Bioretention

Stormwater BMP Type	
Pretreatment BMP	□
Infiltration BMP	□
Filtering BMP	■
Stormwater Pond BMP	□
Stormwater Wetland BMP	□
Water Quality Conveyance BMP	□
Stormwater Reuse BMP	□
Proprietary BMP	□
Other BMPs and Accessories	□
Stormwater Management Suitability	
Retention	■
Treatment	■
Pretreatment	□
Peak Runoff Attenuation	■
Pollutant Removal	
Sediment*	**High**
Phosphorus	**Moderate**
Nitrogen	**Low**
Bacteria	**High**
*Includes sediment-bound pollutants and floatables (with pretreatment)	
Implementation	
Capital Cost	**Medium**
Maintenance Burden	**Medium**
Land Requirement	**Varies**

Description

Bioretention systems are shallow, vegetated depressions that capture, temporarily store, and filter stormwater runoff. Bioretention systems have an engineered soil[86] media below the surface of the system that facilitates stormwater filtration and vegetative growth. Bioretention systems are frequently designed to infiltrate, commonly referred to as "infiltration" or "exfiltration" bioretention systems but can be designed with an underdrain to capture filtered water and assist with drainage from the system, typically referred to as "flow-through" bioretention systems. In certain situations, bioretention systems can also be designed with impermeable liners to prevent infiltration into the underlying soil.

Bioretention systems remove pollutants through a variety of physical, chemical, and biological processes including filtration, pollutant uptake, and adsorption. Vegetation in the soil bed provides uptake of pollutants and runoff, and the root system helps maintain the infiltration rate in the soil bed. If not designed with an impermeable liner, bioretention systems can provide retention of stormwater and reduce runoff volumes through infiltration and groundwater recharge. Bioretention systems may also be used to provide stormwater quantity control when designed as on-line facilities.

Bioretention systems can be implemented on most sites as part of the urban, suburban, or rural landscape. Given their versatility, many design variants of bioretention systems exist, including bioretention basins, stormwater planters, bioswales, tree filters (see Tree Filter section), and

[86] Engineered soil is a manufactured soil consisting of specified ratios of sand, silt, clay, and organic amendments such as compost and designed for a specific application.

other systems that vary based on shape, location, and configuration. The following photographs are examples of common types of bioretention systems.

Bioretention basin at the edge of a parking lot.

Rain garden on a residential lot.

Roadside bioswale in urban residential setting.

Bioretention planter in urban downtown setting.

Advantages

- Applicable to small drainage areas.
- Can be applied to most sites due to relatively few constraints and many design variations (i.e., highly versatile).
- Ideal for stormwater retrofits and highly developed sites.
- High pollutant removal efficiency and water quality benefits.
- Can provide stormwater retention, runoff volume reduction, and groundwater recharge if designed for infiltration.
- Vegetation can also provide aesthetic, ecological, and other green infrastructure benefits, like cooling the urban heat island effect.

Limitations

- Limited to smaller drainage areas.
- Frequent maintenance required.
- Infiltration bioretention systems generally have higher relative construction costs than other stormwater infiltration systems due to cost of bioretention soil media.

Siting Considerations

- **Potential Locations:** Within parking lot islands, along borders of parking lots, roundabouts, planted islands, medians, streetscapes (e.g., between the curb and sidewalk), wide roadway shoulders, and along shared-use paths. Bioretention systems such as small-scale rain gardens are also well-suited to residential areas because of the co-benefits they provide

- **Drainage Area:** Small-scale bioretention systems should have a contributing drainage area of 1 acre or less. The recommended maximum contributing drainage area for bioretention systems is 5 acres. For larger sites, multiple bioretention systems should be distributed throughout the site or off-line designs should be used to bypass larger flows. For curb inlet planters, the recommended maximum ratio of contributing impervious drainage area to planter bed area is 10:1.

- **Soils:** Bioretention systems that return filtered runoff to the conveyance system and do not infiltrate into the ground can be used in almost any soil type. Bioretention designs that rely on infiltration should be used only when the soil infiltration characteristics are appropriate (see Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for design guidance for stormwater infiltration systems).

- **Land Use:** Bioretention systems can be used in most land use settings where space is available.

- **Water Table and Bedrock:** For bioretention systems designed for infiltration (unlined systems), meet the minimum required vertical separation distances from the top and bottom of the filtering system to the seasonal high groundwater table (SHGT) and bedrock, as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

- **Horizontal Setbacks:** For bioretention systems designed for infiltration (unlined systems), meet the minimum horizontal setback distances in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

Soil Evaluation

- Conduct an evaluation of the soil characteristics and subsurface conditions at the location of the proposed system including soil type, depth to the seasonal high groundwater table, depth to bedrock, and soil infiltration rate. Refer to Chapter 10 –

General Design Guidance for Stormwater Infiltration Systems, for soil evaluation guidance.

