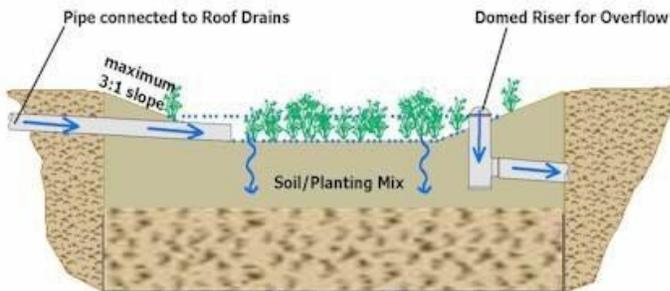


BMP 6.4.5: Rain Garden/Bioretention

RECHARGE GARDEN / BIORETENTION BED



A Rain Garden (also called Bioretention) is an excavated shallow surface depression planted with specially selected native vegetation to treat and capture runoff.

<p style="text-align: center;"><u>Key Design Elements</u></p> <ul style="list-style-type: none"> ▪ Flexible in terms of size and infiltration ▪ Ponding depths generally limited to 12 inches or less for aesthetics, safety, and rapid draw down. Certain situations may allow deeper ponding depths. ▪ Deep rooted perennials and trees encouraged ▪ Native vegetation that is tolerant of hydrologic variability, salts and environmental stress ▪ Modify soil with compost. ▪ Stable inflow/outflow conditions ▪ Provide positive overflow ▪ Maintenance to ensure long-term functionality 	<p style="text-align: center;"><u>Potential Applications</u></p> <p>Residential: Yes Yes Commercial: Ultra Yes Urban: Industrial: Yes Yes Retrofit: Yes Highway/Road: Yes</p>
	<p style="text-align: center;"><u>Stormwater Functions</u></p> <p>Volume Reduction: Medium Recharge: Med./High Peak Rate Control: Low/Med. Water Quality: Med./High</p>
	<p style="text-align: center;"><u>Water Quality Functions</u></p> <p>TSS: TP: 85% 85% NO3: 30%</p>

Other Considerations

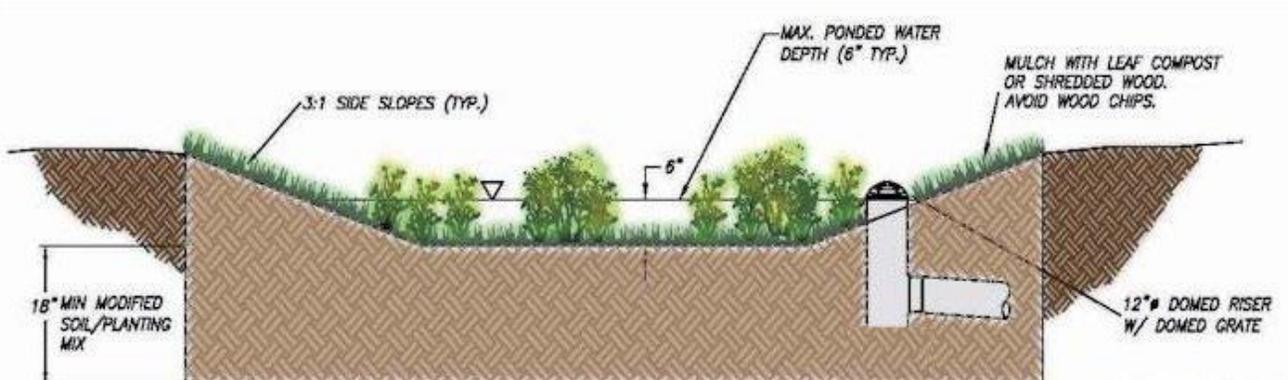
- **Protocol 1. Site Evaluation and Soil Infiltration Testing** and **Protocol 2. Infiltration Systems Guidelines** should be followed, see Appendix C

Description

Bioretention is a method of treating stormwater by pooling water on the surface and allowing filtering and settling of suspended solids and sediment at the mulch layer, prior to entering the plant/soil/microbe complex media for infiltration and pollutant removal. Bioretention techniques are used to accomplish water quality improvement and water quantity reduction. Prince George’s County, Maryland, and Alexandria, Virginia have used this BMP since 1992 with success in many urban and suburban settings.

