

ACTIVITY: Bioretention Areas

Bioretention Areas



Description: Shallow detention area that employs engineered soils and plants to capture and treat runoff.

Variations: Bioretention areas can be designed as “raingardens,” small bioretention areas that serve individual lots or that can be installed in parking lot planting areas or in depressed areas receiving runoff from paved areas.

Components:

- Pretreatment - for coarse sediments that would quickly clog area.
- Ponding area – for water quality treatment through settling and chemical processes
- Soils – water quality treatment through chemical processes and filtering; supports plants
- Mulch – water quality treatment through biological processes; conserves soil moisture between rain events to support plants
- Plants – water quality treatment through biological treatment, plant up-take and filtering
- Spillway system – provides outlet for stormwater runoff when large storm events occur and prevents long-term ponding in planting area

Advantages/Benefits:

- Easily incorporated into new development
- High community acceptance
- Good for highly paved areas such as parking lots
- Good for small drainage areas

Disadvantages/Limitations:

- Sediment-laden runoff can clog soils in bioretention area
- Requires detailed landscape planning
- Not appropriate for steep slopes
- Relatively expensive

Design considerations:

- Maximum drainage area of 5 acres, 2 acres maximum impervious
- Typically requires 5 feet of head
- Underlying soils must have good infiltration or must be replaced
- Underdrain system may be needed to keep planting area from ponding water too long

Selection Criteria:

- Water Quality
80 % TSS Removal**
- Accepts Hotspot
Runoff**
- Residential
Subdivision**
- High Density /
Ultra Urban Use**

Maintenance:

- Replace mulch as needed to maintain depth of mulch
- Replace plant material as needed
- Replace soil if it becomes clogged
- Clean spillway system(s)

M **Maintenance
Burden**

L = Low M = Moderate H = High

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General Description

Bioretention areas, sometimes known as rain gardens, are structural stormwater controls that capture and temporarily store the WQ_v while using soils and vegetation in landscaped areas to remove pollutants from stormwater runoff. Bioretention areas are engineered facilities in which runoff is conveyed as sheet flow to the “treatment area,” consisting of a grass buffer strip, ponding area, organic or mulch layer, planting soil, and vegetation. An optional sand bed can be included in the design to provide aeration and drainage of the planting soil. The filtered runoff is typically collected and returned to the conveyance system, though it can be exfiltrated into the surrounding soil in areas with porous soils.

There are numerous design applications, both on- and off-line, for bioretention areas. These include use on single-family residential lots (rain gardens), as off-line facilities adjacent to parking lots, along highways and road drainage swales, within larger landscaped pervious areas, and as landscaped islands in impervious or high-density environments. However, the structures are not designed to serve as regional stormwater BMPs.

Bioretention facilities can provide a limited amount of water quantity control, with the storage provided by the facility included in the design of any downstream detention structures. However, bioretention areas should be designed so that larger flows bypass them.

Bioretention areas are designed for intermittent flow and to drain and aerate between rainfall events. Sites with continuous flow from groundwater, sump pumps or other areas are not acceptable for bioretention areas.

Components

Figure 3.1 illustrates a bioretention area. Bioretention areas consist of:

1. Grass filter strip between the contributing drainage area and the ponding area;
2. Ponding areas containing vegetation with a planting soil bed,
3. Organic/mulch layer,
4. Planting soil and vegetation, and
5. Gravel and perforated pipe underdrain system to collect runoff that has filtered through the soil layers (bioretention areas can optionally be designed to infiltrate into the soil).

Optional design components include:

1. Sand filter layer to spread flow, filter runoff and aid in aeration and drainage of the planting soil;
2. Stone diaphragm at the beginning of the grass filter strip to reduce velocities and spread flow into the grass filter;
3. Inflow diversion or an overflow structure.

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**Site and
Design
Considerations**

The following design and site considerations must be incorporated into the BMP plan including bioretention areas:

1. The drainage area (contributing or effective) must be 5 acres or less, though 0.5 to 2 acres is preferred.
2. The minimum size for facility is 200 ft², with a length to width ratio of 2:1. Slope of the area immediately adjacent to the facility must be no more than 20%, but must be more than 2% to ensure proper drainage.
3. The planting soil filter bed is sized using a Darcy's Law equation with a filter bed drain time of 48 hours and a coefficient of permeability (k) of 0.5 ft/day. The planting soil bed must be at least 2 feet deep. Planting soils must be sandy loam, loamy sand or loam texture per USDA textural triangle with a clay content rating from 10 to 25 percent. The soil must have an infiltration rate of at least 0.5 inches per hour and a pH between 5.5 and 6.5. In addition, the planting soil should have a 1.5 to 3 percent organic content and a maximum 500-ppm concentration of soluble salts. For bioretention areas using in situ soils, the depth criteria does not apply.
4. The maximum ponding depth in bioretention areas is 6 inches.
5. The mulch layer must consist of 2-4 inches of commercially available fine shredded hardwood mulch or shredded hardwood chips.
6. The sand bed, if used, must be 12-18 inches thick. Sand must be clean and have less than 15% silt or clay content.
7. Pea gravel for the diaphragm and curtain, where used, must be ASTM D 448 size No. 6 (1/8 inches to 1/4 inches).
8. The underdrain collection system must be equipped with 6-inch perforated pipe in an 8-inch gravel layer. The pipe must have 3/8-inch perforations, spaced on 6-inch centers with a minimum of 4 holes per row. The pipe is spaced at a maximum of 10 feet on center, and a minimum grade of 0.5 percent must be maintained. A permeable filter fabric can be placed between the gravel layer and the planting soil bed.
9. The required elevation difference needed from the inflow to the outflow is 5 feet.
10. The depth from the bottom of the bioretention facility to the seasonally high water table must be a minimum of 2 feet.
11. Runoff captured by facility must enter as sheet flow to prevent erosion of the organic or mulch layer. Velocities entering the mulch layer must be between 1 and 2 feet per second.
12. Continuous flow from groundwater, sump pumps or other areas to the bioretention area is prohibited.
13. An overflow structure and a non-erosive overflow channel must be provided to safely pass the flow from the bioretention area that exceeds the storage capacity to a stabilized downstream area. The high flow structure within the bioretention area can consist of a yard drain catchbasin, with the throat of the catchbasin inlet typically 6 inches above the elevation of the shallow ponding area.
14. All components of the BMP must be located within an easement. Access to the BMP must be located within the easement.
15. The area that will house bioretention must not be used as sediment control measure during active construction.

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**Landscaping
Bioretention
Areas**

Landscaping is critical to the performance and function of the bioretention area. A dense and vigorous groundcover must be established over the contributing pervious drainage area before runoff can be diverted into the facility.

1. The bioretention area should be vegetated like a terrestrial forest ecosystem, with an eventual tree canopy, subcanopy of understory trees, scrub layer and herbaceous ground cover. Three species of each tree and shrub type should be planted.
2. The tree-to-shrub ratio should be 2:1 to 3:1. On average, trees should be spaced 8 feet apart. Plants should be placed at regular intervals to replicate a natural forest. Woody vegetation should not be planted at inflow locations.
3. After the trees and shrubs are established, the ground cover and mulch should be established.

Use native plants, selected based upon hardiness and hydric tolerance.

**As-Built
Certification
Considerations**

After the bioretention area has been constructed, the developer must have an as-built certification of the bioretention area conducted by a registered Professional Engineer. The as-built certification verifies that the BMP was installed as designed and approved.

The following components are vital to ensure that the bioretention area works properly and they must be addressed in the as-built certification:

1. Pretreatment, such as a grass filter strip, for coarser sediments must be provided to prevent premature clogging of the system. Design guidance for grass filter strips used as pretreatment is provided in PTP-07 Filter Strip.
2. Surrounding drainage areas must be stabilized to prevent sediment from clogging the filter media.
3. Correct ponding depths and infiltration rates must be maintained to prevent killing vegetation.

A mechanism for overflow for large storm events must be provided.

Maintenance

Each BMP must have an Operations and Maintenance (O&M) agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the O&M Agreement for bioretention areas, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The O&M Agreement is to be used by the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP O&M plan. At a minimum, the operations and maintenance plan must require:

1. Inspect and repair/replace treatment components.
2. Perform annual verification of infiltration rates.
3. Remove debris or dead vegetation.

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**Design
Procedures**

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v).

$$WQ_v = P \times R_v \times A/12$$

Where:

WQ_v = water quality treatment volume, ac-ft

P = rainfall for the 85th percentile storm event (1.1 in)

R_v = runoff coefficient (see below)

A = site area, acres

$$R_v = 0.015 + 0.0092I$$

Where:

I = site impervious cover, % (for example, 50% imperviousness = 50)

Step 2. Determine if the development site and conditions are appropriate for the use of bioretention area.

See the *Site and Design Considerations* in this section, above.

Step 3. Confirm additional requirements and watershed applicability.

Check with Metro Water Services and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply to the site.

Step 4. Compute WQ_v flow rate.

The peak rate of discharge for water quality design storm is needed for sizing of off-line diversion structures.

$$Q = C * I * A$$

Where:

Q = Peak discharge (cfs) for the 3 month storm

C = Runoff coefficient

I = 2.45 in/hour

A = site area, acres

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Design
Procedures
(Continued)

Step 5. Size flow regulator, if needed.

A flow regulator (or flow splitter diversion structure) must be used to divert the WQ_v to the bioretention area.

Size flow regulator to pass the water quality flow rate, computed in Step 4.

