter perimeter walls, as opposed to using solid foundation slabs dug into the earth.

**Piles** are slender elements (pins, screws, or clusters) embedded on end into the ground to support a structural load.

**Perimeter walls** (also called post and beam, grade beam, or fin wall structures) are short and thick walls at building exteriors, that spread the building weight over a larger area of soil.

## Benefits

- Minimizes or eliminates excavation and soil compaction, which helps store and filter stormwater flows.
- Can be installed in areas with poor soils/drainage by accessing structurally superior sub-soils.
- Conserves materials by using 5 to 10 percent of the concrete that would be required for a typical foundation.
- While minimal excavation foundations are often used for boardwalks, decks, porches, and carports, they can also be used for entire houses or small commercial buildings (up to three stories high).

## Design tips

- Pile designs can be installed "pile first," where piles are installed prior to the supporting structure, or "post pile", where the structural walls are constructed and then the piles are driven through precast openings in the walls.
- A variety of materials can be used for piles – concrete, steel, or wood – depending on the design and cost constraints of the project.
- Perimeter walls should be terraced on sloped sites to minimize excavation requirements.
- When on slopes, buildings should be sited along contour lines to reduce excavation (cut and fill) and retain the site's infiltration capability.



### CASE STUDY

Clearwater Commons is a 16-unit cohousing development near North Creek in Bothell, Wash. All homes are built on pin piles in efforts to minimize impacts to the native soils and hydrology of the site. Stormwater runoff and shallow interflow are not interrupted by the building foundations and can maintain pre-development flow patterns.



## What's new in design and installation



Minimal excavation foundations can be installed as a combination of piles and pre-cast walls. This configuration allows for installation of sloped wall bases, with minimal grading requirements.



Pin foundation systems can be installed with large, handheld electric or pneumatic impact hammers, or hammers mounted on small construction equipment (e.g., skid steers). They require a heavy-duty air compressor and minor labor without any assistance from large machinery for installation.



Piles and perimeter walls reduce soil compaction from heavy machinery and equipment that is typically used for excavation.



Some foundation systems can be designed to allow for the removal and replacement of pilings, which can extend the life of the support indefinitely.

## What's New in Maintenance



Good drainage is critical to maintaining foundations. Maintaining a free-draining buffer material that separates the soil from the grade beam or other structural element mitigates risks of rot or corrosion.



Corrosion rates for galvanized or coated steel piling, or degradation rates for concrete piling, are typically very low to non-existent, and piling for these types of foundations can last for the life of the structure.



Maintenance or replacement may be needed for wood piling or systems that are exposed to salt air or highly caustic soils (typically in industrial areas).

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Low Impact Development Technical Guidance Manual for Puget Sound](#)

# Dispersion

**Dispersion is the release of surface and stormwater runoff through a vegetated area, resulting in attenuation of peak flows, some infiltration, and water quality benefits. The four primary types of dispersion are:**

- Downspout dispersion
- Concentrated flow dispersion
- Sheet flow dispersion
- Full dispersion

**Downspout dispersion systems are focused on roof runoff and can include splash blocks or gravel-filled trenches (also called dispersion trenches).**

## Benefits

- Dispersion is a simple design that can be easily installed or retrofitted into a property to handle runoff from driveways, sidewalks, and roofs. Dispersion also works well on linear roadway projects.
- It reduces peak flows by slowing entry of the rainwater into the conveyance system.
- It is generally cost effective, where space is available, as minimal infrastructure and maintenance is required.

## Design tips

- Use a level spreader to evenly distribute collected flows across vegetated areas.
- Avoid slopes greater than 15 percent where possible, unless using a level spreader (which can manage slopes of up to 33 percent).
- Construct flowpaths as groundcover in vegetated flowpaths are traditionally undisturbed native landscape or grass, but constructed flowpaths may be feasible (see What's new in design and installation).
- Dispersion flowpaths may be restricted or infeasible in environmentally critical areas, including steep slopes, contaminated sites, and septic drain fields.
- Minimize the area that needs to be cleared or grubbed. Maintaining plant root systems is important for dispersion areas.



### CASE STUDY

Cordata Park is a 25-acre park in north Bellingham. Stormwater runoff from the park is collected and conveyed to onsite wetlands to maintain hydrologic inputs to the environmentally critical areas. Dispersion trenches are used to diffuse the stormwater into the wetlands across a wide area rather than a point discharge, which may cause erosion.

## What's new in design and installation



Previously developed areas can be converted to native vegetation suitable for dispersion, provided underlying soils are compost amended, soils are de-compacted, and native species are planted to a specified density. Additional information can be found in the Stormwater Management Manual for Western Washington (BMP T5.30 – Full Dispersion).