Bioretention can be integrated into a site with a high degree of flexibility and can balance nicely with other structural management systems, including porous asphalt parking lots, infiltration trenches, as well as non-structural stormwater BMPs described in Chapter 5.

The vegetation serves to filter (water quality) and transpire (water quantity) runoff, and the root systems can enhance infiltration. The plants take up pollutants; the soil medium filters out pollutants and allows storage and infiltration of stormwater runoff; and the bed provides additional volume control. Properly designed bioretention techniques mimic natural ecosystems through species diversity, density and distribution of vegetation, and the use of native species, resulting in a system that is resistant to insects, disease, pollution, and climatic stresses.



Rain Gardens / Bioretention function to:

- Reduce runoff volume
- Filter pollutants, through both soil particles (which trap pollutants) and plant material (which take up pollutants)
- Recharge groundwater by infiltration
- Reduce stormwater temperature impacts
- Enhance evapotranspiration
- Enhance aesthetics
- Provide habitat

Primary Components of a Rain Garden/Bioretention System

The primary components (and subcomponents) of a rain garden/bioretention system are:

Pretreatment (optional)

- Sheet flow through a vegetated buffer strip, cleanout, water quality inlet, etc. prior to entry into the Rain Garden

Flow entrance

- Varies with site use (e.g., parking island versus residential lot applications)
- Water may enter via an inlet (e.g., flared end section)
- Sheet flow into the facility over grassed areas
- Curb cuts with grading for sheet flow entrance
- Roof leaders with direct surface connection
- Trench drain
- Entering velocities should be non-erosive.

Ponding area

- Provides temporary surface storage of runoff
- Provides evaporation for a portion of runoff
- Design depths allow sediment to settle
- Limited in depth for aesthetics and safety

Plant material

- Evapotranspiration of stormwater
- Root development and rhizome community create pathways for infiltration
- Bacteria community resides within the root system creating healthy soil structure with water quality benefits
- Improves aesthetics for site
- Provides habitat for animals and insects
- Reinforces long-term performance of subsurface infiltration
- Should be tolerant of salts if in a location that would receive snow melt chemicals

Organic layer or mulch

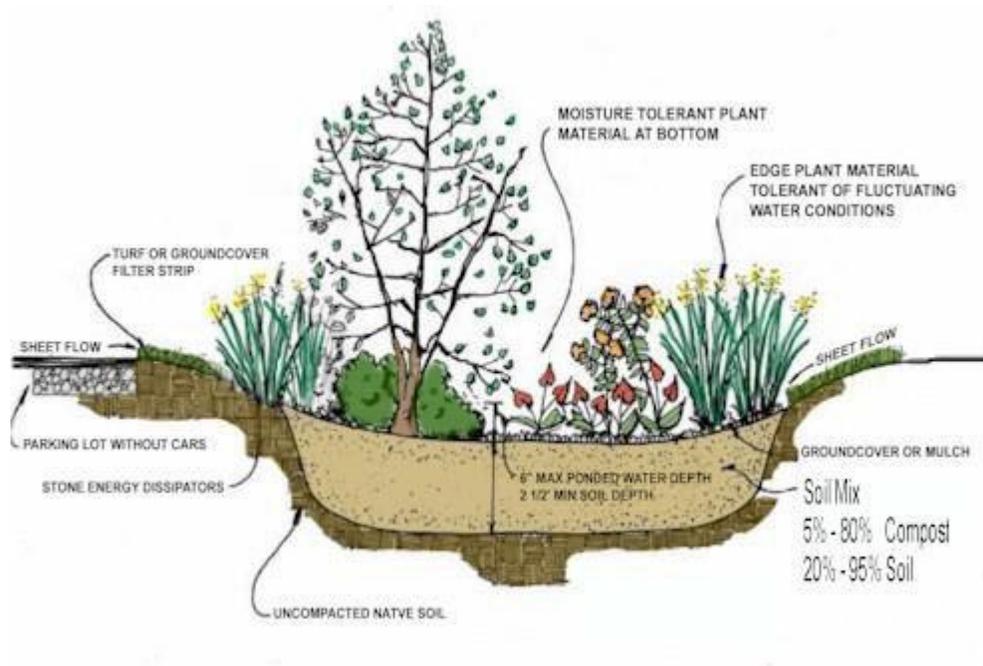
- Acts as a filter for pollutants in runoff
- Protects underlying soil from drying and eroding
- Simulates leaf litter by providing environment for microorganisms to degrade organic material
- Provides a medium for biological growth, decomposition of organic material, adsorption and bonding of heavy metals
- Wood mulch should be shredded - compost or leaf mulch is preferred.

