Bioretention

A Guide for Stormwater Retention & Water Quality Improvement

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Bioretention Overview

Suburban and urban development often creates a loss of natural land, negatively impacting natural aquatic systems through an increase of runoff and polluted waters. Bioretention is a regenerative upland-based water quality and quantity control practice that uses the physical, biological and chemical properties of plants, microbes and soils to remove pollutants from stormwater runoff.

Bioretention facilities provide several benefits, including water quality improvements, environmental stewardship opportunities, aesthetic enrichment and wildlife habitat creation/preservation. There are also various types of bioretention facilities that can be used in an area, and it is important to choose one that suits the particulars of the impacted site. When making a decision on the type of facility to be implemented, the land manager must consider both the aesthetic aspect and stormwater management needs.

Bioretention can be used in both residential and industrial settings. The difference between the two is the scale of the design. When placing bioretention within residential communities, the chief concern is aesthetics and visibility. With thoughtful design and consideration of local building codes, bioretention can be successfully used on residential lots. Typical residential bioretention includes landscaped raingardens, shallow dish design raingardens, shrub and tree pits, sloped "weep" gardens, and side-swale gardens. More information about these types can be found in the Prince George's County, MD Bioretention Manual (2007). Within industrially zoned and commercial areas where landscaping traditionally has not been a focal point, combining stormwater management with bioretention landscaping options has a significant, positive impact.

Design Phases

Although procedures for residential and industrial bioretention areas vary, there are basic design phases necessary no matter the scale.

Different issues and responsibilities occur with each phase of bioretention facility development. The development phases for commercial and industrial bioretention facilities are specific and include: Concept, Engineering and Design, Engineering Plan Review, Pre-Construction, Construction, Final Closeout and Maintenance. For residential bioretention gardens, the steps are much simpler and involve sizing and siting, building, planting and maintenance.

The Concept Phase is the preliminary phase of all development activities, when the site is first evaluated for development potential and any environmental requirements. It is at this time that the designer should consider incorporating bioretention as means to manage stormwater. For residential bioretention, the concept aspects include location, size and depth — and how it will fit into the overall property landscape plan.

The Engineering Design Phase is next for commercial and industrial bioretention facilities. This phase determines whether the specific site identified is appropriate for bioretention. It is also where the designer will determine how to distribute bioretention uniformly across the site, resulting in smaller and more manageable subwatersheds. To determine if a site is suitable for a bioretention, several characteristics must be evaluated, including soil types/conditions, topography, existing drainage patterns, existing vegetation and utilities. Additional considerations can include sizing, underdrain pipes, overflow design, drain outlet structure and rain garden medium, depending on the scale of the bioretention facility or garden.

Once the construction plan is completed, it is the designer's responsibility to determine what information is needed for the review (i.e., contour intervals, sediment and erosion control plan, setbacks, grading plans, etc.) and what offices need to be contacted for the review, if any. This is the Engineering Plan Review Phase. A residential bioretention may not need review, other than a neighborhood ordinance/standards approval.

The Pre-Construction Phase is critical to commercial projects and includes a pre-construction meeting with the county inspector to evaluate the timeline of the construction and sediment controls, as well as when inspections during construction will occur. The Construction Phase follows. During this phase the designer needs to be onsite to make sure the project is implemented correctly and to address any problems. The designer or construction manager must make sure that the design sequence is followed and inspections occur on time.

With residential garden construction, the critical pre-construction issue involves checking with local utility companies to be certain that digging will not interfere will underground lines.

The point at which the designer ensures the project is completed as designed is called the Final Closeout Phase. Any changes to the original plan must be documented. This is also the phase in which any final inspections required for permit compliance are completed and on time. The final phase, Maintenance and Operation, entails developing a maintenance schedule to ensure the project operates as designed and addresses the primary problem identified at the beginning of the project.

It is rather simple to maintain a residential bioretention garden, as this primarily involves weeding for the first couple of growing seasons; thereafter the native plants will out-grow the weeds. Each spring, dead overgrowth will need to be cut back, but other than some isolated weeding, no other maintenance should be necessary.

1 Introduction

Loss of forested land and increases in suburban and urban development can negatively impact aquatic systems. The presence of impervious surfaces can be particularly harmful by increasing runoff volume, nutrient loads and other pollutants that are transported into waterways. Bioretention is a regenerative upland-based water quality and quantity control practice that uses the physical, biological and chemical properties of plants, microbes and soils to remove pollutants from stormwater runoff. Bioretention facilities capture these pollutants through several means including:

Physical: As runoff reaches the bioretention facility, it is slowed. Particles and suspended solids are filtered out as the water moves through the mulch and soil.

Chemical: When certain conditions exist, microorganisms reduce nitrates into forms that return to the atmosphere. A bioretention facility with an anaerobic zone will provide the conditions needed for this process.

Biological: Plants and fungi in the bioretention facility take up nutrients and use them for growth.

Besides improving water quality, bioretention facilities also provide social and aesthetic benefits. For example, these facilities can provide excellent opportunities for environmental stewardship by community groups or individuals. Moreover, native plants used in bioretention facilities provide habitat for local wildlife. And by using aesthetically pleasing landscaping, bioretention facilities can enhance real estate values.

This document was developed as part of a partnership between the Environmental Protection Agency, U.S. Fish and Wildlife Service and the Maryland Department of Natural Resources, in order to describe the steps involved in completing the design and construction of a bioretention facility. This document will be distributed to land managers and other Maryland park personnel to educate and encourage the creation of bioretention facilities in state parks, as well as other state land. Although originally developed for use by land managers in Maryland, the procedures outlined here are also applicable to other areas. The information in this document applies to both new development and retrofits to existing facilities. While the tasks outlined here are comprehensive, detailed descriptions of each step are not included. Several detailed resources are listed at the end of the document to further assist land managers with bioretention design and construction.

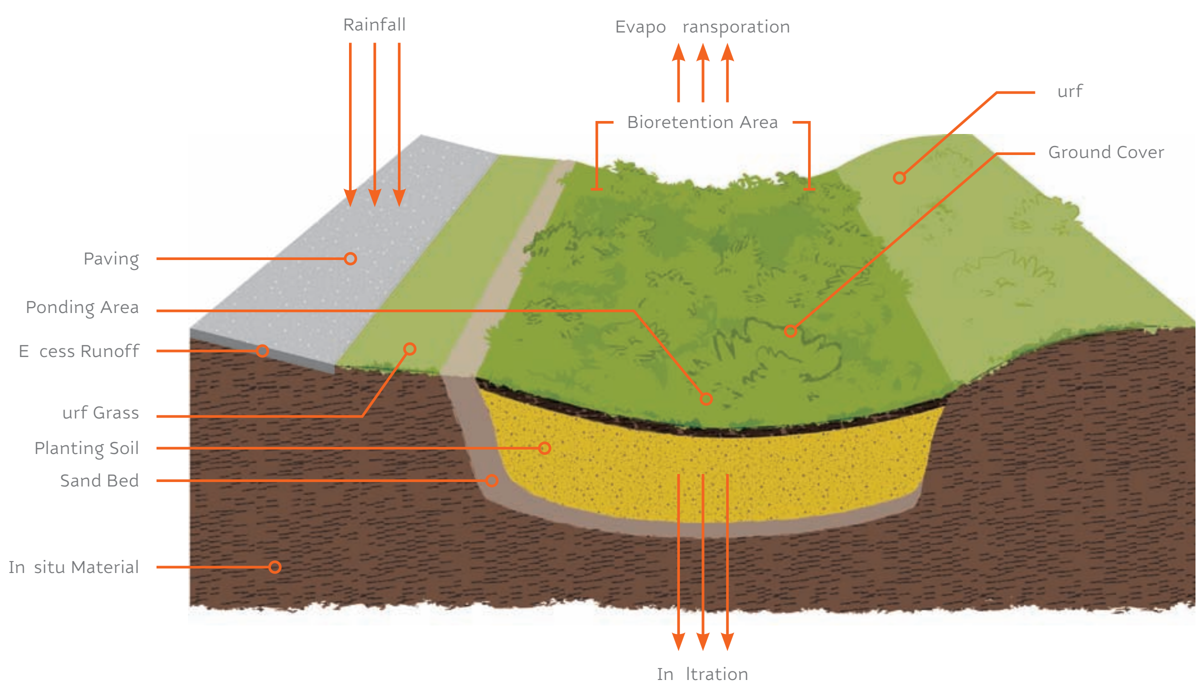
Critical Processes of Bioretention

Bioretention facilities attempt to reproduce the same physical, chemical and biological processes that occur in the natural environment, as well as mimic the predevelopment hydrology. The degree to which certain processes occur depends upon the design of the bioretention facility, the type and quantity of pollutants to be removed, and the frequency, duration and intensity of storm events. Defined below are some of the processes at work[1].