Design Recommendations

General Considerations

This section addresses three types of bioretention system designs (Table 13-5):

- **Bioretention System with Underdrain (Partial Infiltration Bioretention System):** Most bioretention systems should be designed with an underdrain to account for potential infiltration failure due to clogging, groundwater mounding, or periods of excessive rainfall. Underdrained bioretention systems can be used with any soil type or soil infiltration rate, ,although bioretention systems in HSG C or D soils an underdrain is necessary. The underdrain should be raised above the bottom of the system to maximize infiltration and enhance nitrogen removal. Underdrained bioretention systems (without a liner) are suitable for providing stormwater retention, although only the infiltrated volume (not the volume discharged via the underdrain) can be credited toward the Standard 1 retention requirement.

- **Bioretention System with Underdrain and Liner (Flow-Through Bioretention System):** An underdrain and impermeable liner are required for use with Land Uses with Higher Potential Pollutant Loads (LUHPPLs) (see Chapter 10 - General Design Guidance for Stormwater Infiltration Systems), in locations where contaminated soils exist, where the required vertical separation to SHGT cannot be met, or in locations with unacceptable horizontal setbacks for infiltration. Such systems are suitable for providing treatment but do not provide retention credit.

- **Bioretention System with No Underdrain (Infiltration Bioretention System):** Bioretention systems can be designed to fully infiltrate into the native soil without an underdrain. Such systems are best suited for use with Hydrologic Soil Group (HSG) A and B soils. Bioretention systems have higher relative construction costs than other surface infiltration systems presented in this Manual (infiltration basins and trenches) due to the cost of the engineered bioretention soil, plantings, etc. Therefore, infiltration bioretention systems tend to be less cost-effective than other surface infiltration practices.

Figure 13-16. and Figure 13-17. are schematics of these bioretention system designs.

Table 13-2. Bioretention System Design Types

Type of System	Underdrain Type	Infiltration or Filtration Design?	Suitable for Retention?	Suitable for Treatment?	General Conditions for Use
Bioretention System with Underdrain Partial Infiltration Bioretention System	Raised Underdrain	Infiltration and Filtration (partial infiltration)	Yes (infiltration volume only)	Yes	All HSG Soil types Underdrain required for HSG C and D Soils
Bioretention System with Underdrain and Liner Flow-Through Bioretention System	Underdrain and Impermeable Liner	Filtration Only	No	Yes	Land Uses with Higher Potential Pollutant Loads Contaminated sites Where required vertical separation to SHGT cannot be met Sites with unacceptable setback distances for infiltration
Bioretention System Without Underdrain Infiltration Bioretention System	No Underdrain	Infiltration and Filtration (Full infiltration)	Yes	Yes	HSG A and B Soils

Pretreatment

- Incorporate pretreatment measures at locations where runoff enters the bioretention system in accordance with the Pretreatment BMPs section of this Manual.

- Acceptable pretreatment measures include vegetative filter strips, sediment forebays, pretreatment swales, deep sump hooded catch basins,[87] oil grit separators, and proprietary pretreatment devices.

- Sediment forebays should have a minimum storage volume of 25% of the Water Quality Volume (WQV), while flow-through Pretreatment BMPs should treat at least the equivalent Water Quality Flow (WQF). A minimum sediment forebay storage volume of 10% of the WQV may be used in urban settings, space constrained sites, and as retrofits, with the approval of the review authority.

Sizing and Dimensions

- Bioretention Filter Bed (Bottom) Area
  - Bioretention system should be designed by either the Static or Dynamic Methods as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.
  - Bioretention system should completely drain in 48 hours or less after the end of the design storm as described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.
  - For unlined systems, the design infiltration rate used for system sizing and drain time analysis should be equal to 50% of the slowest observed field infiltration rate of the underlying soils or 0.5 inches per hour (1.0 feet per day) for the bioretention soil media, whichever value is lower.
  - For lined systems, use the coefficient of permeability of the bioretention soil media (0.5 inches per hour or 1.0 feet per day or) in the drain time analysis.

- Bioretention Soil Depth
  - Engineered bioretention soil media should have a depth of 24 to 48 inches as necessary to accommodate the required sizing, vegetation species and root establishment, and subsurface conditions.
  - Bioretention systems with trees should have a minimum soil depth of 30 inches.
  - Soil depth may be limited by the requirement to maintain adequate separation to groundwater and bedrock as specified in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems.