Using low-ground pressure vehicles and equipment during construction minimizes compaction.

## What's new in maintenance



Dispersal areas must be watered once every one to two weeks during the establishment period (initial one to two years) and during prolonged dry periods.



If vegetation coverage is poor, assess for nutrient deficiencies, amend soils to promote plant health, and/or replant as needed with appropriate species for the soil and moisture conditions.



Aggregate in rock pads can become eroded or dislodged over time and may need to be replaced occasionally.



Vegetative flowpaths must be maintained to remove obstructions such as weeds and rodent holes or mounds.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Western Washington LID OandM Guidance Document](#)

[Statewide LID Training Program Module 2.1 \(Introduction to LID for Inspection and Maintenance Staff\)](#)

[WSDOT Highway Runoff Manual](#)

# New and retained trees

Tree retention refers to retaining trees during new development and redevelopment activities. If retained trees meet specific size, location, and viability requirements, then a jurisdiction may allow a flow control credit to be applied.

Tree planting refers to planting new trees during new development and redevelopment activities. Similar to retained trees, new trees must meet specific size, location, and viability requirements to receive flow control credit (if allowed by the local jurisdiction). Evergreen trees receive a larger flow control credit than deciduous trees. Flow control credits are not typically applicable to trees in native vegetation areas or in planter boxes.

## Benefits

- Trees can increase property values.
- Retaining trees or planting new trees can reduce the size of other onsite stormwater facilities if flow control credit is applied. Tree retention [has more stormwater benefits](#) over planting seedlings.
- Networks of tree roots can improve soil stability, as roots can bridge weaker soils and anchor to more stable areas.
- Trees can provide additional benefits such as reduced heat island effect and improved air quality.

## Design tips

- Maintain setbacks between structures and new or retained trees in order to provide adequate space and light for optimal growth without interference.
- New and retained trees must meet minimum size requirements and be viable for long-term retention.
- Supplemental irrigation should be incorporated into site designs where new trees are planted to provide irrigation for three to five years following installation.



### CASE STUDY

In 2003, the Seattle Housing Authority redeveloped the High Point neighborhood in West Seattle to increase housing density. Retaining existing mature trees was an important part of the redevelopment, and many trees were marked with a dollar value to convey the importance of maintaining their vitality throughout the phased construction process.



## What's new in design and installation



Approved trees vary by jurisdiction due to local climates and soils. Check with local jurisdictions for currently accepted species if you are planning on planting a new tree in the right-of-way or applying a flow control credit. Consult an arborist if soil disturbance is proposed within the critical root zone (CRZ) of a retained tree. The CRZ is defined as the line encircling the base of the tree with half the diameter of the drip line. Specialized techniques such as augering or compressed air excavation instead of trenching can be used to protect and preserve tree roots during construction activities.



If roots on a retained tree must be cut, minimize impacts by avoiding excavation activities during hot and dry weather. Keep the retained trees well-watered before and after excavation activities and cover the exposed roots with mulch as soon as possible.

## What's new in maintenance



Apply mulch by hand in a ring around the tree to avoid covering the root flare. Avoid mulch volcanos!



Prune trees at the right time of year. Avoid pruning during spring growth flush. Deciduous trees should be pruned from November through February. Hazardous trees should be pruned at any time of the year to avoid risk or injury.



To reduce scald injury, do not prune trees with thin bark in the summer. Do not prune pine or elm species from May through October to reduce possible exposure to bark beetle (pine) or Dutch Elm Disease (elm).



Ensure that newly planted trees receive adequate water during a three- to five-year establishment period. Most trees require 10 to 15 gallons once every one to two weeks during the first summer and every two to four weeks during the second and third summers. Additional watering may be needed during prolonged dry periods.



Retaining or using native tree species will help reduce maintenance requirements, as they require less care within the environment.

## More information and resources

[Stormwater Management Manual for Western Washington](#)

[Low Impact Development Technical Guidance Manual for Puget Sound](#)

[Western Washington LID OandM Guidance Document](#)

[Statewide LID Training Program Module 2.1 \(Introduction to LID for Inspection and Maintenance Staff\)](#)

[King Conservation District Urban Forest Health Program](#)

[A guide to Washington State's Urban Tree Canopy](#)

[Puget Sound Urban Tree Canopy and Stormwater Management](#)

## Section 2: Providing incentives

### Incentivizing LID for developers

This section is intended for use by **municipal staff**. As noted in the **Social Marketing Report**, **incentives are the primary motivator for developers to implement “above and beyond” LID solutions**. This section includes tools to address the gap in available incentive programs by providing jurisdictions with guiding questions to consider when developing or modifying an incentive program. This section also provides incentive program factsheets that offer a more in-depth look at each incentive program type.

