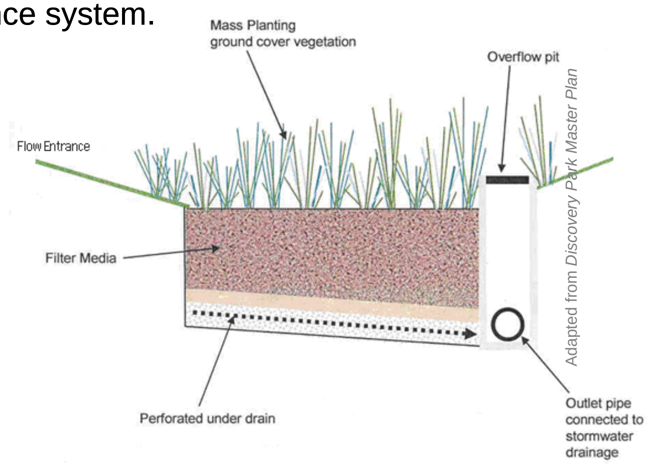
BIORETENTION

Bioretention is a low-impact development (LID) technique that allows for the effective management of stormwater on-site by using a combination of plants and layers of soil, sand, and mulch to reduce quantity and improve quality of stormwater.

How does bioretention work?

Bioretention utilizes the chemical, biological, and physical properties of plants, microbes, and soils to remove pollutants from stormwater runoff.

In cases where bioretention is used, stormwater flows over impervious surfaces and is conveyed as sheet flow down a vegetated slope, which slows the incoming runoff velocity and provides initial filtration of particulates from the runoff. The runoff continues to a ponding area where it is filtered by plants, an organic or mulch layer, and amended soil. Many natural and biological processes, such as adsorption, filtration, and decomposition, occur during filtration. These processes remove pollutants and improve water quality. The filtered runoff is then collected in an underdrain and returned to a conveyance system.



Why use bioretention?

In addition to providing stormwater management benefits, such as runoff quantity control and pollutant removal, bioretention cells often result in cost savings by decreasing the need for traditional stormwater structures, such as inlets and pipes. Bioretention areas can also improve the aesthetics of areas such as parking lots or curbsides. (See pictures at right).

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Stormwater Benefits

- ✓ Runoff quantity control
- ✓ Runoff quality control
- ✓ Pollutant removal
- ✓ Groundwater recharge

Additional Benefits

- ✓ Attractive landscape
- ✓ Wildlife habitat
- ✓ Cost savings
- ✓ Educational potential

Parking lot incorporating bioretention area

Notice how the bioretention area helps to make the parking lot an attractive landscape in addition to managing stormwater effectively.

Parking lot lacking bioretention areas

Not only does this lot have an excessive amount of impervious cover and thus stormwater runoff, it is also an unattractive space.

Upstate Forever

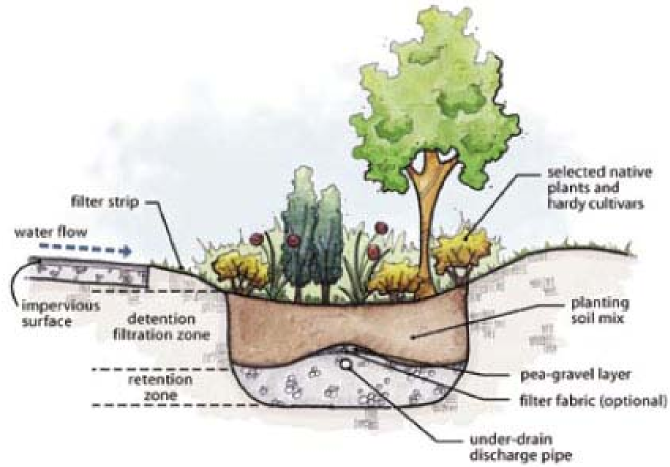
Filter strip (optional)
The filter strip, or pretreatment area, located between the contributing drainage area and the ponding area, reduces incoming runoff velocity and provides an initial filtration of particulates from the runoff. Grass buffer strips or vegetated swales are commonly used as pretreatment devices.