- Ponding Depth
  - Maximum for water quality storm: 12 inches

[87] Only recommended for space constrained sites where no other Pretreatment BMPs are feasible.

  - Maximum for overflow events: 36 inches

- Freeboard Depth
  - Minimum freeboard depth: 3 to 6 inches
  - As measured from the elevation of the maximum ponding depth to the facility's overflow elevation or to the invert of the inlet to the facility, whichever is lower.

- Bottom Width
  - Minimum: 4 feet (ideal). For bioretention planters, narrower widths may be allowed, with a minimum width of 2.5 feet. The design should consider plant health, water quality performance, and implementation costs.

- Bottom Slope
  - Design bottom of infiltration bioretention systems to be level or have a maximum slope of 0.5% to promote infiltration and even distribution.
  - Flow-through bioretention systems with bottom slopes greater than 0.5% should be designed with impermeable check dams (e.g., constructed from granite or concrete curbing) or as a terraced system with relatively flat bottoms in each cell to promote infiltration throughout the bottom of the entire system.

- Side Slopes
  - 3(H):1(V) slopes or flatter are preferred especially on grassed slopes where mowing is required.
  - In ultra-urban locations or space constrained areas; side slopes of 2(H):1(V) may be utilized if properly designed to account for erosion and slope stability. Stabilize the slope with turf reinforcement matting or equivalent if the slope could potentially erode.
  - If site topography does not allow for 3(H):1(V) slopes or adequately stabilized 2(H):1(V) slopes, vertical concrete walls with a maximum height of 30 inches can be used. Drop curbs or similar precast structures can also be used to create stable, vertical bioretention side walls.

Inlet

- Design the inlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Runoff can be introduced to the bioretention system through overland flow, curb cuts, inlet structures, swales/channels, and/or pipes.

- Design the bioretention system in an off-line configuration to the extent feasible if runoff is delivered by a storm drain pipe or is along the main storm conveyance system.

Outlet & Overflow

- Design the outlet in accordance with the Inlet and Outlet Controls section of this Manual.

- Outlets are typically a stabilized spillway, gabion berm, concrete weir, curb cut opening, precast concrete structure, or polyethylene/polyvinyl chloride riser structure.

- On-line systems should have a primary outlet sized to convey the 10-year, 24-hour storm event, at a minimum, to the storm drainage system or stabilized channel. An emergency spillway is required to convey the 100-year storm event (assuming the primary outlet is not designed to pass the 100-year storm event).

- Off-line systems should be designed with a bypass or overflow for flows in excess of the water quality storm.

Underdrain System

- Install an underdrain system when a proposed bioretention system meets one or more of the following conditions:
    - Is in native soil that has an infiltration rate less than 0.3 inch per hour (HSG C and D soils)
    - Does not meet vertical separation distance to SHGT or bedrock (Chapter 10 - General Design Guidance for Stormwater Infiltration Systems) and should be lined
    - Is within a Land Use with Higher Potential Pollutant Loads (LUHPPL) (Chapter 10 - General Design Guidance for Stormwater Infiltration Systems) or area of contaminated soils and should be lined.

- An underdrain is also recommended, but not required, for other bioretention systems to account for potential infiltration failure due to clogging, groundwater mounding, or periods of excessive rainfall.

- Minimum underdrain pipe diameter: 4 inches

- Minimum underdrain pipe slope: 0.5%

- Use two layers of gravel with the underdrain system. Both layers of gravel should be located below and extend across the entire bottom of the bioretention system. The upper gravel layer should consist of 3 inches of pea gravel, and the lower layer should consist of a 12-inch thick gravel sump.

- For unlined bioretention systems, install the perforated underdrain pipe 2 inches below the top of the gravel sump to promote infiltration. For systems that are lined with an impermeable liner to prevent infiltration, install the underdrain pipe 2 inches above the bottom of the gravel sump so the system can drain between storm events.

- For enhanced removal of nitrogen, use an upturned underdrain in combination with a low permeability native soil (HSG C or D soils) or liner to create a thicker saturated zone (also called an Internal Water Storage zone or Internal Storage Reservoir) that extends up to a maximum of 6 inches into the bottom of the bioretention soil media. This type of underdrain configuration is recommended for bioretention systems that discharge to coastal, estuarine, and nitrogen impaired waters where enhanced nitrogen removal is desired.

- If the bioretention system is designed without an underdrain, pea gravel and gravel sump are optional.

- Lay underdrain such that perforations are on the bottom of the pipe.

- Use solid (non-perforated) pipe sections and watertight joints wherever the underdrain system passes below berms, extends down steep slopes, connects to a drainage structure, and/or daylights.