- Interception: the collection or capture of rainfall or runoff by plants or soils
- Infiltration: the flowing of runoff through the planting soil and into the surrounding in situ soils
- Settling: the settling out of particles and suspended solids as runoff slows and ponds within the bioretention facility
- Evaporation: water changing to water vapor by the energy of sunlight
- Filtration: particles filtered from runoff as it moves through mulch and soil
- Absorption: water absorbed into the spaces between soil particles and up by plants
- Transpiration: water vapor that is lost through leaves and other plant parts

- Evapotranspiration: water loss through the evaporation of wet surfaces and transpiration
- Assimilation: plants taking in nutrients and using them for biological processes
- Adsorption: the ionic attraction holding a liquid, gaseous or dissolved substance to a solid's surface
- Nitrification: bacteria oxidize ammonia and ammonium ions forming nitrate (NO3), a highly soluble form of nitrogen that is readily used by plants
- Nitrification: microorganisms reducing nitrate (NO3) to volatile forms, which return to the atmosphere
- Volatilization: converting a substance to a more volatile vapor form
- Denitrification: volatilization plus the transformation of complex hydrocarbons to CO2
- Thermal Attenuation: cooling of runoff as it is filtered through the soil
- Degradation: the breakdown of chemical compounds by organisms in the soil
- Decomposition: the breakdown of organic compounds by organisms in the soil

FIGURE 02.1: Bioretention rea oncept al La o t nctionin li e an n ltration Basin



Bioretention ypes

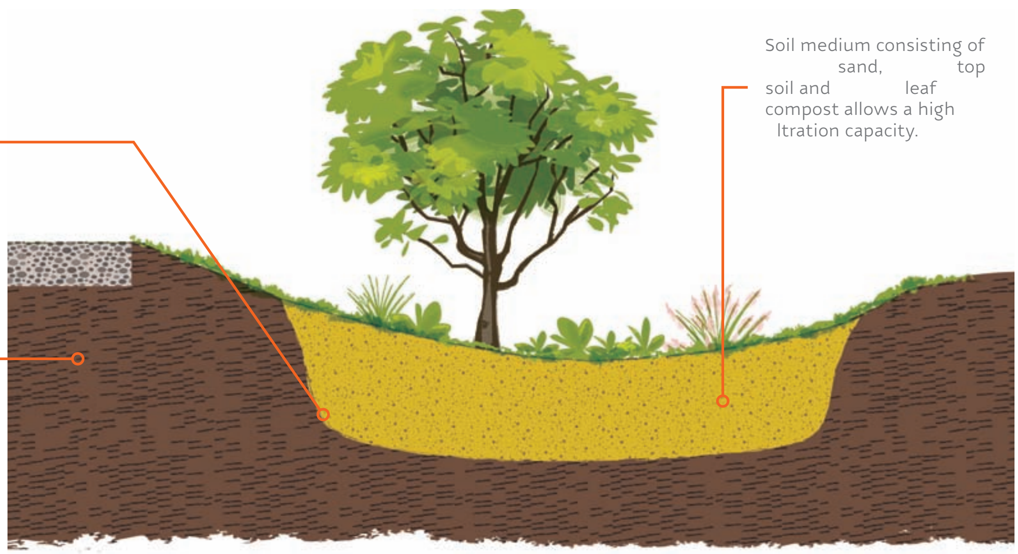
There are various bioretention types that can be employed in an area, and it is important to choose one that suits the particulars of the impacted site. Both the aesthetic aspect and stormwater management needs of the land manager should be considered. General information about bioretention types based on location and performance needs is described below.

This section describes different types of bioretention facilities based on the performance needs of the site.

- **Infiltration/Recharge Facility (Enhanced Infiltration):** This type is recommended for areas where high recharge of groundwater would be beneficial. Because there is no underdrain, the soils must have a high infiltration rate (1 inch/hour or greater) to accommodate the inflow levels. This facility type is suitable for areas and land uses that are expected to generate nutrient runoff (i.e., residential and business campuses).

  Facilities must be at least 2.5 feet deep to allow adequate filtration processes to occur. Location of this facility should be in areas where visibility is not a concern, as the hydraulic overload can cause standing water conditions for extended periods. Fresh mulch can be used to enhance denitrification processes. Soil medium consisting of 50%–60% sand, 20%–30% topsoil and 20%–30% leaf compost allows a high infiltration capacity [1]. Since there is no liner or geotextile fabric, soils will infiltrate to their maximum capacity.

FIGURE 03.1: n ltration ec ar e acilit en anced in ltration

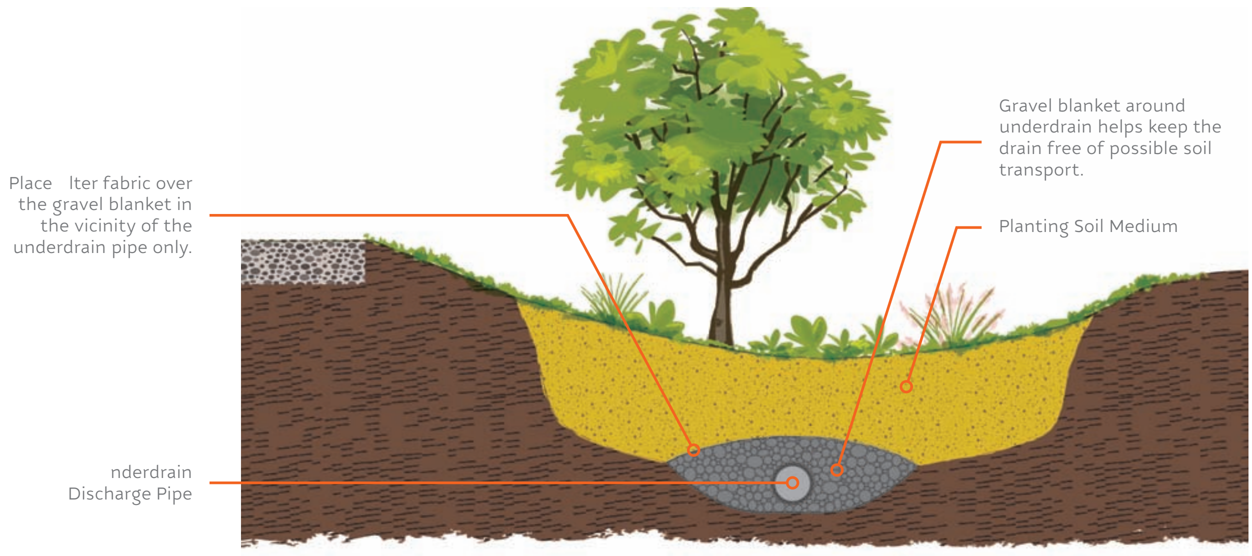


- **Filtration/Partial Recharge Facility:** This type is recommended for areas where high filtration and partial recharge of runoff would be beneficial. This facility is designed with an underdrain at the invert of the planting soil mix to ensure that the facility drains at a desired rate. Since an impervious liner is not used, this facility allows for partial recharge.

  The depth is shallow (2.5 feet) to allow the facility to handle high-capacity flows if necessary. This facility type is suitable for areas and land uses that are expected to generate nutrient and metals loadings (e.g., residential, business or parking lots), and the siting is suitable for visually prominent locations in a community.

  The facility incorporates a filter material between the gravel blanket around the underdrain and the planting soil above. Instead of using a filter fabric, the designer could opt to use a pea-gravel diaphragm over the underdrain gravel blanket . Using a gravel blanket around underdrain helps keep the drain free of soil transport.