Flow entrance
In some cases, space limitations may make it difficult to incorporate pretreatment areas into the site. In such cases, alternative mechanisms may be used at the flow entrance to reduce the velocity of runoff as it enters the bioretention area. For example, curb cuts with energy dissipaters, such as landscape stone, may be used. Such mechanisms are successful in slowing the velocity of incoming runoff but must be cleaned regularly to prevent sediment and debris build-up.

Plant materials
Both woody and herbaceous plants in the ponding area help to remove water through evapotranspiration and remove nutrients and pollutants through plant uptake. Vegetation also serves to stabilize the surrounding soils. Use of native species is highly recommended.

Ponding area
The ponding area provides for temporary storage of stormwater runoff prior to evaporation, infiltration, or uptake, and provides additional settling capacity of particulates. The ponding area is typically three to four inches deep, with an eight-inch maximum depth.

Organic or mulch layer
The organic or mulch layer is placed on top of the planting soil and provides filtration, adsorption and bonding of heavy metals, as well as an environment conducive to the growth of microorganisms that degrade hydrocarbons and organic material. Three inches of mature mulch are recommended.



Source: *LID Technical Guidance Manual for Puget Sound*

Planting soil mix
The planting soil mix in the bioretention area acts as a filtration system, in which clay particles provide adsorption for hydrocarbons, heavy metals, nutrients, and other pollutants. The soil mixture should be approximately 60-75% sand, 25% silt or topsoil, and 10% organic or leaf compost; clay content should be less than 5%. Depth of the planting soil varies depending on the vegetation used, but often ranges from 1.5 to 4 feet.

Sand bed (optional)
A 12- to 18-inch sand bed may be placed between the planting soil and the pea gravel diaphragm to further slow the runoff and help distribute it through the entire basin. The sand must have less than 15% silt or clay content.

Pea gravel diaphragm
A pea gravel diaphragm is a layer of gravel located underneath the planting soil that traps sediment and debris, thereby minimizing clogging of the perforated pipe underdrain. It is recommended that a three- to nine-inch pea gravel diaphragm be placed below the amended soil and above the drainage system.

Filter fabric (In place of pea gravel diaphragm)
Many older bioretention designs use geotextile filter fabric in place of a pea gravel diaphragm to filter sediment and minimize clogging of the perforated pipe below. The filter fabric must meet a minimum hydraulic

conductivity rate of 75 gallons per minute per square foot and must not impede the infiltration rate of the soil medium. The filter fabric may be positioned under the planting soil mix and along the walls of the bioretention area to direct flow downward and to reduce underground lateral flow. The filter fabric must be placed along the sidewalls when installing a facility in a median strip or parking lot landscape island to prevent lateral flow of water under the pavement.

Filter fabric
(In addition to pea gravel diaphragm)

When a pea gravel diaphragm is incorporated into bioretention design, a permeable filter fabric must be placed beneath the pea gravel diaphragm and over the drainage system only above and two feet to either side of the underdrain. In this case, filter fabric is not necessary along sidewalls.

Drainage system

The drainage system consists of a perforated pipe underdrain in about one foot of pea gravel. It collects runoff that has filtered through the soil layers in the ponding area and returns the treated water to a conveyance system. The pipe itself is typically placed two to five inches from the bottom of the gravel to promote drainage and prevent standing water in the drain.

Overflow outlet

An overflow outlet must be provided in order to convey larger storm flows to the downstream drainage system or stabilized watercourse. Non-erosive velocities (0.5 foot per second) must be ensured at the outlet point.

"Design Components" adapted from the Georgia Stormwater Management Manual Vol. 2; Prince George's County, Maryland, Low-Impact Development Design Strategies Manual; Bioretention.com

Stormwater FAQ

What's the difference between rain gardens and bioretention areas?

Bioretention areas and rain gardens often look similar on the surface because they both use plants and ponding techniques to filter stormwater runoff. The terms are often used interchangeably; however, there are *key differences* between the two low-impact development techniques.