Step 6. Determine size of bioretention ponding/filter area.

The required planting soil filter bed area is computed using the following equation (based on Darcy's Law):

$Af = (WQ_v) (df) / [(k) (hf + df) (tf)]$ where:

Af = surface area of ponding area (ft^2)

WQ_v = water quality volume in cubic feet (or total volume to be captured)

df = filter bed depth (2 feet minimum)

k = coefficient of permeability of filter media (ft/day) (must be at least 0.5 ft/day)

hf = average height of water above filter bed (ft)

(typically 3 inches, which is half of the 6-inch ponding depth)

tf = design filter bed drain time (days)

(2.0 days or 48 hours is recommended maximum)

Step 7. Set design elevations and dimensions of facility.

See *Site and Design Considerations* section.

Step 8. Design conveyances to bioretention area.

See Figure 3.2 for examples of conveyance types for different applications.

Step 9. Design pretreatment.

Pretreat with a grass filter strip (on-line configuration) or grass channel (off-line), and stone diaphragm.

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**Design
Procedures
(Continued)**

Step 10. Size underdrain system

See *Site and Design Considerations*.

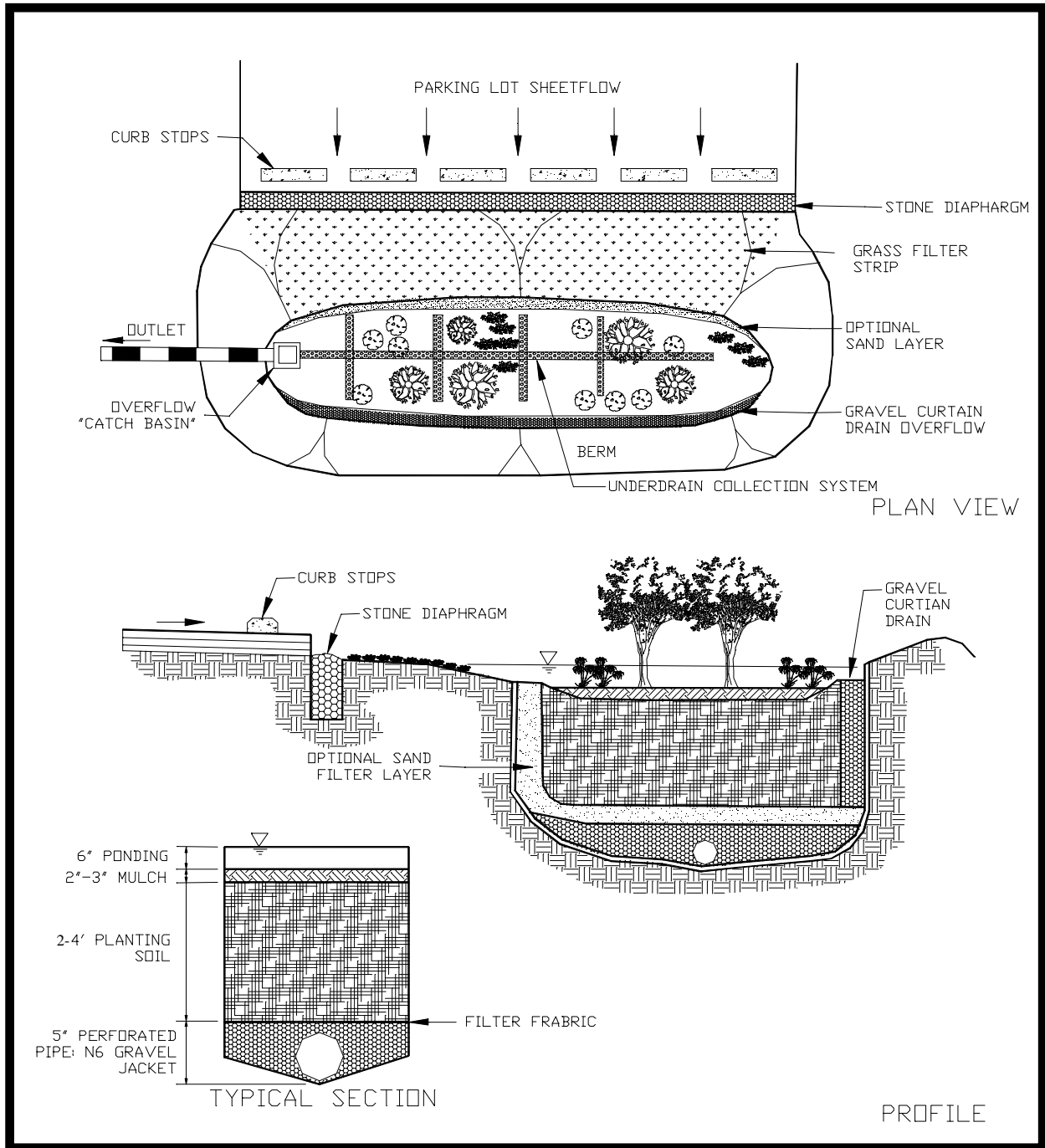
Step 11. Design emergency overflow.