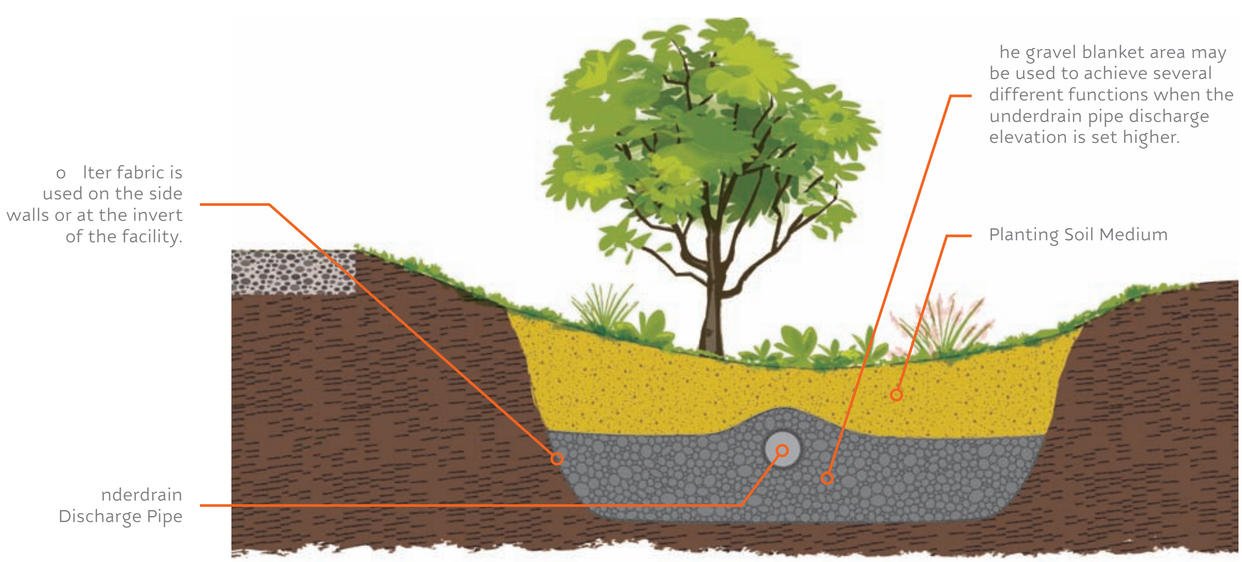
FIGURE 03.2: iltration Partial ec ar e acilit



- **Infiltration/Filtration/Recharge Facility:** This type of facility is recommended for areas where higher nutrient loadings (particularly nitrates) are anticipated. The facility is designed to incorporate a fluctuating aerobic/anaerobic zone below a raised underdrain discharge pipe. The fluctuation created by saturation and infiltration into the surrounding soils will achieve denitrification. A fresh mulch covering enhances natural denitrification. This type of facility is suitable for areas where nitrate loadings are typically a problem (e.g., residential communities).

  The raised underdrain provides a storage area below the invert of the underdrain discharge pipe, which can augment quantity control. This area provides a recharge zone and can be used to meet the Maryland stormwater management requirements .

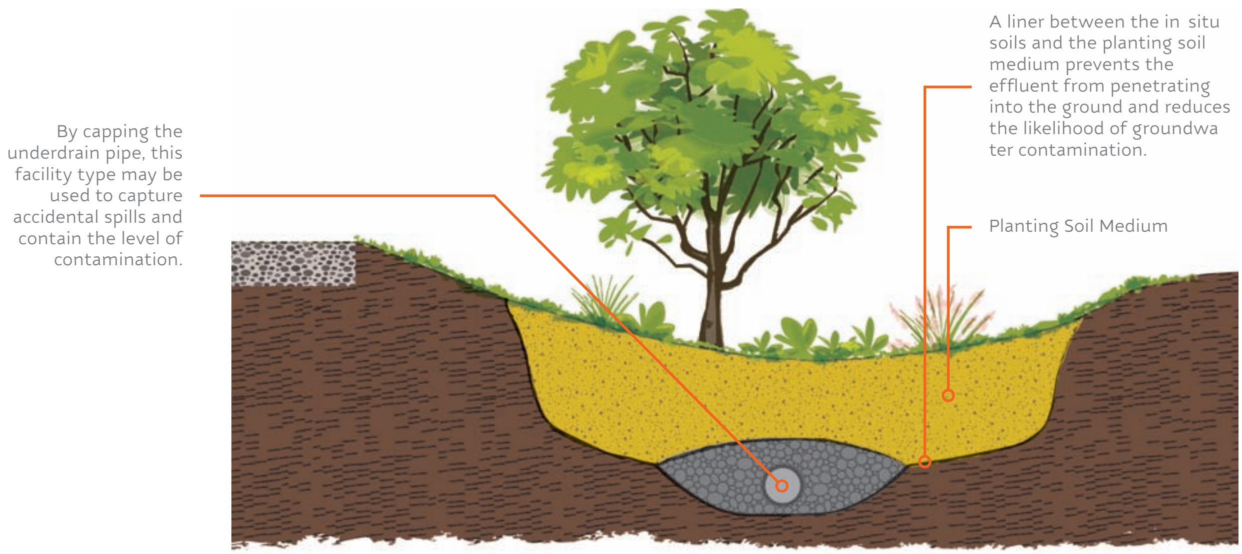
FIGURE 03.3: n ltration iltration ec ar e



- **Filtration-Only Facility:** This facility type is recommended for potential hotspots (e.g., gas stations, transfer sites and transportation depots). An important feature of this type is the impervious liner designed to reduce or eliminate the possibility of groundwater contamination. This facility provides a level of treatment strictly through filtration processes that occur when the runoff moves through the soil material to the underdrain discharge point. If there is an accidental spill, the underdrain can be blocked and the objectionable materials siphoned through the observation well and safely contained.

A liner between the in-situ soils and the planting soil medium prevents the effluent from penetrating into the ground and reduces the likelihood of groundwater contamination by capping the underdrain pipe .

FIGURE 03. : iltration nl



Even in industrially zoned areas where landscaping traditionally has not been a focal point, combining stormwater management with landscaping options has a positive impact. The following bioretention area types provide design ideas for various site conditions in a commercial setting.

- Curbless Parking Lot Perimeter
- Curbed Parking Lot Perimeter
- Parking Lot Island and Median -
- Parking Swale

FIGURE 03. : r less Peri eter Bioretention

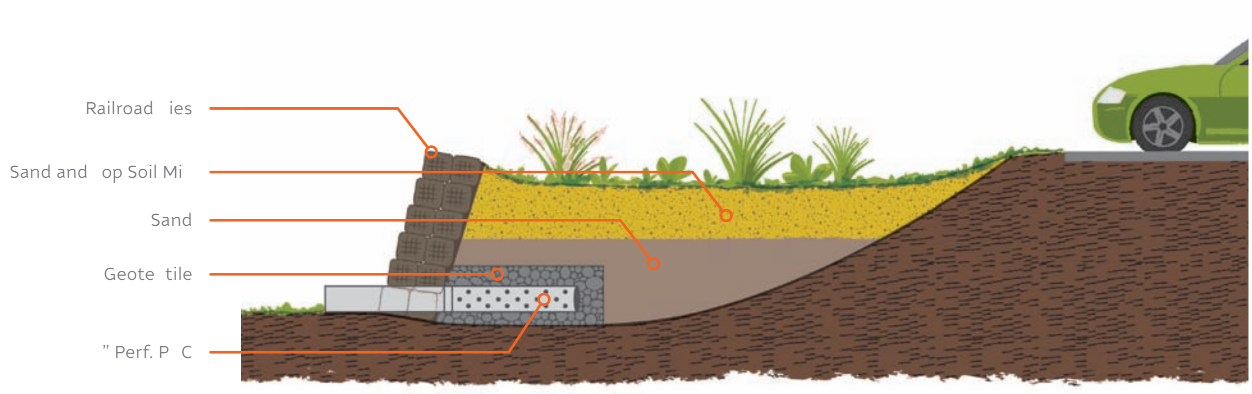


FIGURE 03. : r ed Par in Lot sland edian Bioretention

Safeway, Chester, MD
Photo courtesy of: McCrone, Inc., Civil Engineers and Surveyors

When placing bioretention within residential communities, the chief concern is aesthetics and visibility. With thoughtful design and consideration of local building codes, bioretention can be successfully used on residential lots. Here are several types suitable for residential scenarios.