- Place filter fabric along sidewalls of excavation and above the pea gravel (below the bioretention soil layer) for a distance of 1 to 2 feet on both sides of the underdrain. Filter fabric shall not be placed across the entire width of the bioretention system.

- Other considerations when designing/installing underdrains:
    - Provide a marking stake and an animal guard for underdrains that daylight at grade.
    - If designed with laterals, space collection laterals every 25 feet or less.

- Include a minimum of two observation wells/cleanouts for each underdrain, one at the upstream end and one at the downstream end.
    - Cleanouts should be at least 4 inches in diameter, be nonperforated, and extend to the surface. Cap cleanouts with a watertight removable cap. The cleanout should be highly visible.
    - Provide one cleanout for every 1,000 square feet of surface area (at a minimum) or for every 250 linear feet of total pipe length in larger systems.

Materials

- Surface Cover

- Grass or river stone are the preferred surface cover types for bioretention systems to minimize required maintenance. Mulch may be used directly around the plants, but mulch should NOT be used to cover the entire bottom of the bioretention system.

- If mulch is used, use 2 to 4 inches of shredded hardwood bark mulch, aged for 6 months minimum.
    - Alternative surface covers such as pea gravel may be used if allowed by the review authority.

- Vegetation
    - Select bioretention plantings/vegetation and develop a planting plan with guidance provided in Appendix F of this Manual.

- A native grass/wildflower seed mix can be used as an alternative to groundcover plantings.
- Establish a dense vegetative cover or adequately stabilized surface throughout the bioretention system and any upgradient areas disturbed by construction before runoff can be accepted into the facility.
- Plant layout should be random and natural.
- Trees should be planted primarily along the perimeter of the facility and with 15 feet of separation from underdrain piping.
- Trees should not be planted in lined bioretention systems.
- Do not plant trees, shrubs, or grasses with a mature vegetation height exceeding 24 inches above the surrounding sidewalk or pavement surface in bioretention systems within medians, near intersections, or near pedestrian crossings to avoid obstruction of sight lines.

➢ Engineered Bioretention Soil Media

- The engineered soil media in bioretention systems is designed to filter/treat runoff and to provide sufficient organic material to support plan establishment and growth.

- The engineered bioretention soil media should be a homogeneous soil mix of (by volume):
  - 60–85% Sand
  - 15–25% Topsoil
  - 3–8% Organic Matter

- **Sand** should be washed concrete sand (ASTM C33 or AASHTO M-6) or coarse washed sand that meets the gradation schedule as shown in State of Connecticut Department of Transportation Standard Specifications, Section M.01 (Aggregates), Table M.01.04-1 for Fine Aggregate Gradations.

- **Topsoil** should contain 5–20% organic material, have a pH range of 5.5 to 7.0, and be a sandy loam, loamy sand, or loam per USDA soil texture with less than 5% clay content. Topsoil that meets the State of Connecticut Department of Transportation Standard Specifications, Section M.13.01 (Roadside Development) for Topsoil may also be used, except it should contain less than 5% clay content.

- **Organic matter** should consist of one of the following materials
  - Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 3.4 to 4.8.
  - Wood Derivatives: Shredded wood, wood chips, ground bark, or wood waste; of uniform texture and free of stones, sticks, soil, or toxic materials.

        - Compost shall NOT be used as organic matter since the use of compost in bioretention soil media can result in nutrient export from the system.

    - **Other soil amendments** such as zerovalent iron and/or processed drinking water treatment residuals (alum) may be used to further enhance phosphorus sorption as specified by the designer. Processed drinking water treatment residuals should have a minimum of 30% solids. Drinking water treatment residuals are typically processed and dried using a belt filter press.

    - Bioretention soil media should meet the following particle size distribution according to ASTM D422 (Standard Test Method for Particle-Size Analysis of Soils) as specified in Table 13-6.

Table 13-3. Acceptable Particle Size Distribution of Bioretention Soil Media

Media Type	Sieve #	Size (inches)	Size (mm)	% Passing
Coarse Sand	4	0.187	4.76	100
Medium Sand	10	0.079	2.00	95
Fine Sand	40	0.017	0.42	10-20
Silt/Clay	200	0.003	0.075	0-5

    - Bioretention soil media should also meet the following specifications:
        - pH (soil reaction): 5.5 to 7.5
        - Cation Exchange Capacity (CEC): minimum of 10 milliequivalents per 100 grams of soil (meq/100 g) at pH of 7.0
        - Organic Matter (percentage by volume): 3% to 10%
        - Total Phosphorus: <100 mg/kg

    - Bioretention soil media should NOT contain any of the following materials: stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 0.187 inches (4.76 mm) in any dimension; plants, sod, concrete slurry, concrete layers or chunks, cement, plaster, building debris, asphalt, bricks, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, solid waste, and any other extraneous materials that are harmful to plant growth.