Planting soil/volume storage bed

- Provides water/nutrients to plants
- Enhances biological activity and encourages root growth
- Provides storage of stormwater by the voids within the soil particles

Positive overflow

- Will discharge runoff during large storm events when the storage capacity is exceeded. Examples include domed riser, inlet, weir structure, etc.
- An underdrain can be included in areas where infiltration is not possible or appropriate.



Variations

Generally, a Rain Garden/Bioretention system is a vegetated surface depression that provides for the infiltration of relatively small volumes of stormwater runoff, often managing stormwater on a lot-by-lot basis (versus the total development site). If greater volumes of runoff need to be managed or stored, the system can be designed with an expanded subsurface infiltration bed or the Bioretention area can be increased in size.

The design of a Rain Garden can vary in complexity depending on the quantity of runoff volume to be managed, as well as the pollutant reduction objectives for the entire site. Variations exist both in the components of the systems, which are a function of the land use surrounding the Bioretention system.

The most common variation includes a gravel or sand bed underneath the planting bed. The original intent of this design, however, was to perform as a filter BMP utilizing an under drain and subsequent discharge. When a designer decides to use a gravel or sand bed for volume storage under the planting bed, then additional design elements and changes in the vegetation plantings should be provided.

Flow Entrance: Curbs and Curb Cuts



Flow Entrance: Trench Drain



Positive Overflow: Domed Riser



Positive Overflow: Inlet



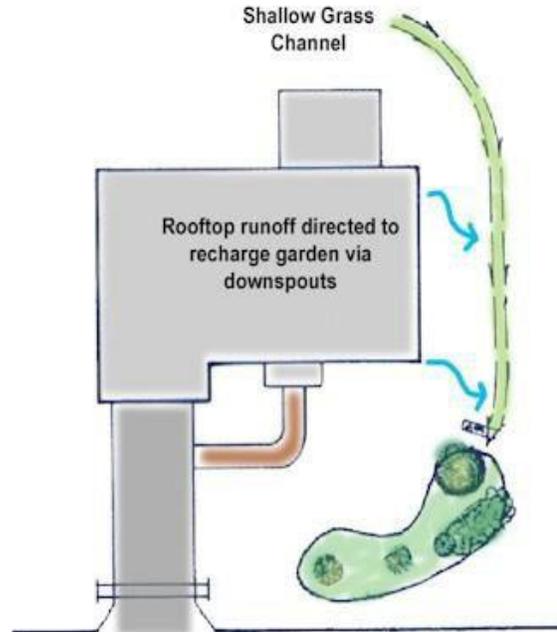
Applications

Bioretention areas can be used in a variety of applications: from small areas in residential lawns to extensive systems in large parking lots (incorporated into parking islands and/or perimeter areas).