- Swale-side
- Green Roof 1 1
- Landscaped Garden 11 1
- Shallow Dish Design 1
- Tree and Shrub 1
- Sloped "Weep Garden" 1
- Swale-side Garden 1

FIGURE 03. : wale-side: Basic Bioretention o ponents

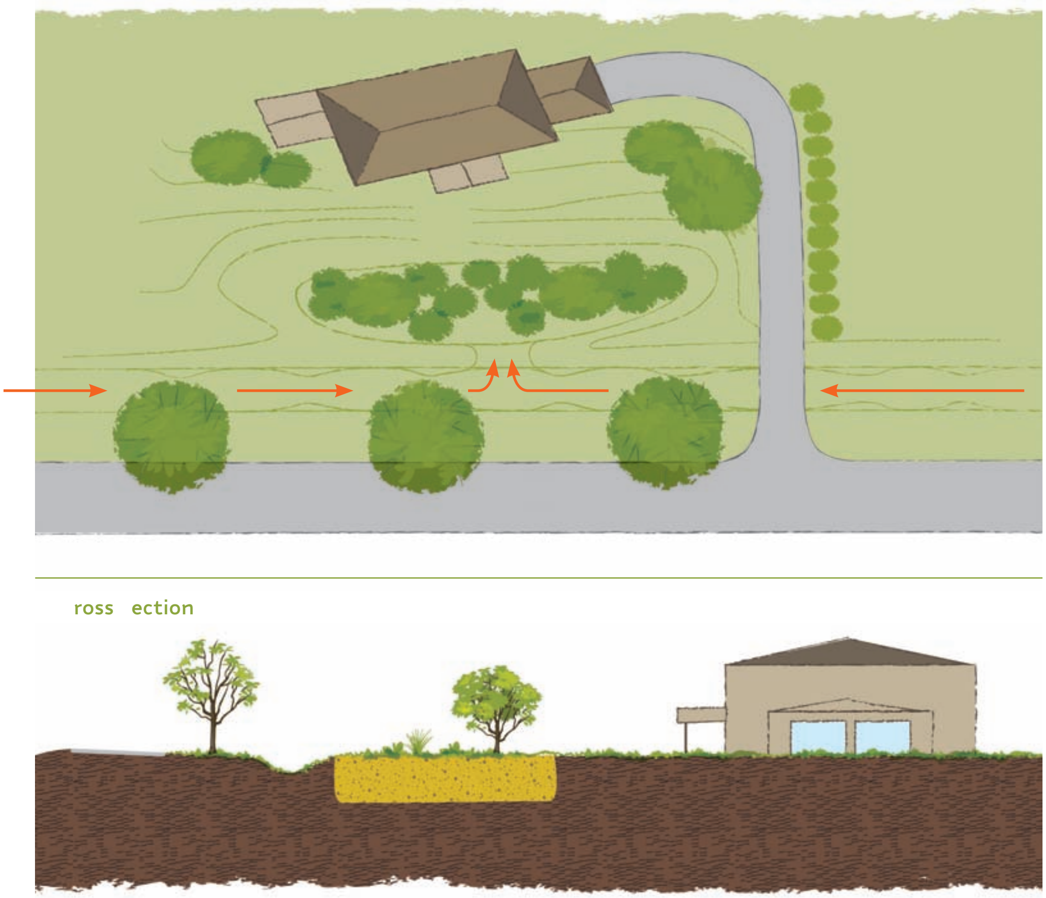


FIGURE 03. : wale-side Bioretention

Photo courtesy of: Abby all and the .S. Environmental Protection Agency

FIGURE 03. : Green oo

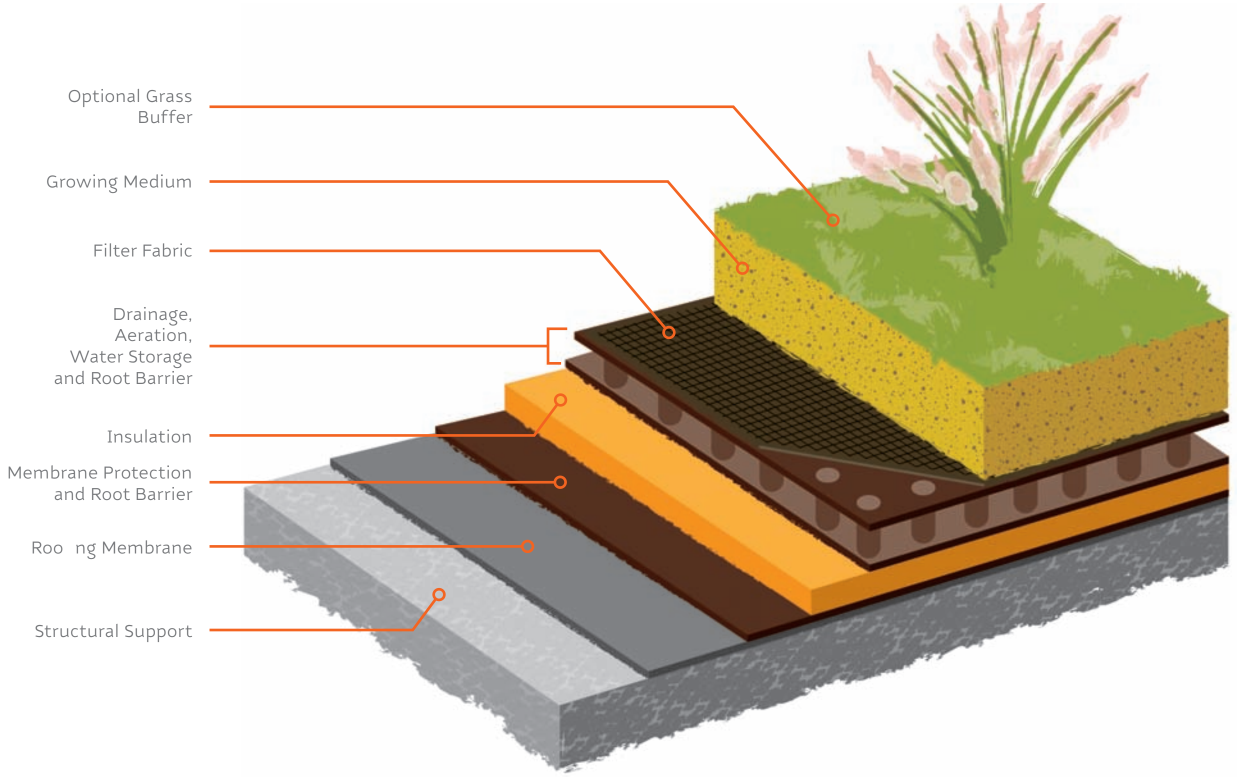


FIGURE 03.10: Green oo

West Library, Odenton, MD
Photo courtesy of: McCrone, Inc., Civil Engineers and Surveyors

FIGURE 03.11: Landscaped Garden Bioretention: Plan View

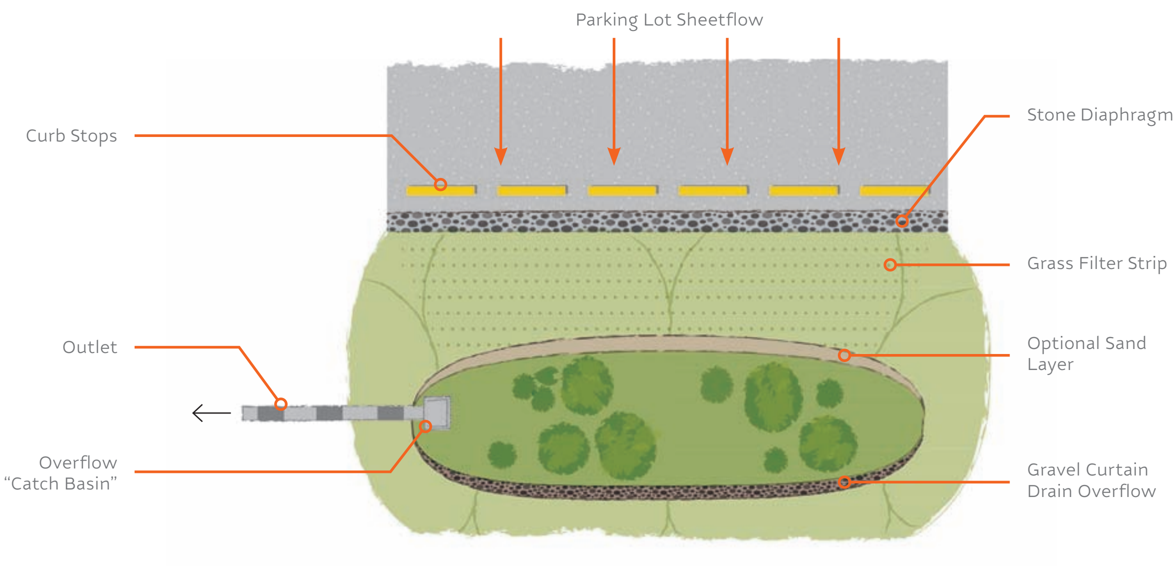


FIGURE 03.12: Landscaped Garden

Kramer Center, Centreville, MD
Photo courtesy of: McCrone, Inc., Civil Engineers and Surveyors