- Pea Gravel
    - Should consist of 3/8" AASHTO No. 8 stone. Pea gravel should be clean (washed and free from dirt and debris) and rounded in shape.

- Gravel Sump
    - Should consist of 3/4" AASHTO No. 5 stone. Gravel should be clean (washed and free from dirt and debris), crushed, and angular.

- Filter Fabric
    - Use non-woven filter fabric that complies with State of Connecticut Department of Transportation Standard Specifications, Section M.08.01.19 (Drainage – Geotextiles).

- Poured-in-place Concrete
    - If used, should be an appropriate class of concrete based on the application and conform to State of Connecticut Department of Transportation Standard Specifications, Section 6.01 (Concrete for Structures).
    - Underdrain (perforated and non-perforated pipe sections)
    - Polyethylene or polyvinyl pipe.

- Liner
    - If used, should consist of a 30 mil (minimum) HDPE or PVC liner, or one of the alternative liner systems described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems with the approval of the review authority.

- Curbing (for Overflow Weirs or Check Dams)
    - If used for check dams, granite or concrete curbing shall conform to State of Connecticut Department of Transportation Standard Specifications, Section M.12.06 (Stone Curbing) and Section 8.11 (Concrete Curbing).

- Turf Reinforcement Matting (TRM)
    - Stabilize the side slopes of the bioretention system with TRM to limit erosion in locations where flow velocities exceed 3 to 5 feet per second (depending on soil and vegetation types) for the 1-year, 24-hour storm event.
    - If used, shall be a woven material included on the CTDOT Qualified Products List that exceeds the design velocity of the design storm and allows for the growth of the proposed vegetative species.

Other Considerations

- If designing a lined system in a location where SHGT is located at or above the bottom of the liner or closed bottom of the system, complete a buoyancy analysis to ensure buoyancy of the system will not be an issue.

- For lined bioretention systems within LUHPPLs, a shutoff valve can be installed on the underdrain outlet to capture and contain accidental spills or releases that reach the bioretention system.

- Roadway stability can be a design issue when installing bioretention systems along roadways. It may be necessary to provide a vertical impermeable barrier to keep water from saturating the road’s sub-base. The barrier should be capable of supporting H-20 loads.

- Non-woven filter fabric should be placed along the sidewalls of the bioretention system to help direct the water flow downward, reduce lateral flows, and to reduce lateral soil migration. Non-woven filter fabric should also be placed above the pea gravel layer (below the bioretention soil layer) for a distance of 1 to 2 feet on both sides of the underdrain pipe. Filter fabric should NOT be placed across the entire width of the bioretention system because filter fabric installed in this manner can result in clogging and system failure.

Winter Operations

- Bioretention systems should not be used as dedicated snow storage areas. To the extent feasible, locate and design the system to avoid snow storage areas and potential damage from snow plowing activities. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations related to winter operations.

Construction Requirements

- The designing qualified professional should develop a detailed, site-specific construction sequence.

- The designing qualified professional should inspect the installation during the following stages of construction, at a minimum:
    - After excavation of the bioretention system and scarification of bottom and sidewalls of excavation
    - After placement of gravel layer
    - After placement of underdrain before covering by the pea gravel layer
    - After placement of bioretention soil media
    - After installation of bypass, outlet/overflow, and inlet controls
    - After plants have been installed

- The designing qualified professional should provide an as-built plan of the completed bioretention system along with a certification that the system was designed in accordance with the guidance contained in this Manual and other local or state requirements and that the system was installed in accordance with the approved plans.

- The bioretention soil mix should be tested prior to placement according to the specifications in this section (at least one test per bioretention system). The designing qualified professional should certify that the bioretention soil mix meets the specifications in the previous section based on soil testing results.

- The entire contributing drainage area should be completely stabilized prior to directing any flow to the bioretention system. Adequate vegetative cover must be established over any pervious area adjacent or contributing to the system before runoff can be accepted.

- Erosion and sediment controls should be in place during construction in accordance with the Connecticut Guidelines for Soil Erosion and Sediment Control and the Soil Erosion and Sediment Control (SESC) Plan developed for the project.

- During clearing and grading of the site, measures should be taken to avoid soil compaction at the location of the proposed bioretention system.

- The bioretention system should be fenced off during the construction period to prevent disturbance of the soils.