- ✓Bioretention areas are typically used on sites where there is extensive impervious surface; common applications include parking lot islands, roadside swales, and some residential areas
- ✓Rain gardens are used most often in residential or commercial landscapes where there are smaller drainage areas
- ✓Because bioretention areas generally drain more surface area, an underdrain helps to prevent ponding by directing excess filtered water to a stormwater conveyance system; rain gardens receive less runoff and therefore do not require an underdrain

Parking Lot Bioretention Area
Iowa

BENEFITS

Runoff Quantity Control

Bioretention areas can reduce runoff quantity by temporarily storing runoff water. Instead of being directed to a storm drain system, runoff is directed to a bioretention area where it filters through the plants and soil and is temporarily stored; this temporary storage reduces the immediate volume load on the storm drain system and it reduces the peak discharge rate. The actual reduction in volume varies depending on the site and size of the bioretention area.

Pollutant Control

Bioretention areas are able to significantly reduce pollutants in stormwater runoff when sized, designed, constructed, and maintained in accordance with recommended specifications. Bioretention areas can remove an average of 80% of the total suspended solids, 60% of total phosphorus, 50% of total nitrogen, and 80% of heavy metals, including cadmium, copper, lead, and zinc. For additional information and data on pollutant removal capabilities, see the National Pollutant Removal Performance Database (2nd Edition) and the National Stormwater Best Management Practices Database.

Additional benefits

Bioretention areas can be designed as attractive landscape features for areas such as parking lots that typically lack aesthetic appeal. In some cases, attractive bioretention areas can **raise nearby property values**. In addition, bioretention areas offer a natural habitat for birds, butterflies, and other animals.

Cost Savings

Bioretention areas can achieve between 15% and 50% net reduction of site development costs compared with conventional best management practices. Bioretention areas intercept runoff near the source, and therefore reduce the amount of storm drainage infrastructure needed, such as traditional curb and gutter systems, reinforced concrete pipes, and catch basins. For example, a hospital in Maryland saved $24,000 by reducing the amount of storm pipe from 800 feet to 230 feet. When the amount of stormwater structures is reduced, the cost of labor and installation is also usually lowered. Grading and sediment-removal costs may also be reduced because natural drainage flow patterns can be preserved.

"Benefits" adapted from the Georgia Stormwater Management Manual Vol. 2 and LID

LID IN THE UPSTATE

Our Lady of the Rosary
Greenville, South Carolina

Our Lady of the Rosary, a local church/school complex, installed a new 1.4-acre parking area on their site in 2004. This increased impervious surface area led to an increase in stormwater runoff volume that required installation of additional treatment structures. Concerns with a dry detention pond included in the initial site design led them to use a bioretention area for post-construction water quality control.

Because the bioretention area was the first to be designed and installed in the county, it was a learning process for all involved. The initial inspection showed that the water did not filter through the bioretention media properly. It was discovered that soil with high clay content had been used and that the area had been compacted during construction. In addition, because the bioretention area had been installed before the contributing drainage areas were stabilized, fine sediment from the surrounding area was clogging the structure. All of these factors contributed to a reduction in the soil's porosity. When stabilization of the new parking lot was complete, contractors fixed the drainage problem by replacing the original soil with the proper planting mix and made sure the soil was not compacted in the process. The bioretention area with turf grass and a maximum standing pool depth of one foot was successfully completed.

Our Lady of the Rosary bioretention area after storm event

SITE CONSIDERATIONS

	Bioretention area
Application	• Residential, commercial, municipal, industrial • Common applications: roadway median strips, parking lot islands, residential drainage
Space Required	• Minimum 200-square-foot area for small sites (10 feet x 20 feet ratio) • All designs except small residential applications should maintain a length to width ratio of at least two to one
Drainage Area	• Five acres maximum; one-half to two acres preferred
Soils	• Engineered soil media required to ensure adequate filtration • Clay soil not a restriction because soil is amended (only five percent clay content) and an underdrain helps with filtration (directs water away from the site)
Slopes	• Recommended slope: less than six percent • Bioretention areas should be constructed downgradient of the building/home
Water table/bedrock	• Minimum two-foot clearance above water table/bedrock
Proximity to building foundations	• Minimum distance of 10 feet downgradient from buildings and foundations is recommended
Proximity to septic field	• Maintain a 50-foot setback from the septic field
Minimum planting soil depth	• 1.5 feet
Special Considerations	• Minimize compaction of both the base of the bioretention area and the required backfill in order to prevent a reduction in infiltration rates and storage volumes

Adapted from the Georgia Stormwater Management Manual Vol. 2 and Maryland's Low-Impact Development Design Strategies Manual