FIGURE 03.13: allow is esi n: calloped Bioretention

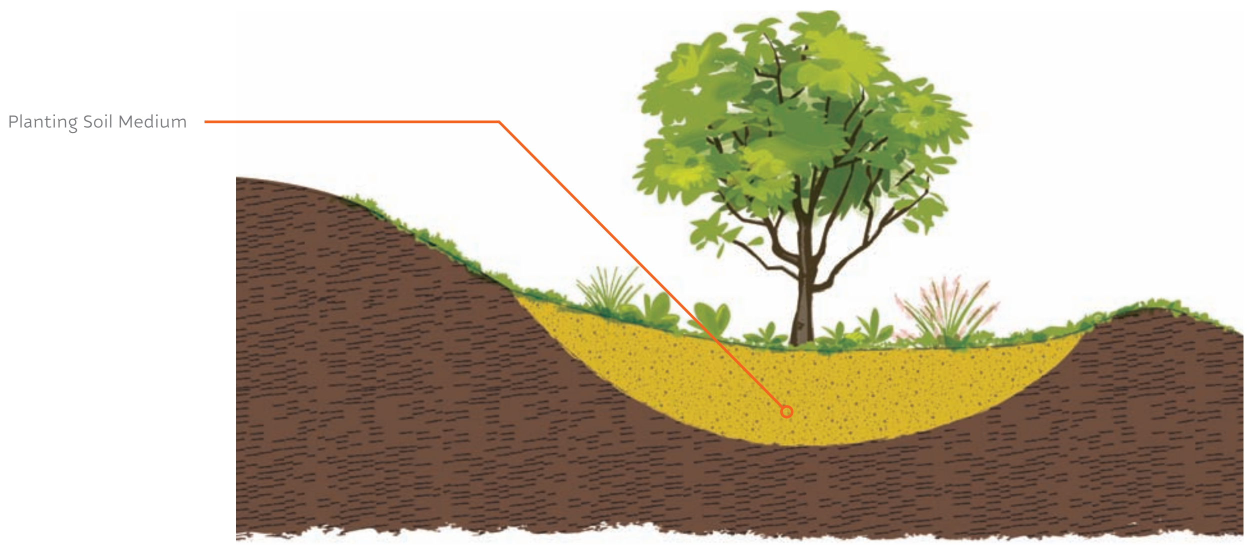


FIGURE 03.1 : ree and r ree Pit Bioretention

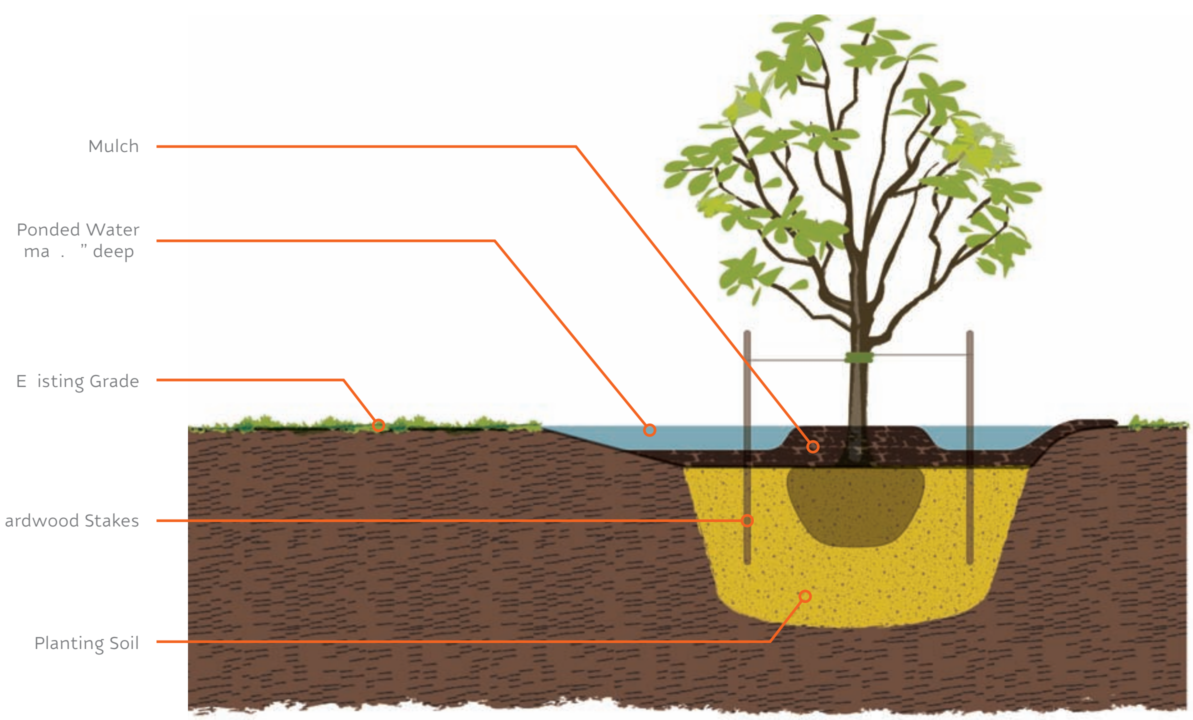
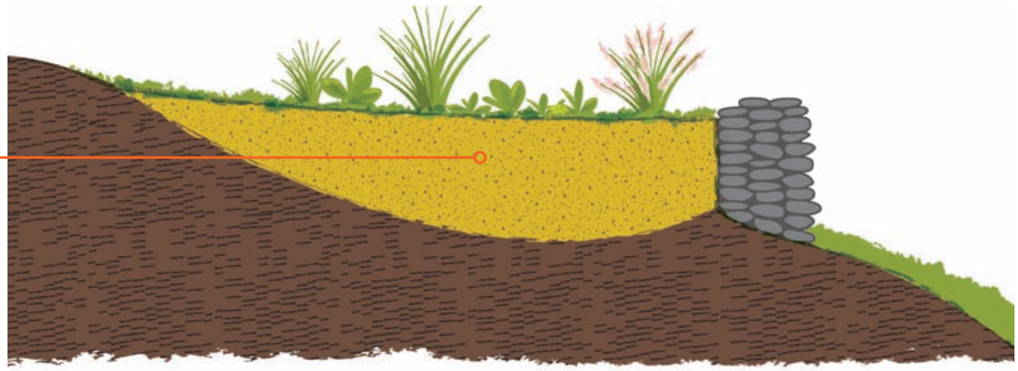


FIGURE 03.1 : loped eep Garden : ieldstone eep Garden



One of the most attractive qualities of bioretention is the variety of design themes that can be employed. By using existing conditions, the design theme helps to aesthetically blend the bioretention area with the surrounding landscape.

- Forest: The most typical design theme, the forest habitat is the most efficient in terms of mimicking pre-existing hydrologic conditions.
- Forest Transition: Forest transition zone bioretention areas are used on larger lots close to existing forest areas or within common space areas.
- Existing Forested Area: This design makes use of existing forest areas by installing a low berm around the tree perimeter area.
- Meadow Habitat: A meadow is community of plants occupying different levels above and below ground. A variety of grasses and wildflowers are generally interspersed throughout the site.
- Meadow Garden: A meadow garden is a more designed approach to using meadow plants. Plants can be seeded in bands of color or zones of short, medium and tall plant mixes.
- Ornamental Garden: This is a formal garden design within a depressed area in the landscape, rather than a mounded one.

Design Phases

Different issues and responsibilities occur with each phase of a bioretention facility development. The development phases include: concept, engineering and design, engineering plan review, pre-construction, construction, final closeout and maintenance.

This is the preliminary phase of all development activities, when the site is first evaluated for development potential and any environmental requirements. It is at this time that the designer should consider incorporating bioretention as means to manage stormwater.

. Problem Identi cation

Excessive water runoff, nutrient reduction, retention of other pollutants, or perhaps a combination of problems will determine the design that should be employed. It is imperative to use the appropriate type of facility (see Facility Performance Types page 2) for the problem identified.