- The bioretention system should be excavated to the dimensions, side slopes, and elevations shown on the plans. The method of excavation should avoid compaction of the bottom of the bioretention system. A hydraulic excavator or backhoe loader, operating outside the limits of the bioretention system, should be used to excavate the system. Excavation equipment should not be allowed within the limits of the bioretention system.

- The gravel, pea gravel, and bioretention soil media should be placed in the excavation by a hydraulic excavator or backhoe loader located outside the limits of the bioretention system and then hand-raked to the desired elevation.

- Place the bioretention soil in 6 to 12-inch lifts. The bioretention soil needs to settle before planting. Lightly tamp or spray the surface of the bioretention soil with water until saturated. The elevation of the bioretention soil can be a couple of inches higher at installation than the design elevation in anticipation of settling. Bring bioretention soil levels back to the design elevation if necessary.

    - Install vegetation (plants, grass, etc.) in the bioretention system in accordance with the planting plan and plant schedule on the plans. Water vegetation thoroughly immediately after planting and as necessary until fully established. The bioretention soil mix provides enough organic material to adequately supply nutrients from natural cycling.

Maintenance Needs

- Bioretention systems should be designed with easy access to all components of the system for maintenance purposes. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices for general design considerations to reduce and facilitate system maintenance.

- Detailed inspection and maintenance requirements, inspection and maintenance schedules, and those parties responsible for maintenance should be identified on the plans and in the Stormwater Management Plan.

- Maintenance should be detailed in a legally binding maintenance agreement.

- Maintenance activities such as sediment removal, mowing, and repairs should be performed with rakes and light-weight equipment rather than heavy construction equipment to avoid compaction of the bioretention soil media and underlying soils. Heavy equipment may be used for sediment removal and other maintenance activities if the equipment is positioned outside the limits of the bioretention system. Heavy construction equipment should not be allowed within the limits of the bioretention system for maintenance purposes.

Recommended Maintenance Activities

- Inspect after major storms (1 inch or more of precipitation) in the first few months following construction.

- Inspect bioretention system annually.

- Refer to Appendix B for maintenance inspection checklists, including items to focus on during the inspections.

- Remove trash and organic debris (leaves) in the Spring and Fall.

- Remove sediment from the sediment forebay or other pretreatment area when it accumulates to a depth of more than 12 inches or 50% of the design depth. Clean outlet of sediment forebay or other pretreatment measures when drawdown time exceeds 36 hours after the end of a storm event.

- Remove accumulated sediment from the bioretention system when the sediment accumulation exceeds 1 inch or when drawdown time exceeds 48 hours after the end of a storm event, indicating that the soil media is clogged. Replace with fresh bioretention soil media that conforms to the specifications in this section.

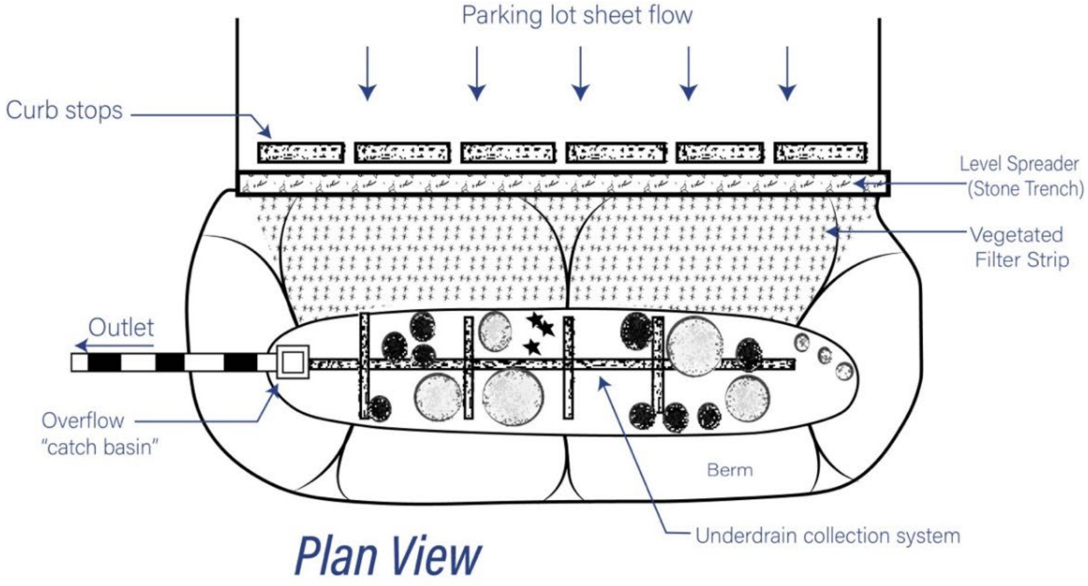
- Maintain vegetated filter strips or grassed side slopes of bioretention system in accordance with maintenance recommendations in Pretreatment BMPs section of this Manual.