MAINTENANCE

Schedule	Maintenance activity
As needed	• Prune and weed plants to maintain appearance • Replace mulch when erosion is evident • Remove trash and debris
Semi-annually	• Inspect inflow points for clogging and remove any sediment as needed • Inspect filter strip/grass channel for erosion or gullying and re-seed or sod as necessary • Inspect trees or shrubs to evaluate their health and remove any dead or severely diseased vegetation
Annually	• Test planting soils for pH, acidic levels preferred • If pH is below 5.2, limestone should be applied • If pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH
2-3 years	• Replace mulch over the entire area • Replace pea gravel layer if clogged or not filtering properly

Source: Georgia Stormwater Management Manual Vol. 2

Residential Bioretention Area

Seattle, WA

COST ESTIMATE

Bioretention Area

Item	Estimated unit cost (2005 dollars)
Excavation	$8-10/cubic yard
Bioretention media	$40-60/cubic yard
Filter fabric (optional)	$1-5/square yard
Gravel	$30-35/cubic yard
Four-inch diameter perforated underdrain pipe	$8-15/linear foot
Plants	$5-20 each
Mulch	$30-35/cubic yard
Total installation cost (for a 900-square-foot bioretention area)*	**$10,000**
Annual maintenance (cost per year after installation)	$550

Adapted from Fairfax County, VA, Bioretention Fact Sheet

*Receiving drainage from one-half acre of impervious surface

US Environmental Protection Agency Building,
Durham, North Carolina

In 2002, the EPA completed construction of a new 1.1 million-square-foot office and laboratory space. A variety of low-impact development techniques were incorporated in the design. Included were 11 bioretention areas, located throughout the site. These areas, planted with trees and shrubs that tolerate both wet and dry conditions, help to filter stormwater runoff as well as reduce the impact on the storm sewer system and receiving water body.

Cost Comparison of Wet Detention Pond and Bioretention Area for 10-Acre Watershed

	Bioretention area (in clay soil)	Wet detention pond
Construction cost	$124,445	$65,357
Annual maintenance cost	$583	$4,411
25 years of maintenance	$14,575	$110,275
Lifecycle cost (construction + 25 years of maintenance)	**$139,020***	**$175,632***

Adapted from NC State University Stormwater BMP Fact Sheet and Fairfax County, VA, Bioretention Fact Sheet

*Although bioretention areas have higher construction costs, their reduced maintenance costs result in significantly lower lifecycle costs than wet detention ponds.

ADDITIONAL LINKS

1. Prince George's County, Maryland, Bioretention Design Manual (http://www.co.pg.md.us/Government/AgencyIndex/DER/ESD/Bioretention/bioretention.asp)
   - Information regarding design, landscaping, construction, and maintenance
   - One of the most-used bioretention sources
2. Georgia Stormwater Management Manual, Vol. 2, Bioretention (www.georgiastormwater.com/vol2/3-2-3.pdf)
   - Describes benefits, design, construction, and maintenance
   - Provides engineering drawings
3. Low Impact Development Technical Guidance Manual for Puget Sound (http://www.psp.wa.gov/downloads/LID/LID_manual2005.pdf)
   - Comprehensive low-impact development manual with information about bioretention design, as well as many other LID techniques

4. Bioretention.com
(www.bioretention.com)
   - Provides comprehensive look at bioretention components, design, maintenance, and sizing
   - Contains suggested plants for bioretention in North and South Carolina
5. Low Impact Development Center (EPA), Bioretention Cell Specifications
(http://www.lowimpactdevelopment.org/epa03/biospec.htm)
   - Specifications regarding the materials, construction, placement, and maintenance of bioretention cells
6. An Evaluation of Costs and Benefits of Structural Stormwater Best Management Practices in North Carolina, NC State University
(http://www.neuse.ncsu.edu/Stormwater_BMP_Factsheet.pdf)
   - Provides cost comparison and pollutant removal information for bioretention areas, wet ponds, stormwater wetlands, and sand filters in North Carolina
7. Fairfax County, Virginia, Bioretention Fact Sheet
(http://www.lowimpactdevelopment.org/ffxcty/1-1_bioretentionbasin_draft.doc)
   - Provides basic information about bioretention areas, design, cost, maintenance, performance, and potential LEED credits

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