[Guiding Questions for Developing or Modifying an Incentive Program](#) asks jurisdictions to consider key questions when developing an incentive program. It also points to a set of incentives that align with specific goals, audiences, and resources for the jurisdiction to consider. It may be helpful to review the incentive factsheets before answering these questions.

**Incentive program factsheets** build upon the guiding questions for developing or modifying an incentive program and provide information about:

- Advantages and disadvantages of incentive program types.
- Suitability for various jurisdiction circumstances.
- Recommendations for program design and implementation.
- Case studies for programs currently offered in local jurisdictions.
- The incentive factsheets address the following program types:

#### **The incentive factsheets address the following program types:**

[Award and recognition](#)

[Fee discounts](#)

[Grants](#)

[Land use and permitting](#)

[Expedited process](#)

[Rebate and cost-share programs](#)

# Incentive programs as a key motivator

Given that incentives are the primary motivator for developers to implement “above and beyond” LID solutions, this section of the guidebook aims to address the gap in current incentive programs offered by jurisdictions. Incentive programs that address developers’ key considerations of affordability, feasibility, and return on investment, will be the most effective in motivating developers to go “above and beyond.”

## LID incentives survey results

An LID incentives survey was circulated to public works, community development and planning, and stormwater permit staff throughout Washington state to obtain information on the [existing incentives jurisdictions are using to encourage the use of LID BMPs](#); 93 participants took the survey across 65 jurisdictions. **When asked what incentives, assistance, or other strategies their jurisdiction offers to increase use of LID, 43% reported “none.”**

Incentive programs that address developers’ key considerations of affordability, feasibility, and return on investment, will be the most effective in motivating developers to go “above and beyond.”

## Affordability

During the social marketing research interviews, **all developers** indicated financial benefits would be a motivator to implement LID solutions in their projects or to go above and beyond a jurisdiction’s stormwater code requirements. Financial incentives like [grants, tax credits, and/or rebates](#) can minimize installation costs and help make LID a financially attractive, and possibly cost-saving, feature. During the social marketing research interviews, municipal staff noted financial incentive programs were very popular, and that these programs would benefit from increasing the dollar amount of the financial incentive and/or rebate.

## Feasibility

Developers noted strict regulations or lack of flexibility from jurisdictions as a barrier in considering creative LID solutions above and beyond the stormwater code requirements, and expressed an interest in code variances, such as allowing developers to increase density in exchange for incorporating LID above and beyond solutions. Flexibility was key in motivating developers to explore innovative stormwater solutions.

One developer shared a story about being required to buy custom planters only a few inches taller than standard planters. This requirement increased the cost of the planters ten-fold and added several months to the project timeline for manufacturing. In the developer’s mind, money and time were wasted for no perceived benefit. To incentivize developers, jurisdictions can increase the flexibility and feasibility of LID BMPs by offering [expedited process](#) and [land use and permitting](#) incentive programs. The City of Auburn’s Flexible Development Alternatives program does this by offering points for each LID BMP implemented; points then count toward incentives, including expedited permitting, density bonuses, and relaxed height restrictions.

## Return on Investment (ROI)

Developers favored financial incentives such as [reduced utility and permit fees](#) as they mitigate financial risks associated with LID implementation and create long-term cost savings for property owners. Respondents to the LID incentives survey also identified fee discount programs as popular programs in the jurisdictions that provided them.

During the research interviews, developers referred to the LEED certification or green-building programs as a reason to include additional environmentally friendly features. They see green [awards and recognition](#)

programs as a way to make their properties more attractive to public demand, improving their return on investment.

**Figure 6. Barriers and motivators for developers to implementing LID solutions**

	Barriers ( - )	Motivators ( + )
AFFORDABLE	Expense Burdensome permitting/approval process	Tax credits Grants or refunds Expedited permitting process LID points program
FEASIBLE	Building site limitations Site/jurisdiction requirements Jurisdictional staff/code inflexibility	Code variances Training and resources
SOLID ROI	Ongoing maintenance needs Evolving technologies	Reduced utility rates Reduced permit fees LEED or green certification Awards or recognition



# Guiding questions for developing or modifying an incentive program

Jurisdictions are encouraged to use these questions when developing incentive programs to think through: goal, audience, and resources. After using this guide to identify the best incentive type(s), jurisdictions can review the factsheets for each of the below incentive types.