- Periodically remove grass clippings to prevent clogging of the surface of the bioretention system.

- Mowing should not be performed when the ground is soft to avoid the creation of ruts and compaction, which can reduce infiltration.

- Bioretention systems require other seasonal landscape maintenance, including:
    - Watering plants as necessary during first growing season
    - Watering as necessary during dry periods
    - Replacing dead or dying plants, or pruning plants, as necessary
    - Inspection of soil and repairing eroded areas
    - Removal of litter and debris

Figure 13-16. Bioretention System Schematic (Plan View and Elevation)



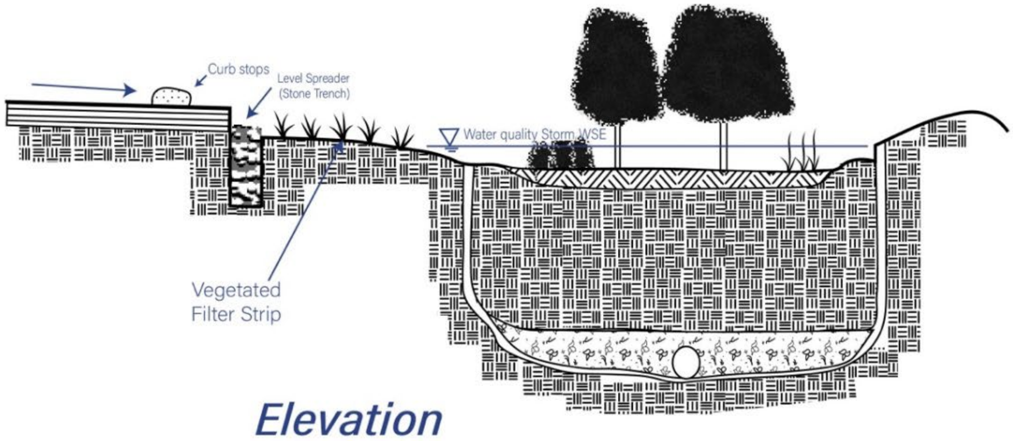
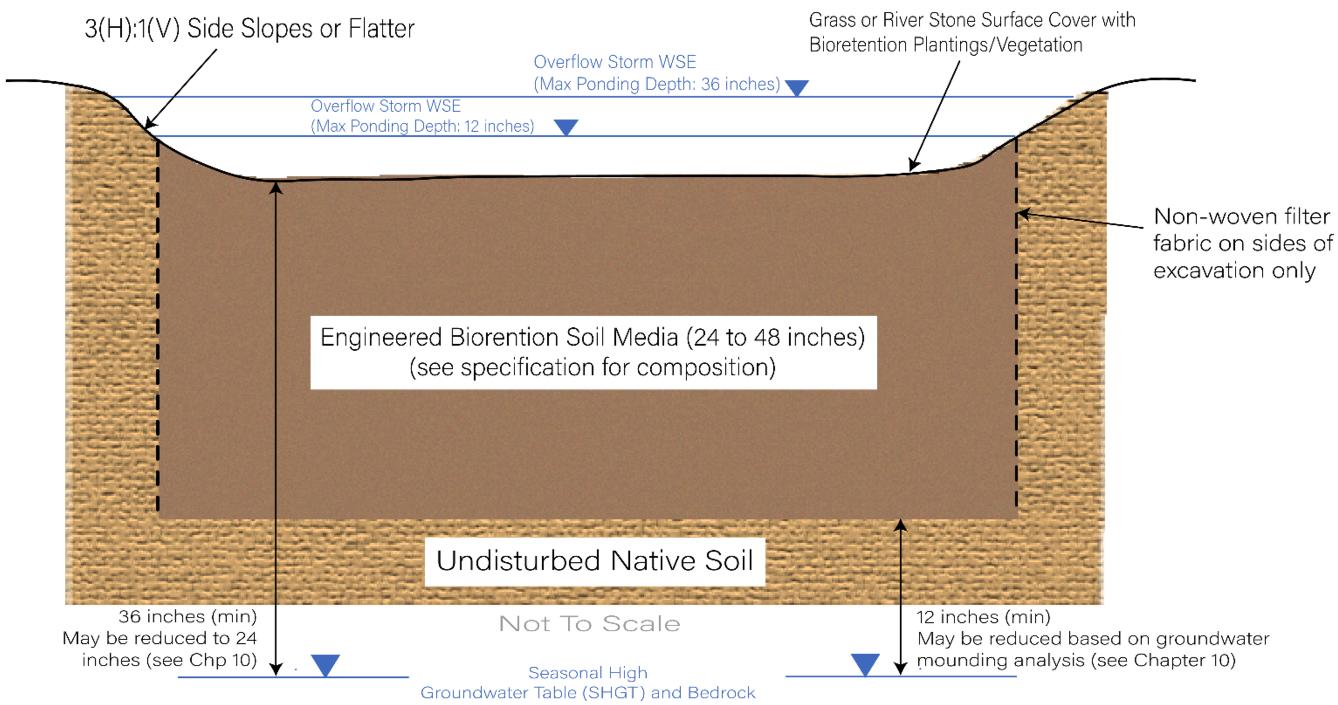