- Residential On-lot**

Rain Garden (Prince George’s County)

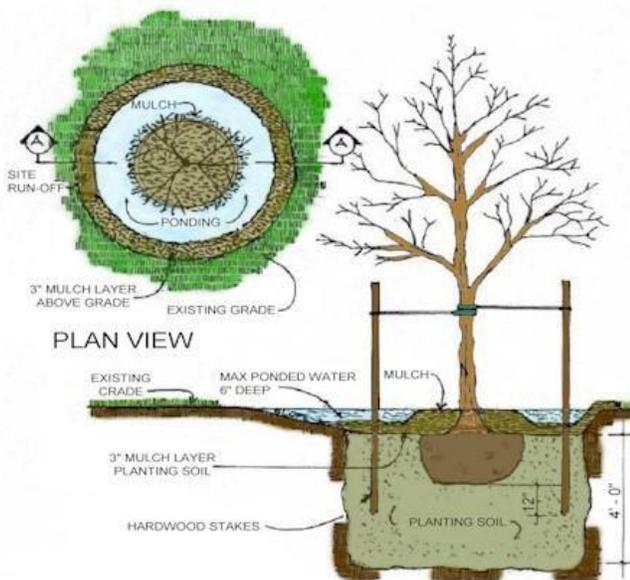
Simple design that incorporates a planting bed in the low portion of the site



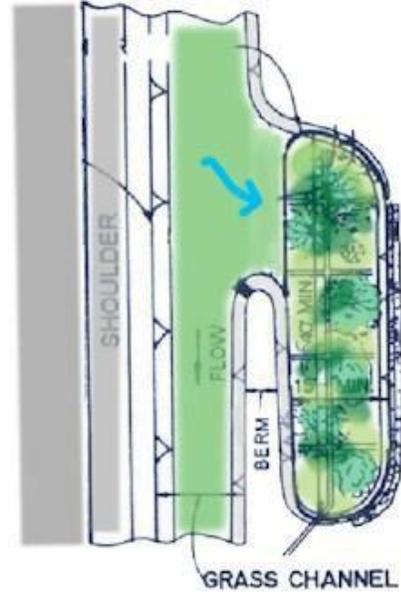
- Tree and Shrub Pits**

Stormwater management technique that intercepts runoff and provides shallow ponding in a dished mulched area around the tree or shrub.

Extend the mulched area to the tree dripline



- **Roads and highways**



- **Parking Lots**
- **Parking Lot Island Bioretention**



- **Commercial/Industrial/Institutional**

In commercial, industrial, and institutional situations, stormwater management and greenspace areas are limited, and in these situations, Rain Gardens for stormwater management and landscaping provide multifunctional options.

- **Curbless (Curb cuts) Parking Lot Perimeter Bioretention**

The Rain Garden is located adjacent to a parking area with no curb or curb cuts , allowing stormwater to sheet flow over the parking lot directly into the Rain Garden. Shallow grades should direct runoff at reasonable velocities; this design can be used in conjunction with depression storage for stormwater quantity control.



- **Curbed Parking Lot Perimeter Bioretention**



- **Roof leader connection from adjacent building**



Design Considerations

Rain Gardens are flexible in design and can vary in complexity according to water quality objectives and runoff volume requirements. Though Rain Gardens are a structural BMP, the initial siting of bioretention areas should respect the Integrating Site Design Procedures described in Chapter 4 and integrated with the preventive non-structural BMPs.

It is important to note that bioretention areas are not to be confused with constructed wetlands or wet ponds which permanently pond water. Bioretention is best suited for areas with at least moderate infiltration rates (more than 0.1 inches per hour). In extreme situations where permeability is less than 0.1 inches per hour, special variants may apply, including under drains, or even constructed wetlands.

Rain Gardens are often very useful in retrofit projects and can be integrated into already developed lots and sites. An important concern for all Rain Garden applications is their long-term protection and maintenance, especially if undertaken in multiple residential lots where individual homeowners provide maintenance. In such situations, it is important to provide some sort of management that insures their long-term functioning (deed restrictions, covenants, and so forth).