The following questions should be answered during the problem identification stage:

- What are the site requirements for water quality and quantity control?
- What design storm is required to meet the stormwater management criteria?
- Can bioretention be used for water quality and quantity control?
- Can the bioretention facility be used independently, or will it be installed along with other stormwater management practices (BMPs)?

. General Site Evaluation

The general site evaluation is conducted to determine whether the application of bioretention is appropriate for the location. Layout of a bioretention area will vary according to specific site constraints, such as topography, soils, existing vegetation, drainage patterns, location of utilities, vehicular and foot traffic, and aesthetics.

The following general guidelines can help the designer determine when to use bioretention for stormwater management:

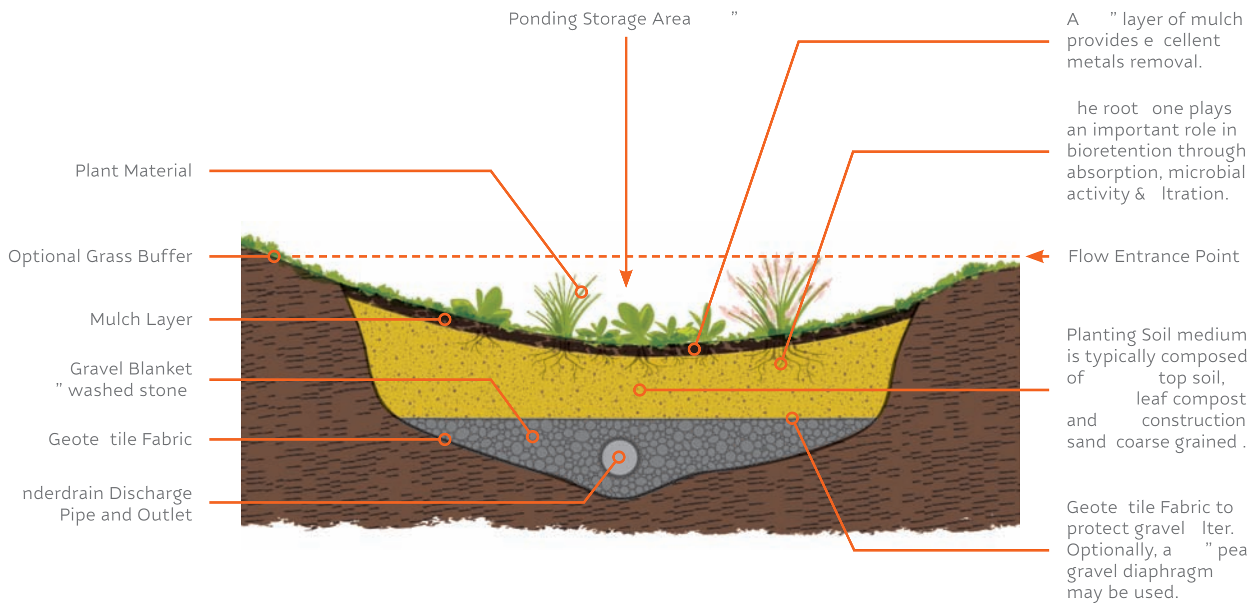
- Can facilities be placed close to the source of runoff generation?
- Does the site permit the dispersion of flows, and can bioretention facilities be distributed uniformly?
- Are sub-drainage areas smaller than 2 acres and preferably less than 1 acre?
- Is there available room for installation, including setback requirements?
- Is the stormwater management site integration a feasible alternative to end-of-pipe BMP design?
- Are suitable soils available at the site?

. Components of Bioretention Facilities

In order for the critical biological and physical processes to occur, the bioretention area must have the proper components 1 . Over time, the components blend together with plant growth, organic decomposition and development of a microorganism community to develop a natural soil structure that will lengthen the life span of the facility and reduce the need for maintenance. The typical components of a bioretention facility include:

- Pretreatment: Vegetated buffer strips pretreat runoff prior to it entering the soil medium.
- Flow Entrance: This is how water flows into the bioretention facility. The best method is to allow water to sheet flow over grassed areas.
- Ponding Area: This provides storage evaporation of runoff and settling of particles.
- Plant Material: This includes plants, bind nutrients and other pollutants.
- Organic Layer: This layer provides a medium for biological growth, decomposition of organic material, adsorption and bonding of heavy metals.
- Planting Soil and Filter Media: This provides water and nutrients for plants. Clay, in particular, adsorbs heavy metals, nutrients hydrocarbons and other pollutants.
- Pea Gravel Diaphragm: This is a filter layer between the soil and gravel around the underdrain.
- Underdrain and Outlet: This component increases the ability of soils to drain quickly and keeps soils at an aerobic state, allowing plants to flourish.
- Surface Overflow: Paved areas can generate large quantities of runoff, so a safe discharge point is often required.

FIGURE o .1 : wale-side: Basic Bioretention o ponents



This phase determines whether the specific site identified is appropriate for bioretention. It is also where the engineer will determine how to distribute bioretention uniformly across the site, resulting in smaller and more manageable subwatersheds. Bioretention facilities should be applied where the sub-drainage areas are less than 2-3 acres and, preferably, less than 1 acre.

To determine if a location is a suitable site for a bioretention facility, evaluate these characteristics:

- Soil Types/Conditions: Soil must have an infiltration rate exceeding one-half inch/hour (e.g., sand, loamy sand, sandy loam or loam).
- Slopes/Topography: Sloped areas adjacent to proposed bioretention areas should be less than 20% but at least 2% to ensure positive flow.
- Existing Drainage Patterns: Where possible, use existing flow patterns and paths.
- Existing Vegetation: Wooded areas should not be cleared for a bioretention facility; however, do remove any noxious weeds.
- Utilities: Apply standard utility practices for setback criteria when near utilities.

. Si ing

Prior to sizing a bioretention facility, the designer should refer back to its intended purpose (i.e., the problem and/or problems already identified). The designer can use the following procedure for sizing bioretention areas for water quality and quantity criteria, adjusting according to the specific site constraints.

- Determine the drainage area for pre- and post-conditions.
- Determine the pre- and post-development Curve Number (CN) using TR-55 methodology.
- Calculate CN based on the connectivity of site imperviousness.
- Determine the required design storm and design depth. Remember, the storm design can vary depending on the stormwater management objective.
- Determine the storage volume to maintain runoff volume or CN.
- Determine the storage volume to maintain pre-development peak runoff using 100% retention.

- Determine the percentage-of-site needed pre-development, peak runoff and runoff volume.
- Determine the percentage-of-site available for retention practices (this may need to be revised).

FIGURE o .2:

Impervious Area Discovery Center Parking Lot and Driveway : , s . ft.
otal Area: , s . ft. . acres
Impervious Percentage:

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WQv . Rv A

where Rv . . I I
Percent Impervious Area A
Drainage Area acres

I . . .

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Af WQv df k hf df tf

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Per the MDE Stormwater Design Manual, for bioretention areas:
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. Other Design Considerations

There are various other considerations when choosing a design. Some of the most common are included below.

a. nderdrain Pipes

Underdrain pipes are required for residential lots and recommended for all facilities in general. They ensure proper drainage for plants and that suitable infiltration rates occur. Underdrains are typically located at the invert of the bioretention facility to intercept any filtered water that does not infiltrate into the surrounding soils. Underdrain material must be of approved material and have a hydraulic capacity greater than the planting soil infiltration rate. Underdrains typically include a gravel/stone blanket encompassing a horizontal, perforated discharge pipe. The following provides some guidance for underdrain requirements:

- Layout: Underdrains are typically located at the invert of a bioretention facility in order to intercept any filtered water that does not infiltrate into the soil. They must connect to an existing drainage system to achieve positive flow.
- Sizing: Perforated OVC is commonly used with ¼" to ½" perforations, 6" center to center. No perforations are to be within 5" of where the underdrain connects with the stormdrain structure.
- Materials: Gravel bed materials are sometimes used to protect an underdrain, reducing the clogging potential. The gravel stone should be no greater than ½" to 1½" in diameter. Pea gravel use, versus geotextile fabric, is preferred. River run gravel is preferred.

b. Overflow Design

If runoff is delivered by a storm drain pipe or is along the main conveyance system, the bioretention system must be designed off-line. Overflow for the 10-year storm must be provided to a non-erosive outlet point to prevent downstream slope erosion.

c. Drain Outlet Structure

Overflow from bioretention areas should be conveyed to a discharge point, such as a storm drain system, stream channel or swale.

d. Rain Garden Medium

Soil must have an infiltration rate that can draw down pooled water within 3-4 hours after a storm event (a rate that exceeds 1.5 inches/hour). To compensate for unsuitable areas, a planting soil mixture can be imported and an underdrain system can be used to achieve the desired infiltration rate.

e. Bioretention Site Integration

Site integration is key to managing stormwater runoff using bioretention. This entails locating the facility close to the where the runoff is generated and making use of the existing landscape, such as areas of conservation to preserve trees and existing grading. Integration also means placing facilities throughout the area to be managed using existing features and being aware of constraints and setbacks, such as from utilities, property lines, building and roadways.