Figure 13-17. Bioretention System without and with Underdrain Schematic

Without Underdrain



With Underdrain

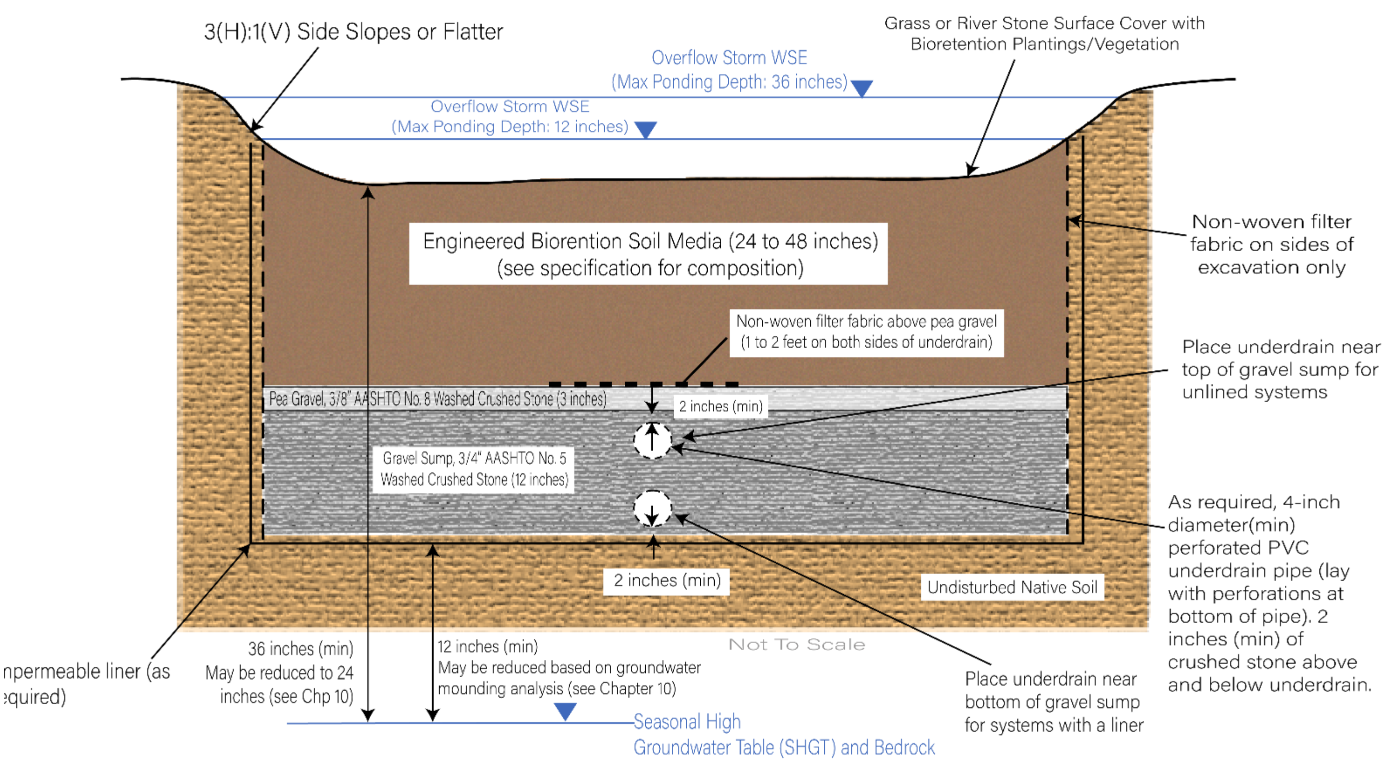


Figure 13-18. Bioretention System with Underdrain and Internal Water Storage Zone