1. Sizing criteria

- a. **Surface area** is dependent upon storage volume requirements but should generally not exceed a maximum loading ratio of 5:1 (impervious drainage area to infiltration area; see Protocol 2. Infiltration Systems Guidelines (Appendix C) for additional guidance on loading rates.)
- b. **Surface Side slopes** should be gradual. For most areas, maximum 3:1 side slopes are recommended, however where space is limited, 2:1 side slopes may be acceptable.
- c. **Surface Ponding depth** should not exceed 6 inches in most cases and should empty within 72 hours.
- d. **Ponding area** should provide sufficient surface area to meet required storage volume without exceeding the design ponding depth. The subsurface storage/infiltration bed is used to supplement surface storage where feasible.
- e. **Planting soil depth** should generally be at least 18" where only herbaceous plant species will be utilized. If trees and woody shrubs will be used, soil media depth may be increased, depending on plant species.

2. **Planting Soil** should be a loam soil capable of supporting a healthy vegetative cover. Soils should be amended with a composted organic material. A typical organic amended soil is combined with 20-30% organic material (compost), and 70-80% soil base (preferably topsoil). Planting soil should be approximately 4 inches deeper than the bottom of the largest root ball.

3. **Volume Storage Soils** should also have a pH of between 5.5 and 6.5 (better pollutant adsorption and microbial activity), a clay content less than 10% (a small amount of clay is beneficial to adsorb pollutants and retain water), be free of toxic substances and unwanted plant material and have a 5 –10% organic matter content. Additional organic matter can be added to the soil to increase water holding capacity (tests should be conducted to determine volume storage capacity of amended soils).

4. Proper **plant selection** is essential for bioretention areas to be effective. Typically, native floodplain plant species are best suited to the variable environmental conditions encountered. If shrubs and trees are included in a bioretention area (which is recommended), at least three species of shrub and tree should be planted at a rate of approximately 700 shrubs and 300 trees per acre (shrub to tree ratio should be 2:1 to 3:1). An experienced landscape architect is recommended to design native planting layout.
5. **Planting periods** will vary, but in general trees and shrubs should be planted from mid-March through the end of June, or mid-September through mid-November
6. A maximum of 2 to 3 inches of shredded **mulch** or leaf compost (or other comparable product) should be uniformly applied immediately after shrubs and trees are planted to prevent erosion, enhance metal removals, and simulate leaf litter in a natural forest system. Wood chips should be avoided as they tend to float during inundation periods. Mulch / compost layer should not exceed 3" in depth so as not to restrict oxygen flow to roots.
7. Must be designed carefully in areas with **steeper slopes** and should be aligned parallel to contours to minimize earthwork.
8. Under drains should not be used except where in-situ soils fail to drain surface water to meet the criteria in Chapter 3.

Detailed Stormwater Functions

Infiltration Area

Volume Reduction Calculations

The storage volume of a Bioretention area is defined as the sum total of 1. and the smaller of 2a or 2b below. The surface storage volume should account for at least 50% of the total storage. Inter-media void volumes may vary considerably based on design variations.

$$1. \text{ Surface Storage Volume (CF)} = \text{Bed Area (ft}^2\text{)} \times \text{Average Design Water Depth}$$

$$2a. \text{ Infiltration Volume} = \text{Bed Bottom area (sq ft)} \times \text{infiltration design rate (in/hr)} \times \text{infiltration period (hr)} \times 1/12.$$

$$2b. \text{ Volume} = \text{Bed Bottom area (sq ft)} \times \text{soil mix bed depth} \times \text{void space.}$$

Peak Rate Mitigation

See Chapter 8 for Peak Rate Mitigation methodology, which addresses link between volume reduction and peak rate control.

Water Quality Improvement

See Chapter 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

The following is a typical construction sequence; however, alterations might be necessary depending on design variations.