- Financial Incentives
  - [Grants](#)
  - [Fee discounts](#)
  - [Rebate and cost-share programs](#)
- [Award and recognition](#)
- [Land use and permitting](#)
- [Expedited process](#)

## Instructions

1. Consider and answer the questions to the best of your ability for each of the three sections.
2. After each section, review your answers and read the accompanying text to determine which incentive type(s) best meet your needs for that section.
3. Use the results for each section to identify the best incentive type(s) to develop or modify.
4. Once you have identified your best incentive type(s), you can find additional information in the associated factsheets in this guidebook.

## Defining your goal

### Q: What is your primary goal for modifying or developing an incentive program?

#### **Awareness**

Increase awareness about Low-Impact Development and stormwater issues

#### **Enhancement**

Improve or adapt an existing incentive program or create a new incentive program

#### **Implementation**

Motivate or empower audiences to go above and beyond state and federal requirements

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If your primary goal is **awareness**, an [award and recognition](#) incentive program may be the best option for you, as it is a lower-cost program that can increase awareness about LID and stormwater issues. The financial incentives ([grants](#), [fee discounts](#), and [rebates and cost-share programs](#)) are also good options for awareness incentive programs.

If your primary goal is **enhancement**, a [land use and permitting](#) incentive program may be the best option for you as it reduces some of the barriers to participating in an incentive program.

If your primary goal is **implementation**, any of the incentive programs will accommodate this goal, though during the social marketing research, financial incentives ([grants](#), [utility fee discounts](#), and [rebates and cost-share](#)) were rated most favorably by developers as a motivator.

## Characterizing your audience

**Q: What customer type makes up the largest impervious surface area?**

- Commercial
- Residential

**Q: Are smaller or larger property types most in need of LID incentivization?**

- Smaller
- Larger

**Q: What type of development do you want to focus on?**

- New development
- Redevelopment
- Retrofit

**Q: How much new development do you expect in your jurisdiction?**

- Not a lot of new development
- A lot of new development

**Q: Are there priority areas for localized flooding or erosion control or that have good infiltration potential?**

- Yes
- No

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**Most incentive types will fit the needs for any audience type.** If you are targeting smaller properties or areas without a lot of new development, an [expedited process](#) program may not be the best fit because implementing the program will have less of a ROI for these audiences.

## Aligning your resources

**Q: What resources can you allocate to a program? Consider small and large needs.**

- Budget
- Staff capacity
- Public-private partnerships
- Infrastructure

**Q: What barriers limit the creation of the program?**

- Budget
- Staff capacity
- Support from management
- Inability to collaborate across programs and jurisdictions
- Technical knowledge

**Q: Do you have a stormwater utility fee (needed for fee discounts) or another means of funding the program?**

- Yes
- No

**Q: Are grant opportunities available? Section 3 lists possible financial resources for jurisdictions, including grant opportunities.**

- Yes
- No

**Q: Are other departments within the jurisdiction supportive? Alternatively, is there upper level management or executive level support, or environmental goals that this program could support?**

- Yes
- No



## Q: How does equity play into potential incentive program design?

It is important to consider equity when investing in green infrastructure. Environmental pollutants, including stormwater runoff, disparately affect low-income neighborhoods, communities of color, and other marginalized communities. LID offers opportunities to address inequities through improving air and water quality, increasing tree canopy, and enhancing outdoor green spaces.

Examples of strategies local jurisdictions use include:

- The City of Seattle uses an [equity checklist](#), which asks a set of guiding questions for staff to consider.
- The City of Tacoma uses an [equity index](#), an interactive tool that highlights the disparities within the city, to evaluate projects and funding.

Each jurisdiction will face different considerations regarding environmental equity. We encourage staff to review any jurisdiction-specific materials regarding equity and to consider how they may apply to LID incentives.

- Does your jurisdiction offer funding for projects that align with citywide diversity and/or equity efforts? How may your program leverage this funding?
- Are there opportunities to partner with outside organizations, nonprofits, or other community leaders doing environmental equity work? How may your program incentivize these partnerships?
- How do historic planning and development inequities, like redlining and superfund sites, continue to impact communities in your jurisdiction? How may your program address these impacts?

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If you have **limited budget, staff capacity, and additional funding opportunities**, the financial incentives ([grants](#), [fee discount](#), and [rebates and cost-share programs](#)) might not be the best fit for your jurisdiction. The remaining incentive options would be most feasible to explore: [award and recognition](#), [land use and permitting](#), [expedited process](#).

Because developers see the highest value in financial incentives, **you may want to pursue a financial incentive program regardless of local context**. Consider beginning with a pilot program that you can scale up if/when additional resources become available. The pilot program could also increase management and executive level support before launching a full incentive program. Some of the resources listed in Section 3 may help with funding for starting an incentive program.