. Design Development

The information regarding existing conditions, sizing, drainage and integration can now be used to develop the design. Design development is an interactive process where shapes, depths and other bioretention components can be adjusted in order to address the problem originally identified. Once the design meets this purpose, you can proceed with construction drawings.

. Construction Drawings Information

Regulations vary as to what must be included in the construction plans. In order to determine what is required in a particular state and county, the designer must refer to the appropriate permitting. In most cases, to obtain proper permits, a registered engineer, licensed landscape architect or the equivalent needs to stamp the construction plans. However, this can vary from state to state, and local regulations should be checked.
[*Note: The specifications in this document comply with Maryland requirements. If this information is applied to projects outside the state of Maryland, users should consult appropriate state and local requirements.*]

Construction drawings typically contain the following components:

- Existing Conditions: These baseline maps, which denote current site conditions before any adjustments or improvements have been made, typically include topographic contours, utilities, roads, trees, property boundaries and other features that may influence the bioretention design.
- Proposed Conditions: These topographic maps of the selected site show the projected location of the bioretention area, as well as any other site adjustments.
- Cross Sections: Cross sections of the bioretention design that include existing topography, proposed grading, elevations and/or depths, materials, material placement, boring logs and structural components (piping, inlet structures, etc.).
- Construction Sequence: Describes grading, soil amendments, allowance for compaction of soils, preplanting installation, etc.
- Soil and Erosion Plan: This plan typically shows existing and proposed topography, proposed improvements, pertinent drainage information, proposed grading, and earth disturbance and sediment control features to prevent erosion and sedimentation both on and off the site. Check with the applicable state and county for specific requirements.

- **Planting Plan:** Plants that have excellent nutrient uptake and can tolerate various hydrologic conditions are among the criteria of the planting plan, which is critical to the success of the bioretention area. Detailed information is provided in the next section.

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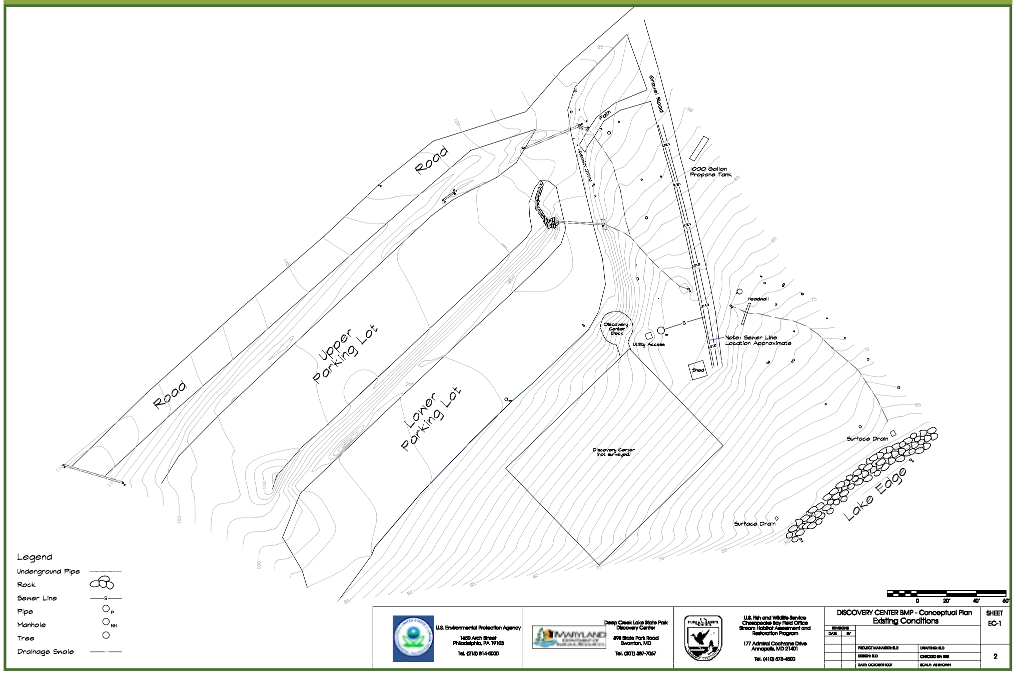
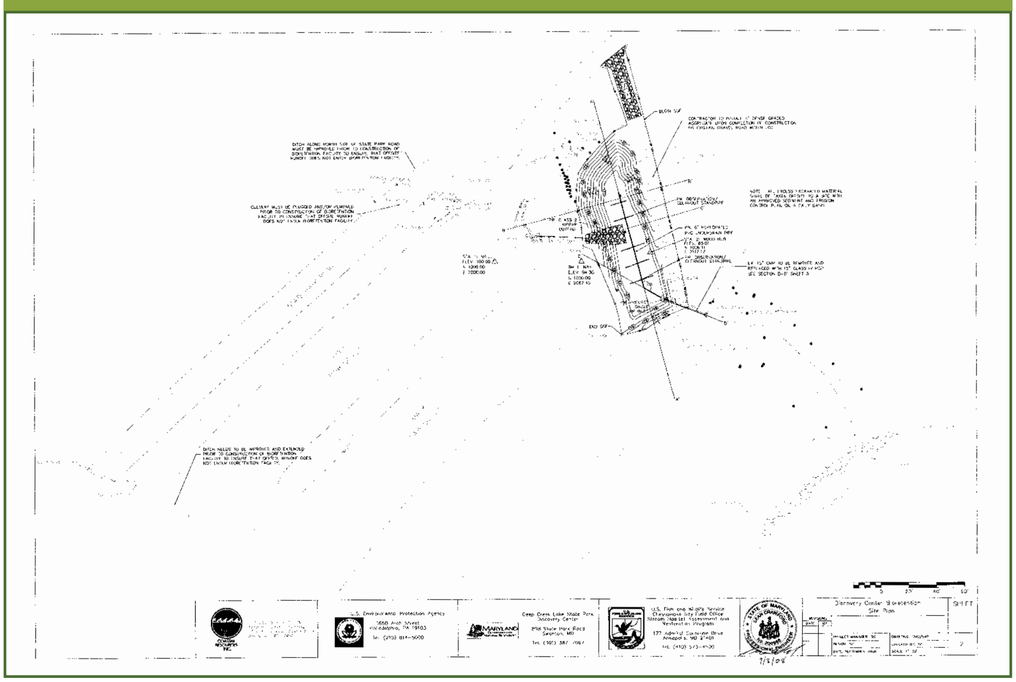


FIGURE o . : Proposed onditions and ite Plan or eep ree La e tate Par isco er enter wanton



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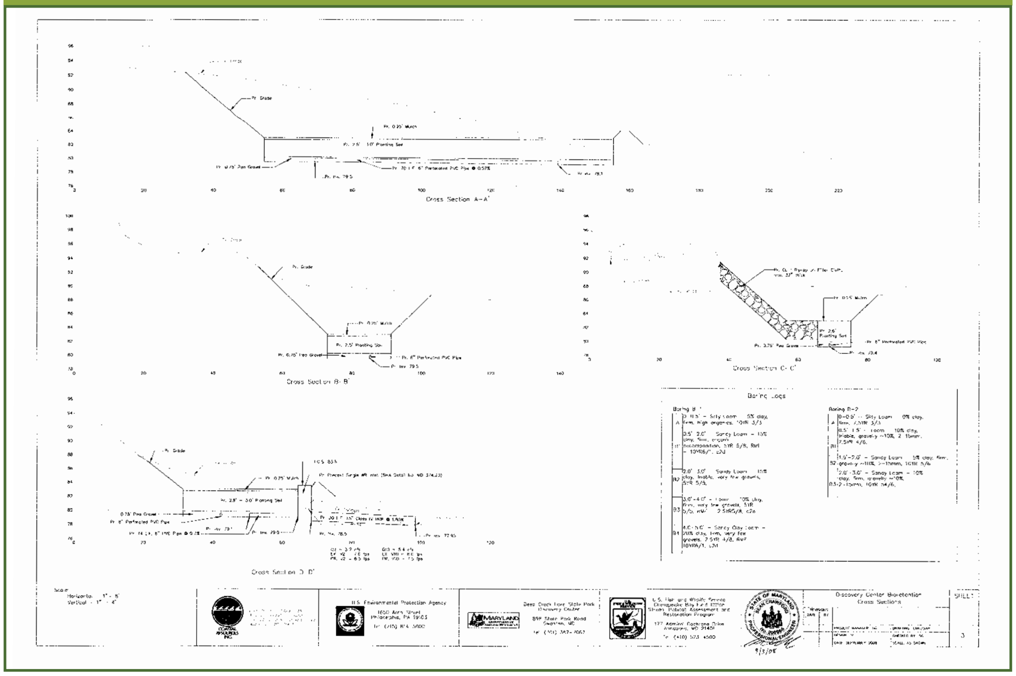