An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Non-erosive velocities need to be ensured at the outlet point.

Step 12. Prepare Vegetation and Landscaping Plan.

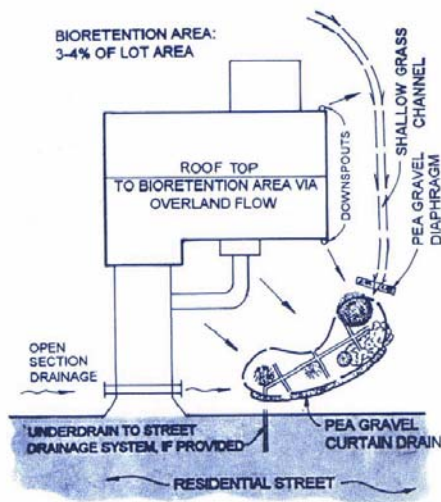
A landscaping plan for the bioretention area should be prepared to indicate how it will be established with vegetation.

See the *Landscaping Bioretention Areas* section for more details.

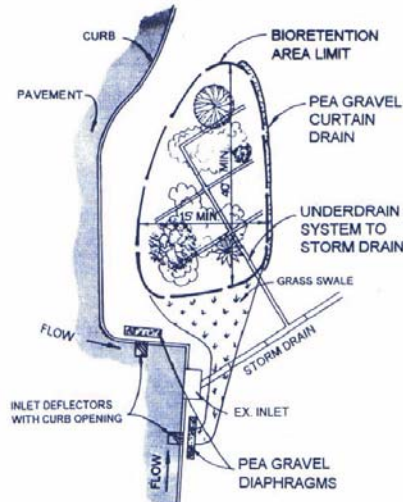


(Source: Center for Watershed Protection)

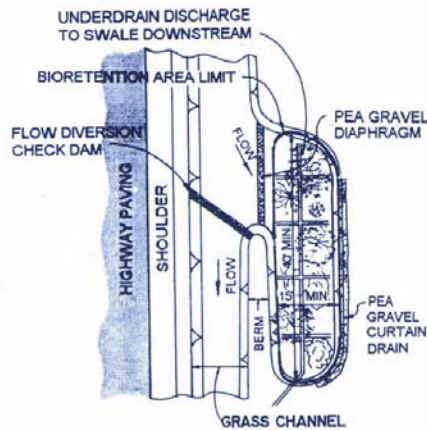
Figure 3.1 Bioretention Area



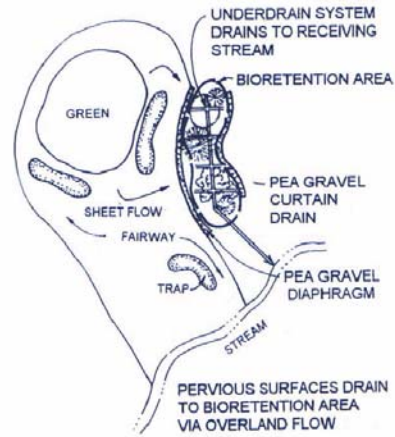
RESIDENTIAL LAND USE
ON-LINE APPLICATION



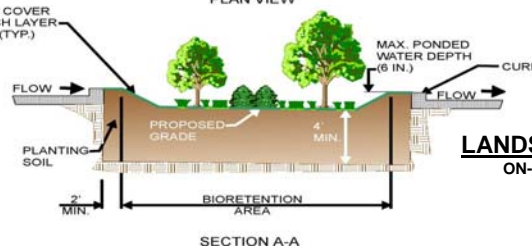
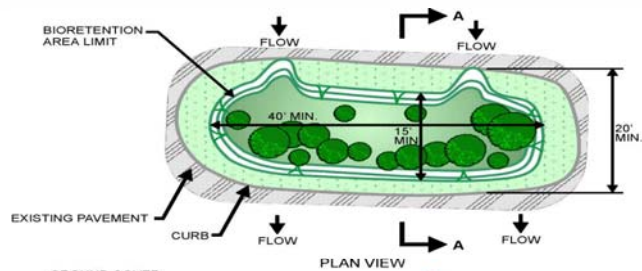
PARKING LOT RUNOFF
OFF-LINE APPLICATION



HIGHWAY DRAINAGE
OFF-LINE APPLICATION



PERVIOUS SURFACE (GOLF COURSE)
ON-LINE APPLICATION



LANDSCAPED ISLAND
ON-LINE APPLICATION

(Adapted from Claytor and Scheuler, 1996)

Figure 3.2 Applications of Bioretention Areas

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Suggested Reading

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