1. Install temporary sediment control BMPs as shown on the plans.
2. Complete site grading. If applicable, construct curb cuts or other inflow entrance but provide protection so that drainage is prohibited from entering construction area.
3. Stabilize grading within the limit of disturbance except within the Rain Garden area. Rain garden bed areas may be used as temporary sediment traps provided that the proposed finish elevation of the bed is 12 inches lower than the bottom elevation of the sediment trap.
4. Excavate Rain Garden to proposed invert depth and scarify the existing soil surfaces. Do not compact in-situ soils.
5. Backfill Rain Garden with amended soil as shown on plans and specifications. Overfilling is recommended to account for settlement. Light hand tamping is acceptable if necessary.
6. Presoak the planting soil prior to planting vegetation to aid in settlement.
7. Complete final grading to achieve proposed design elevations, leaving space for upper layer of compost, mulch or topsoil as specified on plans.
8. Plant vegetation according to planting plan.
9. Mulch and install erosion protection at surface flow entrances where necessary.



Maintenance Issues

Properly designed and installed Bioretention areas require some regular maintenance.

- While vegetation is being established, pruning and weeding may be required.
- Detritus may also need to be removed every year. Perennial plantings may be cut down at the end of the growing season.
- Mulch should be re-spread when erosion is evident and be replenished as needed. Once every 2 to 3 years the entire area may require mulch replacement.
- Bioretention areas should be inspected at least two times per year for sediment buildup, erosion, vegetative conditions, etc.
- During periods of extended drought, Bioretention areas may require watering.
-
- Trees and shrubs should be inspected twice per year to evaluate health.

Cost Issues

Rain Gardens often replace areas that would have been landscaped and are maintenance-intensive so that the net cost can be considerably less than the actual construction cost. In addition, the use of Rain Gardens can decrease the cost for stormwater conveyance systems at a site. Rain Gardens cost approximately \$5 to \$7 (2005) per cubic foot of storage to construct.

Specifications

The following specifications are provided for informational purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1Vegetation - See Appendix B

2 Execution

a. Subgrade preparation

1. Existing sub-grade in Bioretention areas shall NOT be compacted or subject to excessive construction equipment traffic.
2. Initial excavation can be performed during rough site grading but shall not be carried to within one feet of the final bottom elevation. Final excavation should not take place until all disturbed areas in the drainage area have been stabilized.
3. Where erosion of sub-grade has caused accumulation of fine materials and/or surface ponding in the graded bottom, this material shall be removed with light

equipment and the underlying soils scarified to a minimum depth of 6 inches with a York rake or equivalent by light tractor.

4. Bring sub-grade of bioretention area to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction. All bioretention areas shall be level grade on the bottom.
5. Halt excavation and notify engineer immediately if evidence of sinkhole activity or pinnacles of carbonate bedrock are encountered in the bioretention area.

b. Rain Garden Installation

1. Upon completion of sub-grade work, the Engineer shall be notified and shall inspect at his/her discretion before proceeding with bioretention installation.
2. For the subsurface storage/infiltration bed installation, amended soils should be placed on the bottom to the specified depth.
3. Planting soil shall be placed immediately after approval of sub-grade preparation/bed installation. Any accumulation of debris or sediment that takes place after approval of sub-grade shall be removed prior to installation of planting soil at no extra cost to the Owner.
4. Install planting soil (exceeding all criteria) in 18-inch maximum lifts and lightly compact (tamp with backhoe bucket or by hand). Keep equipment movement over planting soil to a minimum – **do not over compact**. Install planting soil to grades indicated on the drawings.
5. Plant trees and shrubs according to supplier's recommendations and only from mid-March through the end of June or from mid-September through mid-November.
6. Install 2-3" shredded hardwood mulch (minimum age 6 months) or compost mulch evenly as shown on plans. Do not apply mulch in areas where ground cover is to be grass or where cover will be established by seeding.
7. Protect Rain Gardens from sediment at all times during construction. Hay bales, diversion berms and/or other appropriate measures shall be used at the toe of slopes that are adjacent to Rain Gardens to prevent sediment from washing into these areas during site development.
8. When the site is fully vegetated and the soil mantle stabilized the plan designer shall be notified and shall inspect the Rain Garden drainage area at his/her discretion before the area is brought online and sediment control devices removed.
9. Water vegetation at the end of each day for two weeks after planting is completed.

Contractor should provide a one-year 80% care and replacement warranty for all planting beginning after installation and inspection of all plants.