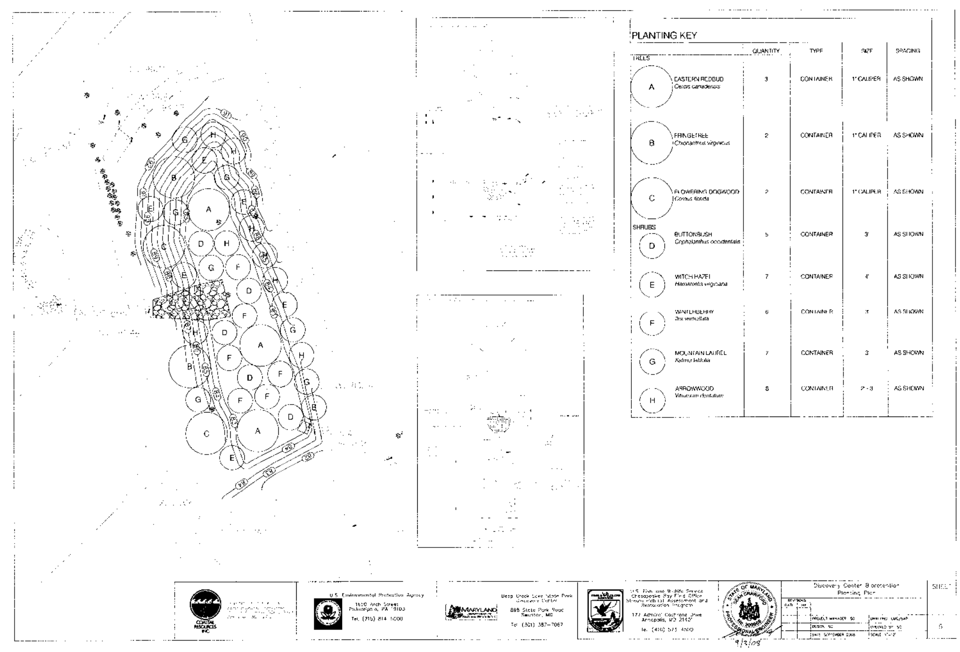
a. Planting Plan

The planting plan for a bioretention facility is developed very much like a conventional landscape plan. This plan, however, illustrates the stormwater management control and aesthetic appeal - . Planting plans should include:

- Plant list: Native plant species should be used in bioretention facilities. Native plants are defined as those species naturally evolved to live in the region, specifically referring to those species that lived in the area prior to European exploration and American settlement. Native plants have distinct genetic advantages over non-native species. Because they evolved locally, native plants are best suited for local climate. This translates into greater survivorship and less replacement and maintenance over the long term. (For further information, see the USFWS Native Plants Guide, Slattery, Reshetiloff and Zwicker, 2003.)

- Plant Layout Plan: Differing hydrologic zones are created in a bioretention facility. Hydrologic zones describe the degree to which an area is inundated with water. Plants have differing tolerances to inundation, and species need to be selected to correspond with a zone. Hydrologic zones can be divided as:
  - Deep Water Area: 1- to 6-foot deep permanent pool
  - Shallow Water Bench/Low Marsh: 6 inches to 1 foot deep
  - Shoreline Fringe/High Marsh: regularly inundated
  - Riparian Fringe: periodically inundated
  - Floodplain Terrace: infrequently inundated
  - Upland Slope/Pond Buffer: seldom or never inundated

FIGURE o . : Plantin Plan or eep ree La e tate Par isco er enter wanton



b. Planting Speci cations

Planting specifications typically include:

- Sequence of Construction: This describes the site preparation, soil amendments, erosion and sediment control measures, as well as step-by-step procedures for plant installation through site clean-up.
- Contractor's Responsibilities: These include watering, care of plants during transport, timeliness of installation, replacement due to vandalism, etc.
- Planting Schedule and Specifications: This includes plants to be installed, type of plant material, time and sequence of installation, fertilization, watering and general care.
- Maintenance: This involves the inspection period, mulching frequency, replacement of dead/diseased plants, treatment of diseased trees, watering schedule, and repair/replacement of staking and wires.
- Warranty: This specifies the warranty period and the required survival rate and expected condition of plant species at the end of the warranty period.

Once the construction plan is completed, it is the designer's responsibility to determine what information is needed for the review (i.e., contour intervals, sediment and erosion control plan, setbacks, grading plans, etc.) and what offices need to be contacted for the review. Typically two full-sized copies of the sealed and stamped designs are needed, although this may vary. There may be a fee associated with the review. Particular issues to keep in mind are:

- Types of Permits Needed: These include sediment/erosion control, stormdrain permit and easement/maintenance covenant.
- Timelines: Permits should be obtained prior to pre-construction meeting.

This critical phase includes a pre-construction meeting with the county inspector to evaluate the timeline of the construction and sediment controls. In addition, the inspector will indicate when inspections during construction will occur. Included in this phase are the following:

- Pre-construction Meeting with County Inspector: The inspector reviews the stormdrain plans, sequence of construction and checklist.
- Completed Bioretention Inspection Checklist: This includes the required inspections and certifications needed to finalize the project.
- Installed and Inspected Sediment Controls: After the pre-construction meeting, sediment controls must be installed and the county inspector must approve them prior to construction.

During this phase the designer needs to be onsite to make sure the project is implemented correctly and to address any problems. The designer or construction manager must make sure that the design sequence is followed and inspections occur on time.

In this phase the designer must ensure the project is completed as designed. Any changes to the original plan must be documented. This is also the phase in which any final inspections required for permit compliance are completed and on time.

FIGURE o . : a ple Bioretention ec list

Pre-constr ction eetin

- ☐ Approved Stormwater Management Plan
- ☐ Disseminate inspection re uirements what needs inspection
- ☐ icket and tag re uirements and a copy of the geotechnical report if available

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- ☐ Suitable sub grade materials
- ☐ Presence of moisture or water
- ☐ Dimensions and placement of e cavation conforms with plans
- ☐ Sediment and erosion control devices in place

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- ☐ Optional sand layer placed per plan
- ☐ Back ll soil conforms with speci cations and placed per details and speci cations
- ☐ Correct placement of ground cover or mulch cover
- ☐ Correct placement of underdrains si e, schedule, location , where re uired
- ☐ Correct placement of lter fabric
- ☐ Proper placement of plant materials type, si e, uantity, tags
- ☐ Proper grade establishment

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- ☐ Original signed sealed Certi cation Letter for private facilities and or As Built Plan for public facilities from a State Regis tered Professional Engineer
- ☐ Changes in grading, facility depth, si e, soil medium, plant materials, etc., re uire an As built Plan, whether private or public, to reflect the changes
- ☐ Maintenance Agreement Covenant for bioretention facilities located on private property
- ☐ All landscaping installed landscape warrantee documentation received
- ☐ Bioretention con guration, si e and depth in accordance with approved plans
- ☐ Landscaping certi cation documentation for bioretention facility ies
- ☐ Drainage area conforms to approved plan
- ☐ Drainage area completely stabili ed

This final step entails developing a maintenance schedule in order to ensure the project operates as designed and addresses the primary problem identified at the beginning of the project.

Maintenance typically involves the land manager completing the following tasks:

- Inspect and repair erosion monthly
- Reapply mulch every six months
- Weed at least monthly
- Inspect for disease/pest monthly
- Water immediately after completion of project and 14 days after completion (unless there is sufficient rain); then water as needed
- Replace dead and diseased plants in early spring and late fall
- Remove stakes and wires after trees have taken root; remove tags at end of warrantee period

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